Imperial College
OF SCIENCE, TECHNOLOGY AND MEDICINE

SOCIAL INCLUSION: TRANSPORT ASPECTS (UG320)

Final Report

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EXECUTIVE SUMMARY

Introduction

The overall aim of the project *Social Inclusion: Transport Aspects* was to identify ways in which social inclusion (and related concepts) might be better integrated into the Department's current transport modelling and appraisal techniques, with a particular focus on potential modifications to the NATA framework. The project involves four interrelated streams of work:

- A review of the conceptual issues associated with the relationship between transport and social inclusion.

- An appraisal of the extent of which existing transport modelling techniques enable the representation of social impacts.

- A review of the NATA appraisal framework leading to recommendations concerning how it might be extended to better accommodate considerations of social inclusion

- An application study, based in the West Midlands, to illustrate the practical issues involved in extending existing modelling techniques.

The work was undertaken by a consortium lead by the Centre for Transport Studies at Imperial College and also including Mott MacDonald and the Institute for Transport Studies, University of Leeds.

Conceptual Issues

Social inclusion is one of a collection of related concepts that have proliferated in recent years in a number of areas of public policy. These concepts include, in the United Kingdom, 'social exclusion' and 'transport poverty' and in the United States, 'environmental justice' and 'just transport'. Although each of these concepts has a distinct provenance and a specific institutional and political locus, they share the perception that there are aspects of well being that are of relevance to public policy and that are not adequately captured by traditional measures of poverty (which are largely based on concept of relative wealth). In the context of transport, these are two key aspects that are emphasised:

- Inadequacies in transport provision (either in terms of access to the system itself or the level of service provided by the system) may create barriers limiting certain individuals and groups from fully participating in the normal range of actives, including key activities such as employment, education, health care and shopping. This concern focuses attention on the link between transport provision and activity participation and the role of accessibility, issues that have long been the focus of activity-based transport analysis.

- The transport system itself may generate disbenefits (in the form of environmental and social externalities) that bear disproportionately on certain individuals and groups. This concern focuses attention on the partial and socio-economic disaggregation of transport system externalities.

In contrast to the extensive discussion that has taken place in the literature regarding the sociological status of these concepts, only limited progress has been made on the definition of useful measurable indicators. In particular, the current UK definition of social exclusion based on the Index of Local Deprivation is largely immune to influence by transport policy interventions. This is regrettable, but also probably to some degree inevitable, given the relative immaturity of the field. Nevertheless, from the point of view of coherent public policy assessment, it is clear that there is an urgent need to develop broadly applicable (i.e., multi-sectoral) operational definitions of the relevant concept(s). This issue was outside the scope of the current project.

Modelling Issues

Given the conclusions of the conceptual review, we identified two broad types of modelling requirement: (i) tools to predict the effects of changes in transport provision on individuals' ability to participate to different activities and (ii) tools to predict the fine-grained spatial and socio-economic distribution of transport system externalities.

Modelling activity participation and accessibility: The transport modelling techniques commonly used by British local authorities do not in general deal well with this issue. There are four main weaknesses:

- The treatment of accessibility tends to be focused largely on accessibility to public transport stops and interchanges (e.g., PTAL measures), rather than on the characteristics of the complete door-to-door movement.

- The analysis of accessibility is dominated by spatial and topological considerations, with little or no account taken of temporal and financial aspects.

- No account is taken of the actual pattern of movement that are desired nor of the fact that travel and activities are linked in chains.

- The nature of the activity undertaken at the destination is often not well represented by conventional trip purpose classifications (e.g., a 'personal business' trip could subsume both a vital hospital appointment and an ephemeral visit to the hairdresser).

Addressing all these shortcomings in a comprehensive fashion poses a considerable challenge, but is, we believe, within the scope of currently emerging activity based modelling approaches. However, we recognise that such developments are of relevance only to the medium term and beyond. Fortunately, in the short term, useful developments based mainly on existing methods and data can also be made. At the simplest, the opportunity exists to significantly improve the treatment of accessibility by making use of standard network skimming technologies to produce estimates of full door-to-door travel times. Beyond this, further short term improvements may also be possible by using more sophisticated concepts of accessibility, designed to accommodate such factors as trip chains and temporal constraints on transport system performance and activity opportunity availability. The methods would provide a staging post between the current situation and a fully configured activity based treatment.

Socio-demographic and spatial disaggregation: Conventional transport models offer only limited opportunities for socio-demographic and spatial disaggregation. The former is usually

limited to, at best, crude unidimensional classifications and the latter to the level of traffic zones. This makes the identification of the differential impact of policy interventions on particular groups extremely difficult. In the medium term, techniques of synthetic population generation linked to detailed GIS residential and facility inventories may enable many of these limitations to be overcome. We note in passing that these techniques have emerged in recent years as the preferred method of articulating the demand side of activity based models and this, we believe, constitutes another persuasive consideration in favour of pursuing a programme of activity-based model development. However, these techniques can and have also been used in more conventional model systems.

In the short term, a form of disaggregation can be achieved by taking the network performance outputs (i.e., link travel times and flows) of a conventional transport modelling exercise and 'projecting' them onto a detailed (e.g., Enumeration District level) spatial matrix, producing a disaggregation of the model outputs to the ED level. For example, conditional on the link travel times estimated by the travel demand model, it is possible to calculate the door-to-door travel time from a given ED to the nearest key facility centre (e.g., hospital, grocery shop etc.). Similarly, conditional on the link flows estimated by the travel demand model, it is possible to calculate the exposure of people living in a given ED to various externalities such as emissions and noises. Provided that the EDs in question are reasonably homogeneous with respect to relevant socio-demographic, this procedure provides a plausible approximation to a disaggregation according to these socio-demographic characteristics. This form of ex-post disaggregation of model outputs, though clearly less theoretically satisfying than a complete and consistent fully disaggregate treatment throughout, does nevertheless enable social exclusion-relevant outputs to derived from standard transport modelling setups, without the need for extensive new data or model development.

Application Study

The application study undertaken in the West Midlands illustrated how the short term treatments of both accessibility and disaggregation sketched above (i.e., network skim-based accessibility measures and *ex-post* disaggregated model outputs to the ED level) can be applied in a typical local authority context using readily available data sources and modelling technology.

Although the results were intended only to be illustrative in nature, they nevertheless highlight some interesting aspects of and provide a basis for optimism that similar could be carried out in other areas.

The NATA Framework

Against the backdrop of a dual modelling emphasis on more detailed and refined treatments of (i) activity participation and accessibility and (ii) spatial and socio-economics disaggregation, we propose to extend the AST to accommodate these considerations. The extensions can either be of the form of adding extra lines to the AST, to correspond to the additional attributions such as door-to-door accessibility by the transport system or they can take the form of additional AST sheets, one for each distinct dimension of socio-economics dissagregation.

Overall Conclusions

Despite the challenging nature of the modelling requirements associated with the representation of social inclusion, we have presented proposals that illustrate that useful progress can be made in the short term in providing practitioners with relevant guidance on how best to accommodate these considerations in the appraisal of transport projects.

Useful though they may be, we should remember that the short term fixes that we have proposed are properly considered as stop-gap measures, Ideally, they would be combined with a longer term research agenda aimed at addressing current shortcomings in a more comprehensive fashion. We see two main requirements in this respect. First, work needs to be done to define appropriate measurable indicators of social exclusion (or the lack of social inclusion), in particular measures that are sensitive to the effect of transport policy interventions. And second, new modelling techniques need to be developed that better reflect the emerging requirements of practitioners than do current techniques. We believe that activity-based modelling approaches have an important contribution to make to these developments.

1 INTRODUCTION

1.1 Background and Objectives

The establishment by the current Government of the Social Exclusion Unit and the subsequent initiatives stemming from the Unit have propelled the concept of social exclusion/inclusion to the forefront of the policy debate in a number of fields, including transport.

Although social exclusion and related concepts have been extensively discussed in the social science literature (see DfT, 2000a for a review of some of this material) it remains the case that in many policy domains, including transport, the concept still lacks a clear operation definition. Moreover, there does not yet exist an operationally tractable methodology informing on how transport provision influences social exclusion or promotes social inclusion. Without an operational definition of social exclusion or a methodology relating transport provision and social exclusion, it is difficult to assess the extent to which current transport provision is or is not "inclusive" in nature or to formulate in an effective manner new policy measures to address any shortcomings believed to in exist in this provision. In particular, the lack of a clear operational definition of the transport-related aspects of social exclusion disconnects the concept from standard transport modelling and appraisal methodologies, making it difficult for transport policies aimed at addressing problems of social exclusion to be appraised on a consistent basis with other policies. It is clear that these are challenging problems, many of which raise issues that are beyond the immediate scope of the current project. However, our work has been framed against this background.

The overall aim of the project *Social Inclusion: Transport Aspects* was to identify ways in which social inclusion (and related concepts) might be better integrated into the Department's current transport modelling and appraisal techniques, with a particular focus on potential modifications to the NATA framework.

The project involved four interrelated streams of work:

- A review of the conceptual issues associated with the relationship between transport and social inclusion.

- An appraisal of the extent of which existing transport modelling techniques enable the representation of social impacts.

- A review of the NATA appraisal framework leading to recommendations concerning how it might be extended to better accommodate considerations of social inclusion

- An application study, which was based in the West Midlands, to illustrate the practical issues involved in extending existing modelling techniques.

The work was undertaken by a consortium lead by the Centre for Transport Studies at Imperial College and including Mott MacDonald and the Institute for Transport Studies, University of Leeds. The Imperial College team included Dr Brain Morton (Chapel Hill, North Carolina, USA) who contributed insights from recent US experience in the definition and modelling of "environmental justice", "transport poverty" and "just transport" which are

concepts that has been current in US transport planning since the mid-1990s and which have many similarities to the British notion of "social inclusion".

1.2 Report Structure

The remainder of this report is structured as follows. Chapter 2 sets out the specific objectives of the conceptual review and summarises the principal findings and their implications. Chapter 3 sets out the specific objectives of the review of existing modelling practice and summarises the results in terms both of modelling needs and relevant current and future developments. This review takes into account recent relevant developments in US practice associated with "environmental justice" and related concepts. A background paper giving fuller details of recent US experience is included as an Appendix. Chapter 4 presents the results of our review of the NATA framework in the light of the requirements highlighted in Chapters 2 and 3 and proposes a number of relatively simple modifications to improve the ability of the framework to cope with social inclusion considerations. Chapter 5 presents the results of the West Midlands pilot application study, which was designed to illustrate how, through the judicious use of readily available existing models and data, significant short term improvements in the representation of social inclusion considerations can be achieved. Finally, Chapter 6 presents some overall conclusions from the work.

2 CONCEPTUAL REVIEW

2.1 Objectives

The principal objectives of the conceptual review were:

- To develop a systematic understanding of the ways in which transport provision (and hence transport policy interventions) affect social inclusion.

- Based upon this, to make recommendations regarding what additional characteristics and/or processes should, in principle, be represented within transport models in order to enable then to adequately represent the relationship between transport provision and social inclusion.

The conceptual review drew upon a number of sources including the general social policy literature, existing studies within the transport domain and the literature describing the development of closely related concepts in the United States.

The starting point for the conceptual review is to attempt to clarify the concept of social inclusion. This is in fact a relatively new term in UK policy debates, but one that is closely related to the more well-established term, social *exclusion*. Although it is still an area of some contention in literature, in broad terms, most commentators seem to regard social inclusion as simply the absence or negation of social exclusion. For example, the Centre for Economic and Social Inclusion (2002) define social inclusion as:

> "…a process for dealing with social exclusion and integrating individuals into society"

The conceptual review therefore starts by considering the relevant aspects of social exclusion.

2.2 Concepts of Social Exclusion

The concept of social exclusion has its origins in French social policy debates of the 1980s (Allen *at al*., 1998; Berghman, 1995; Burchardt *et al*., 1999; Room, 1995; Walker and Walker, 2000; Whelan and Whelan, 1995). Since its emergence in this period, the concept has attracted growing interest and political credence in the UK, culminating in the creation, in 1997, of the Social Exclusion Unit, based in the Cabinet Office. The initiatives stemming from the SEU have propelled the concept of social exclusion to a prominent position in policy debates in a number of areas of government activity, including transport.

The concept of social exclusion seems originally to have been proposed by social theorists as a portmanteau term to describe the coexistence and co-development of a number of social problems (such as unemployment, poor educational attainment, poor housing, poor health, low uptake of social service provision, failure to participate in political processes etc.) associated with the fragmentation of traditional social structures and relations, the decline in participation in the normal institutions and processes of society and the growth of deprivation amongst of particular social groups. These problems were seen as being both related to one another and related to, though not completely explained by, traditional notions of relative or absolute poverty.

Thus whilst traditional measures of poverty focus principally on the lack of material wealth and its consequences (Townsend, 1979), the concept of social exclusion is seen as emphasising the importance of a wider set of inter-related social factors (Church *et al.*, 2000), including, but not limited to, wealth. Indeed, there is a particularly strong emphasis in much of the social policy literature on distinguishing the concept of social exclusion from the more traditional concepts of poverty (e.g., Atkinson, 1998; de Haan, 1999), the argument being put that although social exclusion and poverty are likely to be strongly correlated (Walker, 1995) they are not equivalent or interchangeable concepts, since the effects of poverty are mediated by a variety of social institutions. As pointed out by Murray (1998):

> "Traditional references to poverty relate to income levels and material considerations - what people have or don't have. The more sophisticated work on deprivation [and social exclusion] is multi faceted and is about access to services, the quality of the environment, or the ability to participate - what people can or can't do."

However, it is interesting to note that the desirability of maintaining a hard distinction between the concepts of poverty and social exclusion is not necessarily universally accepted and indeed has recently been challenged in the academic literature (Hills *et al*., 2002). Moreover, within Government the distinction is also not always clearly maintained. For example, Gaffron *et al.* (2001) point out that the *Poverty and Social Exclusion (National Strategy) Bill* of 1999 (House of Commons, 1999) always uses the two concepts together. Likewise, in the Government's headline indicators of sustainable development (DEFRA, 2002), social exclusion and poverty are consistently bracketed together (indicators H4).

A further related concept which has a significant history and established role in public policy in the UK is deprivation. The concept has recently been defined by Folwell (1999) as:

> "a lack of access to resources and denial of opportunities in areas which most affect people's life chances (particularly, education, employment, housing) and ultimately, an inability to participate in those lifestyles, customs and activities which define membership of society"

Indices of deprivation (calculated at ward and enumeration district level, using census data) have been used in one form or another by the UK Government since the 1970s in order to target regeneration policies on the most deprived areas. In their most recent form – Indices of Deprivation 2000 – (Index Team, 2000; DfT, 2000c) these indices suggest a somewhat broader concept than poverty, including a range of measures covering six key 'domains' (income, employment, health and disability, education, skills and training, housing, geographical access to services), spanning both economic and social factors. Graffron *et al*. (2001) point out that this contemporary concept of deprivation has considerable overlap with the notion of social exclusion, but also assert that the correspondence is not exact.

One reason why some argue that the concept of deprivation as embodied in ID 2000 does not correspond exactly with the concept of social exclusion as expounded in the social policy literature is that the latter emphasises the idea that social exclusion should be seen as a dynamic process (rather than a static state) involving the interaction of various contributing factors over time. This leads to the idea that social exclusion is potentially cumulative over time. Thus, for example, Walker and Walker (2000) describe social exclusion as a:

> "dynamic process of being shut out, fully or partially, from any of the social, economic, political and cultural systems which determine the social integration of a person in society"

A number of authors also point out that social exclusion can have a strong geographical dimension. For example, Madanipour *et al.* (1998) propose a definition of social exclusion that emphasises the notion of social excluded neighbourhoods:

> "[social exclusion is] a multi-dimensional process, in which various forms of exclusion are combined: participation in decision-making and political processes, access to employment and material resources, and integration into common cultural processes. When combined, they create acute forms of exclusion that find a spatial manifestation in particular neighbourhoods."

However, it is recognised that the relationship between spatial location and social exclusion is highly complex (Power and Wilson, 2000). Not only is there seen to be a tendency for social exclusion to be clustered spatially, but the properties of location and accessibility are seen as fundamentally important in determining the ability of individuals to participate in normal social institutions and processes.

Recent UK Government definitions of social exclusion broadly reflect the general trust of the social policy literature, placing emphasis on the multi-sectoral nature of the concept. In 2000, for example, the Social Exclusion Unit (2000) offered the following definition:

> "Social exclusion is a shorthand term for what can happen when people or areas suffer from a combination of linked problems such as unemployment, poor skills, low incomes, poor housing, high crime environments, bad health and family breakdown."

And more recently, (Social Exclusion Unit, 2002) this official definition has been refined to add explicit emphasis on the dynamic or cumulative effects and (lack of) full participation in society:

> "The term 'social exclusion' refers to more than poverty or low income, but it is closely related to them. It is used to describe a number of linked problems such as unemployment, poor educational achievement, low incomes, poor housing, physical barriers and bad health which tend to have a cumulative and reinforcing effect on each other, preventing people from fully participating in society."

And in a broadly similar fashion, the European Commission (1997) has defined social exclusion as:

> "…an accumulation and combination of several types of deprivation which go beyond poverty to social exclusion: lack of education, deteriorating health conditions homelessness loss of family support non participation in the regular life of society and lack of job opportunities"

Overall, it is clear that although there remains active debate amongst social theorists on various nuances of the concept of social exclusion (e.g., Barry (1998) speculates on whether someone who *deliberately* decides to withdraw from particular economic or social

institutions is or is not socially excluded) there appears to be a substantial measure of agreement on the broad nature of the concept. However, as a number of authors have pointed out (e.g., Graffron, 2001; Stewart, 2002), the definitions around which this agreement has coalesced are extremely vague. For example, Stewart (2002) comments that:

> "…the concept of social exclusion continues to dodge efforts to pin it down definitively, [despite it being] broadly agreed that it is concerned with overlap between deprivation in several spheres."

One consequence of this definitional vagueness is that the measurement of social exclusion has proven to be distinctly problematic.

2.3 The Measurement of Social Exclusion

Most definitions of social exclusion are far too vague to form the basis of operational measurement. Though it has been argued by some that this vagueness is a virtue (e.g., Littlewood and Herkammer, 1999), this is not the dominant view and accordingly in recent years there have been many attempts to develop operational measures of social exclusion.

The general approach adopted in developing operational measures is to define a number of functional dimensions (or 'domains') of social exclusion and for each domain to propose one or more measurable indicators. This process results in a set of indicators, which together constitute the measure of social exclusion.

Burchardt *et al.* (1999) proposed one of the first quasi-operational definitions:

> "An individual is socially excluded if (a) he or she is geographically resident in a society and (b) he or she does not participate in the normal activities of citizens in that society".

This goes beyond the definitions of social exclusion discussed in section 2.2 in that it refers to entities ("participation in normal activities") that are at least in principle measurable. However, it is incomplete as an operational definition because it does not define what constitute normal activities or what level of engagement in these normal activities constitutes participation (this an example of the much more general problem of designing an appropriate comparator for use in a relative measure). Burchardt *et al.* (1999) sought to address the former (though not the latter) weakness by proposing a five-way classification of key activities (Graffron, 2001):

- Consumption activity – the ability to consume at least to a certain level the goods and services considered normal for the society

- Savings activity – the ability to accumulate savings and pension entitlements and/or to own property, both as a way of fulfilling individual and social aspirations (such as home ownership) and to provide security for periods outside the labour market

- Production activity – the ability to engage in an economically and/or socially valued activity (incl. paid work, education, training, retirement over state pension age or looking after a family), which helps the individual to gain or maintain self-respect for

being engaged in an activity valued by others and makes a direct or indirect economic contribution to society

- Political activity – the ability to engage in some collective effort to improve or protect the immediate or wider social and physical environment (including voting, membership of political parties and or campaigning groups)

- Social activity – the ability to engage in significant social interaction with family or friends and identifying with a cultural group or community (social isolation and denial of cultural rights are considered significant factors in social exclusion

One interesting feature of the measure proposed by Burchardt *et al.* is that it is inherently defined at the level of the individual i.e., social exclusion is seen as an attribute of the individual. In more recent work, Burchardt *et al*. (2001) use data from the British Household Panel Study to operationalise a related definition of social exclusion, based on four dimensions of participation: consumption, production, political activity and social engagement. They show although exclusion on one dimension is positively and significantly correlated with exclusion on other dimensions, the correlation is not strong.

In contrast to such individual-oriented measures, most of the other operational measures of social exclusion that have been proposed in the literature have explicitly or implicitly defined social exclusion on a geographical basis i.e., in these approaches social exclusion is seen as an attribute of an geographical area, via the aggregate characteristics of the population living there. This is an important distinction, which we will discuss further in Chapter 3.

One of the first examples of this latter approach is the work Vidler and Curtis (1999) which proposed a multi-dimensional measure consisting of 16 indicators developed from existing data census and survey data sources and organised in six themes: low incomes; access to employment; housing quality; education; health and fertility; and citizenship and community participation. Conceptually (though not in their operational detail) this proposal is very similar to DEFRA's Indices of Deprivation, that were discussed in section 2.2.

It is important to note however, that the Indices of Deprivation go one stage further than the proposal of Vidler and Curtis in that the various indicators were *combined* using weights to produce an overall Census ward level Index of Multiple Deprivation. A rather similar measure was proposed by Church *et al.* (2000) in the context of their study of social exclusion and transport in London. Their measure combined a number of indicators derived from the 1998 Index of Local Deprivation, augmented with additional indicators of local accessibility, calculated from a network transport model. One reason why Church *et al*. found it necessary to augment the 1998 Index of Local Deprivation in this way is that this index contained very little information about transport-related phenomena and that consequently was not able to reflect the effects of transport policy measures on social exclusion.

The Indices of Deprivation published in 2000 improved on this situation to some degree by including a new domain concerned with "access to services" (see Table 2.1). However, access in this context is defined in terms is distance (rather than travel time or cost or generalized cost), so even these these indicators remain relatively insensitive to most transport policy interventions (which in their nature tend to affect travel times and cost, rather than distance).

A number of studies undertaken recently for the Joseph Rowntree Foundation (e.g., Gordon, 2000; Rahman *et al.*, 2002) have developed an extensive set of 50 indicators of poverty and social exclusion (see, Table 2.2). Although these indicators are structured in a rather different manner to the ID 2000 indicators (with a much greater focus on population groups, rather than functional domains), the overall coverage is rather similar, though it should be noted that the Rowntree measures include no director descriptors of transport-related outcomes.

In addition to these proposals, a number of UK government departments have also proposed measures of social exclusion and related concepts. In September 1999 the DSS published the Government's first annual report on social exclusion (DSS, 1999; Vidler and Bardgett, 2000), which included a set of 32 indicators of social exclusion (see Table 2.3).

TABLE 2.1 Summary of Indicators in Indices of Deprivation 2000 (Source: DfT 2000c)

Income
Adults in Income Support
Children in Income Support
Adults in Income Based Job Seekers Allowance
Children in Income Based Job Seekers Allowance
Adults in Family Credit
Children in Family Credit
Adults in Disability Working Allowance
Children in Disability Working Allowance
Non-earning, non-IS pensioner and disabled Council Tax Benefit

Employment
Unemployment claimant counts
People out of work but in TEC delivered government supported training
People aged 18-24 on New Deal options
Incapacity Benefit recipients aged 16-59
Severe Disablement Allowance claimants aged 16-59

Health
Comparative Mortality Ratios for men and women at ages under 65.
People receiving Attendance Allowance or Disability Living Allowance
Proportion of people of working age (16-59) receiving Incapacity Benefit or Severe Disablement Allowance
Age and sex standardized ratio of limiting long-term illness
Proportion of births of low birth weight (<2,500g)

Education, skills and training
Working age adults with no qualifications
Children aged 16 and over who are not in full-time education
Proportions of 17-19 year old population who have not successfully applied for HE
KS2 primary school performance data
Primary school children with English as an additional language
Absenteeism at primary level

Housing
Homeless households in temporary accommodation
Household overcrowding
Poor private sector housing

Access to services
Access to a post office
Access to food shops
Access to a GP
Access to a primary school

TABLE 2.2 Summary of the Poverty and Social Exclusion Indicators Proposed by the Joseph Rowntree Foundation. (Source: Rahman, *et al.*, (2002)

Income

1 Gap between low and median income
2 Individuals with low income (below 50% of average income)
3 Intensity of low income (below 40% of average income)
4 In receipt of means-tested benefits or tax credits (working-age only)
5 Long-term recipients of benefits (all ages)
6 Periods of low income (at least 2 years in 3 on a low income)
7 The location of low income

Children

8 Living in workless households
9 Living in low income households (below 60% of median income)
10 Low birth-weight babies (%)
11 Accidental deaths
12 Low attainment at school: pupils gaining no GCSE above grade D
13 Permanently excluded from school
14 Children whose parents divorce
15 Births to girls conceiving under age 16 Improved
16 In young offenders institutions (age 10 to 16)

Young adults

17 Unemployed (age 16 to 24)
18 On low rates of pay (age 16 to 21)
19 Not in education, training or work (age 16 to 18)
20 Problem drug use (age 16 to 24)
21 Suicide (age 15 to 24)
22 Without a basic qualification (age 19)
23 With a criminal record (age 18 to 20)

Adults (age 25 to retirement)

24 Individuals wanting paid work
25 Households without work for two years or more
26 On low rates of pay
27 Insecure at work
28 Without access to training
29 Premature death
30 Obesity
31 Limiting long-standing illness or disability
32 Mental health

Older people

33 No private income
34 Spending on 'essentials'
35 Excess winter deaths
36 Limiting long-standing illness or disability
37 Anxiety (feeling unsafe out at night)
38 Help from social services to live at home (%)
39 Without a telephone

Communities

40 Non-participation in civic organisations
41 Polarisation of work (%)
42 Spending on travel
43 Lacking a bank or building society account
44 Burglary
45 Without household insurance
46 Dissatisfaction with local area (%)
47 Without central heating
48 Overcrowding
49 Households in temporary accommodation
50 Mortgage arrears

TABLE 2.3 DSS Indicators of Social Exclusion (Source: DSS, 1999)

Children and Young People

1. An increase in the proportion of seven-year-old Sure Start children achieving level 1 or above in the Key Stage 1 English and maths tests.
2. Health outcomes in Sure Start areas:
 a. a reduction in the proportion of low birth-weight babies in Sure Start areas;
 b. a reduction in the rate of hospital admissions as a result of serious injury in Sure Start areas.
3. An increase in the proportion of those aged 11 achieving level 4 or above in the key stage 2 tests for literacy and numeracy.
4. A reduction in the proportion of truancies and exclusions from school.
5. An increase in the proportion of 19-year-olds with at least a level 2 qualification or equivalent.
6. A reduction in the proportion of children living in workless households, for households of a given size, over the economic cycle.
7. Low-income indicators:
 a. A reduction in the proportion of children in households with relatively low incomes;
 b. A reduction in the proportion of children in households with low incomes in the absolute sense; and
 c. A reduction in the proportion of children with persistently low incomes.
8. A reduction in the proportion of children living in poor housing.
9. A reduction in the proportion of households with children experiencing fuel poverty
10. A reduction in the rate at which children are admitted to hospital as a result of an unintentional injury resulting in a hospital stay of longer than three days.
11. A reduction in the proportion of 16 – 18-year-olds not in education or training.
12. An improvement in the educational attainment of children looked after by local authorities.
13. Teenage pregnancy: a reduction in the rate of conceptions for those aged under 18 and an increase in the proportion of those who are teenage parents, in education, employment or training.

People of working age

14. An increase in the proportion of working age people in employment, over the economic cycle
15. A reduction in the proportion of working age people living in workless households, for households of a given size, over the economic cycle.
16. A reduction in the number of working age people living in families claiming Income Support or income-based Job Seekers Allowance who have been claiming these benefits for long periods of time.
17. An increase in the employment rates of disadvantaged groups and a reduction in the difference between their employment rates and the overall rate for
 a. People with disabilities;
 b. Lone parents;
 c. Ethnic minorities; and
 d. The over 50's.
18. Low-income indicators:
 a. A reduction in the proportion of working age people in households with relatively low incomes;
 b. A reduction in the proportion of working age people in households with low incomes in an absolute sense; and
 c. A reduction in the proportion of working age people with persistently low incomes.
19. An increase in the proportion of working age people with a qualification.
20. A reduction in the number of people sleeping rough.
21. A reduction in cocaine and heroin use by young people.
22. A reduction in adult smoking rates in all social classes.
23. A reduction in the death rates from suicide and undetermined injury.

Old people

24. An increase in the proportion of working age people contributing to a non-state pension
25. An increase in the amount contributed to non-state pensions.
26. An increase in the proportion of working age individuals who have contributed to a non-state pension in at least three years out of the last four.
27. Low-income indicators:
 a. A reduction in the proportion of older people in households with relatively low incomes;
 b. A reduction in the proportion of older people in households with low incomes in an absolute sense; and
 c. A reduction in the proportion of older people with persistently low incomes.
28. A reduction in the proportion of elderly households experiencing fuel poverty.
29. A reduction in the proportion of older people whose lives are affected by fear of crime.
30. An increase in healthy life expectancy at age 65.
31. A reduction in the proportion of households containing at least one person aged 75 or more living in poor housing.
32. An increase in the proportion of older people being helped to live independently.

In a rather similar fashion to the Joseph Rowntree Foundation measure, these indicators are organised around population groups rather than functional domains and in addition focus on participation in a number of specific government programmes In the context of its work on sustainable development, DEFRA (2002) proposed four indicators of poverty and social exclusion, computed at the regional level, that are based on a subset of the DSS indicators.

The European Union has also been active in the area of developing measures of social exclusion proposing the use of indicators covering five key domains: material well-being, participation in productive (economic) activities, education, health and social participation (Atkinson, *et al.*, 2002; Eurostat, 2000; European Commission, 2002; Stewart, 2002).

Note that in the various indicator-based measures of social exclusion proposed by the Joseph Rowntree Foundation, Vidler and Curtis, DSS, DEFRA-Sustainable Development and the EU, individual indicators are listed separately and no attempt made to combine the various indicators into a single scalar value. This contrasts markedly with the approach adopted in the ID 2000, which individual indicators are combined into an overall scalar value.

In view of the vagueness of the underlying concept of social exclusion, it is perhaps not surprising that the overriding impression that emerges from this brief review of recent attempts to quantify the concept is that the current state of the art leaves much to be desired. Although a multitude of measures have been proposed (originating from both the academic community and from within different tiers and functional units of government) as yet there appears to be no consensus on the most appropriate approach. This lack of consensus in part reflects the persistence of a number of significant weaknesses in the existing measures. Although it is clearly beyond the scope of the current project to address these weaknesses, it may be helpful to briefly enumerate them.

Firstly, whilst social theorists have been at pains to assert the distinctiveness of the concept of social exclusion in contrast to earlier concepts of poverty, deprivation and well being, there turns out to be little difference between the indicators typically chosen to characterise social exclusion and those used to characterise these earlier notions. In so far as social exclusion is indeed a usefully distinctive concept, the currently proposed measures do not succeed in capturing this distinctiveness. A second weakness with the existing measures is that although social theorists have stressed the importance of capturing the cumulative effect of disadvantage in different dimensions, most of the measures proposed only consider each dimension separately. Only the ID 2000 measure attempts to combine indicator values from different dimensions into an overall measure and even this takes no account of the possibility of interactions (positive or negative) across different dimensions. A third problem is that the current measures take no account of the persistence or accumulation over time of social exclusion; i.e., just as there is no means of systematically aggregating across dimensions so there is also no means of systematically aggregating over time. A final methodological difficulty, which is of particular importance in the context of the relationship between transport and social exclusion, is the apparent inconsistency that exists been the conceptual definition of social exclusion as a phenomenon operating at the individual level and the operational definition of most measures at the level of a geographical area. When the geographical area in question is small (e.g., in the case of ID 2000, a census enumeration district), the effect of the implicit averaging *may* not be great, however, when measures are computed for larger geographical aggregates, the effects are unclear.

2.4 Transport and Social Exclusion

It is clear that the concept of social exclusion as presently used in Government has dimensions that extend well beyond the realm of what has conventionally been regarded as dependent upon, or for that matter potentially open to influence by, transport policy. However, it is equally clear that transport provision can potentially play an important role in influencing many of the outcomes that are enveloped by the concept of social exclusion since, in most instances, *inclusion* implies *participation* in processes and activities (e.g., labour markets, social services, social networks etc.) and this participation will often in turn depend upon *physical access* to the relevant facilities.

The notion of social exclusion can therefore usefully be conceived of as (at least in part) related to constraints on individuals' capacity to command the means and resources to access key facilities. The nature of these constrains have been explored by a number of recent studies. DfT (2000a) investigated the relationship between social exclusion and public transport use and concluded that:

> "People are excluded from activities they wish to undertake
>
> - *spatially*, because they cannot get there at all,
> - *temporally*, because they cannot get there at the appropriate time,
> - *financially*, because they cannot afford to get there, and
> - *personally*, because they lack the mental or physical equipment to handle the available means of mobility."

A related but somewhat broader set of factors were identified by Church *et al*. (2000) in their study of social exclusion and transport in London. They proposed a framework for understanding the spatial dimension of social exclusion, which identified three inter-related processes:

> "The first set of processes were those related to the nature of time-space organisation in households, the interaction between household members and other individuals (e.g. friends and relatives) and the manner in which time-space budgets influence the ability to travel and travel choices. The second set of processes influencing individual mobility were the nature of the transport system in terms of cost, network coverage and service patterns, personal security and public space. The final set of processes related to the nature of the time-space organisation of the activities that people are seeking to access."

Based on this framework Church *et al*., identify seven dimensions of transport-related exclusion:

- Physical exclusion – based on physical, cognitive or linguistic barriers.
- Geographical exclusion – based on shortcomings in spatial coverage of transport provision.
- Exclusion from facilities – based on the location and/or nature of the facilities themselves.

- Economic exclusion – based on the cost of transport services.

- Time-based exclusion – based in scheduling conflicts and incompatibilities between the schedules of transport services and the temporal

- Fear-based exclusion – based on concerns regarding personal safety and security associated with the use of transport services.

- Space exclusion – based on inappropriate design of transport interchanges and related public spaces.

Although the dimensions identified by Church *et al*. are different to those proposed by DfT (2000a), it is clear that there is a substantial degree of overlap between the two proposals.

In the context of work undertaken for the Scottish Executive, Graffron *et al*. (2001) and Hine and Mitchell (2001) propose five broad dimensions of transport related social exclusion, that neatly reconcile the ideas put forward by DfT (2000a) and Church *et al*. These dimensions are:

- Physical
- Economic
- Temporal
- Spatial
- Psychological

A number of authors (e.g., Ampt, 1994; DfT, 2000a; Richardson and Ampt, 1997; Root, 1998; SEU, 1998) have recently used the term 'transport poverty' to refer in broad terms to the cumulative effect of poor public transport services, poor provision for walking and cycling (including access to public transport) and low levels of car ownership, particularly affecting women, the poor, the disabled, dwellers in rural areas and other classically disadvantaged groups. Although this concept has, rather like social exclusion itself, so far resisted a clear or agreed definition[1], it is a useful linguistic label for certain archtypal conjunctions of transport related problems.

In summary, it is clear that the general trust of all these studies is to highlight the fact that inadequacies in transport provision (either in terms of access to the system itself or the level of service provided by the system with respect to key destinations and facilities) may create barriers limiting certain individuals and groups from fully participating in the normal range of actives, including key activities such as employment, education, health care, shopping and social interactions. This concern focuses attention on the link between transport provision and activity participation and the role of accessibility (both to the transport system itself and within the system from origin to destination), issues that have long been the focus of transport analysis.

[1] For example, DfT (2000a) comments that: "The term 'transport poverty' is increasingly used. There is an assumption that there exists a general understanding of this term. But unlike the term 'income poverty' which is defined as being an income below half the national average, no common definition exists for transport."

2.5 Recent US Experience: 'Environmental Justice' and 'Just Transportation'

In parallel to the development in Europe of the concept of social exclusion, a related set of concepts under the general rubric of environmental justice, have emerged in the United States. These concepts are now enshrined in US policy and practice and have spawned significant innovations in analysis and modelling (Forkenbrock and Schweitzer, 1996), which we will consider in more detail in Chapter 3. Whilst it is clear that the concepts of environmental justice and social inclusion are in no sense equivalent, it is also apparent that there is a substantial degree of overlap. The development and impact of these concepts therefore provide an interesting counterpoint to the European experience.

The concept of environmental justice has its roots in Title IV of the Civil Rights Act of 1964, which prohibits the exclusion from participation in, denial of benefits of, and other forms of discrimination under Federally-assisted programs (Marchese, 2001). The relevant legislation states that:

> "No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."[2]

From the 1960s onwards various attempts were made to interpret Title IV in the context of planning and transportation issues. However, it was not until President Clinton signed Executive Order 12898 in February 1994 that such interpretations became officially endorsed. This Executive Order directs each federal agency in the United States to develop an Environmental Justice strategy for:

> "…identifying and addressing... disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations."[3]

The Presidential Executive Order was followed up in 1997 by the publication by the U.S. Department of Transportation of an Order setting out a more detailed definition of environmental justice in the context of transport. This definition comprised four key ideas:[4]

- an identification of adverse effects associated with a policy or scheme
- a comparison of the adverse effects borne by minority or low-income populations to the adverse effects borne by the population as a whole
- a judgment as to whether adverse effects on minority or low-income populations are disproportionate
- if a disproportionate impact is likely, a determination of whether it is acceptable.

[2] 42 United States Code 2000d.
[3] U.S. President, Executive Order 12898. "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," *Federal Register* 59, no. 32, February 16, 1994, 7629.
[4] U.S. Department of Transportation. Order on Environmental Justice (no. 5610.2). February 3, 1997. The Order was published in the *Federal Register* 62, no. 72, April 15, 1997, 18377.

The Order applies to programs, policies, and activities, including financial assistance provided by the Department, that significantly affect human health or the environment A year later, the Federal Highways Administration issued a parallel and nearly identical order[5].

Table 2.4 summarises the key features of the DOT Order.

TABLE 2.4 US DOT Operational Definition of Environmental Justice

Key Groups
These are defined as any readily identifiable group of low-income, Black, Hispanic, Asian, American Indian, or Alaskan Native persons who live in geographic proximity, and, if circumstances warrant, geographically dispersed or transient persons who would be similarly affected by a proposed action. Migrant workers and Native Americans are examples of the latter.

Key Impacts
The key impacts to be considered (both individually and cumulatively) include:

- Bodily impairment, infirmity, illness, or death.
- Air, noise, and water pollution and soil contamination.
- Destruction or disruption of man-made or natural resources.
- Destruction or diminution of aesthetic values.
- Destruction or disruption of community cohesion or a community's economic vitality.
- Destruction or disruption of availability of public and private facilities and services.
- Vibration.
- Adverse employment effects.
- Displacement of persons, businesses, farms, or non-profit organizations.
- Increased traffic congestion.
- Isolation, exclusion, or separation of minority or low-income individuals within a given community or from the broader community.
- Denial of, reduction in, or significant delay in the receipt of benefits of DOT's actions

Definition of Disproportionate Impacts
Impacts are considered to be disproportional when either:

- An adverse effect that will be predominately borne by a minority population and/or low-income population, or
- An adverse effect that will be borne by a minority population and/or low-income population to a degree that is appreciably more severe or greater in magnitude than the effect that will be borne by the non-minority population and/or non-low-income population.

Justification of Disproportionate Impacts
Two circumstances in which disproportionate impacts may be justified are defined:

- When mitigation measures or alternative actions would result in significant adverse effects on other important social, economic, or environmental resources
- If the previous condition holds and in addition: (i) a "substantial need" for the action exists "based on the overall public interest" and ii) the alternatives that meet the identified need and are less harmful for the protected groups either would severely affect others or would involve increased expenses of "extraordinary magnitude".

[5] U.S. Department of Transportation. Federal Highways Administration. "FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Order 6640.23. December 2, 1998.

There are a number of interesting points of similarity and difference between this definition and the typical UK definitions of social exclusion. In terms of the similarities, it is notable that both approaches are concerned with the impact of transport provision and policies on specific groups, including but not limited to low-income groups. A second important similarity is that both approaches are concerned with the cumulative effects of impacts considered across a number of different dimensions.

More interesting, however, are the differences, which are broadly of three types. First, whereas the UK approach focuses attention mainly on the direct contribution of transport provision and policies to facilitating (or otherwise) individuals' access to and participation in various economic and social activities, the US approach focuses more attention on the indirect consequences of transport infrastructure and provision in terms of environmental, aesthetic, safety and social externalities. Clearly, both direct and indirect effects are potentially important and a genuinely comprehensive approach would seek to account for both.

Second, whereas the concepts and measures of social exclusion developed in the UK are principally descriptive of individuals or geographical areas, the operational definition of environmental justice is strongly oriented towards the task of describing and evaluating specific policies and programmes in terms of individuals and groups affected. In this respect, the US DOT interpretation of the concept of environmental justice is rather close in spirit to the territory of NATA.

The third difference is that the US approach directly addresses the issue of defining an appropriate comparator against which to judge the impact of policies on key groups. This is done very straightforwardly by stipulating that the relevant comparison is between levels of impact on the key groups and those in the population as a whole. The potentially points a way forward for

Closely associated with the concept of environmental justice, is the concept of 'just transportation' (Bullard and Johnson, 1997). Whereas environmental justice is principally concerned with preventing disproportionate adverse impacts on disadvantaged groups, the aim of the advocates of just transport is to achieve parity across race and class lines in the provision of transportation.

> "development of a regional transportation system that ensures equal access to all places of employment, housing, worship and public facilities, including access for populations that do not own or operate motor vehicles, without imposing disparate cost and travel time burdens on such populations."[6]

Unlike the other concepts considered in this Chapter, just transportation is essentially normative in nature. It adds little to the analytical insights provided by concepts such as social exclusion, transport poverty and environematal justice but rather derives its distinctive character from the emphasis it places on equality of transport outcomes, advocacy on behalf of disadvantaged groups and (as part fo the latter) the endorsement of citizen participation in the planning and decision making process.

[6] Representative John Lewis *et al*. to Rodney Slater, Secretary of the U.S. Department of Transportation, December 2000.

2.6 Summary and Implications for Modelling

This brief review has revealed that social inclusion is one of a collection of related concepts that have proliferated in recent years in a number of areas of public policy. These concepts include, in the United Kingdom, 'social exclusion' and 'transport poverty' and in the United States, 'environmental justice' and 'just transport'. Although each of these concepts has a distinct provenance and a specific institutional and political locus, they share the perception that there are aspects of well being that are of relevance to public policy and that are not adequately captured by traditional measures of poverty (which are largely based on concept of relative wealth).

In the context of transport, there are two key aspects that are emphasised:

- The first is that inadequacies in transport provision may create barriers limiting certain individuals and groups from fully participating in the normal range of actives, including key activities such as employment, education, health care, shopping and social/recreational pursuits. This concern focuses attention on the link between transport provision and activity participation, in particular on the way in which the physical, financial, spatial, temporal and psychological constraints imposed by the transport system may specifically and cumulatively affect particular target groups.

- The second is that the operation of the transport system itself may generate disbenefits (in the form of environmental, aesthetic and social externalities) that bear disproportionately on certain individuals and groups, compared to the population as a whole. This concern focuses attention on the spatial and socio-economic disaggregation of transport system externalities.

In contrast to the extensive discussion that has taken place in the literature regarding the sociological status of these concepts, only limited progress has been made on the definition of useful measurable indicators of social exclusion, and this remains a contentious and developing area. None of the widely available indicator-based measures take explicit account of the details of transport provision, although ID 2000 does at least include measures of the spatial proximity of key facilities. It therefore seems likely that, at least in the immediate future, transport analysts will need to augment these generic measures of social exclusion with additional measures, more directly related to transport provision and outcomes.

There are a number of important implications of this conceptual review in terms of the requirements placed on transport models to deal comprehensively with social exclusion issues:

- The first requirement is for a significantly greater degree of socio-economic and spatial disaggregation in modelling. This stems from the need to be able to identify the differential impacts of policies on socio-economically and spatially specific population groups, in particular groups that are . Whereas most existing transport models provide a reasonably detailed treatment of the spatial dimension, the treatment of socio-economic dimensions (e.g., income, employment, family structure etc.) is usually very crude.

- The second requirement is for modelling approaches that are able to explicitly inform on the magnitude and nature of individuals participation in key activities (such as

employment, education, health care, shopping and social/recreational persuits), since it is the lack of such participation that is one key indicators of social exclusion. Most existing models tell us little about the nature, frequency or duration of activity participation, beyond the purpose of the bracketing trips.

- The third requirement is for the development of a significantly extended concept of accessibility. Conventionally, transport analysts have regarded accessibility purely in spatial terms, focusing principally on motorised movements within the transport system. However, it is clear that in order to capture the full range of issues associated with social exclusion, the concept of accessibility must be broadened to include temporal, financial and situational factors and to include consideration of access to the transport system, as well as access within it.

The implications of these requirements are considered in more detail in the following chapter.

3 MODELLING REVIEW

3.1 Objectives

Given the nature of the modelling requirements highlighted in the conceptual review, the principal objectives of the review of modelling approaches are:

- To identify the key strengths and weakness of existing data and modelling approaches with respect to the requirements for representing the effect of transport policies on social inclusion.

- To propose appropriate modifications to existing techniques to enable them to better address the issue of social exclusion.

It is convenient to discuss the salient features of existing modelling techniques in the context of the three key requirements identified in Chapter 2.

3.2 Disaggregation

An important issue to emerge from the conceptual review is the requirement for a significantly greater degree of socio-economic and spatial disaggregation in modelling, stemming from the need to be able to identify the differential impacts of policies on socio-economically and spatially specific population groups.

Aggregate and Disaggregate Modelling Approaches

Much of current practice is still based on the use of aggregate 4-stage transport models, which use an aggregate analysis of demographic characteristics and transport network characteristics to predict the aggregate travel patterns between zones. A major drawback with this approach is that the zonal averaging that is built into aggregate 4-stage can potentially mask the behaviour of socially excluded groups. For example, if lower income groups tend to be more socially excluded, then by averaging incomes within a zone one may lose behavioural information on those within the lowest income brackets, making it difficult to assess the effects of policy measures on these groups compared to the population as a whole. Whilst it is possible to work with different demand segments within the framework aggregate 4-stage models, the mechanisms for doing this are cumbersome if a large number of segments are required. Similarly, on the supply side, traditional zone centroid/centrod-connector formalisms for the representation of intra-zonal movement make accommodating differential levels of access to the transport network (as a result for example of the effects of disability on access to public transport) problematic, since access movements are essentially averaged at the zonal level. Overall, it is clear that aggregate 4-stage modelling techniques are not particularly well suited to accommodating the analysis of issues associated with social exclusion.

A well established alternative to aggregate 4-stage modelling is the class of disaggregate discrete choice modelling techniques (see, Ben-Akiva and Lerman, 1985). Whereas aggregate models typically work with zonal averages, disaggregate techniques work with data from specific individuals, usually collected in travel surveys. Response models are estimated using individual level data and in application, estimates of aggregate responses and aggregate impacts are built up by aggregating the responses and impacts of representative samples of

individuals. Thus disaggregate modelling techniques can in principle provide a much finer grain analysis of the impacts of transport policies on particular groups of individuals, since the process of aggregation from individual to population can readily be modified to identify impacts on specific population sub-groups. Cameron (1994) for example, uses disaggregate modelling techniques to evaluate the costs and benefits of various policies across five income quintiles.

However, in practice the degree of disaggretaion that is possible often limited by the lack of adequate survey data describing socially excluded groups. This arises both because socially excluded groups tend to be numerical minorities within the population as a whole and because such individuals are often more difficult to contact and more likely to refuse to respond to surveys than other members of the population (Zmud and Arce, 2000). These features combine to make it very difficult to collect data on representative samples of socially excluded groups. This affects both model estimation and application. This problem can to some extent be overcome by better survey design, targeted at addressing the particular methodological difficulties associated with surveying socially excluded groups.

The treatment of socially excluded groups is a particular problem for the application of disaggregate models, because standard aggregation procedures require representative samples. One solution to this problem is to create a representative but synthetic sample of individuals by combining information from (possibly several) sample surveys with information from census data. Beckman *et al*. (1996), Gunn (1985) and Arentze and Timmermans (2000) present a number of different statistical and computational techniques to combine survey and census data to synthesize full population characteristics that are consistent with the available information on joint (normally obtained from sample data) and marginal (normally obtained from census data) distributions. Synthetic sample approaches have already been used extensively in the Dutch national model system (Daly *et al*., 1983) and in a number of other national model systems (e.g., Algers *et al*., 1995) and more recently have been applied at a metropolitan scale in Portland (Bradley *et al*. 1998) and San Francisco (Bradley *et al*., 2001). They also form the basis of several of the new generation of microsimulation models such as TRANSIMS (Barrett *et al*., 1999) and ALBATROS (Arentz and Timmermans, 2000) that are currently emerging in the US and Europe (see, section 3.3 below).

Synthetic sample generation clearly offers a tractable way of addressing some of the model application issues associated with the use of disaggregate modelling techniques to analyse issues of social exclusion. However, the operational details associated with the implementation of the concept, both in context of UK data sources and with a focus on social exclusion considerations, remain to be worked out.

Ex-ante and Ex-post Disaggregation

It is important to point out that in seeking to model the disaggregate impacts of policy measures, there are two quite distinct conceptual approaches that can be adopted.

The first and most comprehensive approach is to embed the required level of disaggregation directly within the specification model itself, so that the model explicitly operates with an *ex-ante* disaggregate description of the population. This is the philosophy underlying the disaggregate approaches discussed above. It enables the transport model to explicitly estimate the behaviour of particular population segments and the costs that they bear. The great

attraction of this approach is that it enables one to accurately estimate the costs and benefits incident on different groups,. The disadvantage is that such models are, as discussed above, inevitably more complex and data hungry than existing (aggregate) approaches.

The alternative approach does not depend upon modifications to the transport model *per se*, but rather, in effect, on overlying the typical outputs of a transport model (e.g., trip patterns, network speeds, fares, emissions etc.) on a spatially and socio-economically disaggregate population map (of the sort that can easily be derived from Census and/or ID 2000 data). With such an *ex-post* approach the disaggregation occurs after the transport model is run and inevitably involves an additional levels of approximation. It is possible to estimate (within the limits of the transport model) what conditions would be experienced by a particular geographically-defined population segment, *if* it attempted say to access a certain facility, but it is not possible to compute the costs and benefits actually borne by that segment, since these are not directly computed by the transport model. Hence, in particular, such an approach cannot render credible estimates of the economic welfare changes associated with policy interventions. An explicit *ex-ante* disaggregation is clearly the most desirable approach but is also the most complex and analytically demanding. It is possible that for certain forms of policy analysis, the simpler implicit *ex-post* disaggregation approach may have some value. However, it is important to appreciate the severe limitations of this approach (especially in regard to its inability to generate sound evaluation measures).

Disaggregation and Measures of Economic Welfare

When transport models are formulated explicitly as disaggregate discrete choice model systems, it is well established that theoretically valid measures welfare changes can readily be computed (McFadden, 1981; Small and Rosen, 1982; Williams, 1976, 1977). In the case of the most commonly used model forms (the multinomial logit and the nested logit), these welfare measures are directly related to the inclusive value or log-sum terms associated with the logit models. This approach has been widely applied to generate coherent measures of the welfare impact of transport policy measures (e.g., Rodier and Johnston, 1998).

However, these simple relationships only hold in their exact form in the absence of non-linear income effects in the (indirect) utility function. Whilst existing empirical work suggests that this is a reasonable assumption at the aggregate level of the population as a whole (e.g., income effects are rarely found in empirical work), it is much less obviously valid for low income groups, for whom changes in transport prices may well have direct and significant welfare effects. This is particularly so in the light of current policy discussions concerning the direct charging for road space.

When such income effects are present, welfare computations become substantially more complex, both because there is a necessity to distinguish between Hicksian (compensating variation) and Marshallian (consumer surplus) concepts of welfare and because exact welfare measures are in general not available in closed form (Herriges and Kling, 1999) and therefore must be computed either by direct simulation (McFadden, 2000) or approximated using suitable methods (Morey *et al*., 2001; Karlstrom, 2000).

Thus, if in future, transport models are to be required to support high levels of explicit population disaggregation, then it may be necessary to make further developments to existing methods of assessing welfare effects.

3.3 Activity Participation

From the perspective of analysing social exclusion, one of the key limitations of existing transport modelling approaches is that they tell us little about the nature or extent of individuals' participation in different activities. This is because the focus of classical 4-stage transport modelling techniques is on modelling the number and characteristics of trips, rather than the activities that they serve (Pas, 1990). At best, trips are categorised by purpose, where the latter is defined in broad groupings such as 'work', 'personal business', 'shopping' etc. Often, limitations of data and/or model structures mean that only 'work' and 'non-work' are distinguished. Moreover, conventional transport models tell us very little about the intensity, duration or frequency of individuals' participation in different activities, all of which are potentially important issues from the perspective of social exclusion.

Activity Based Approaches

An alternative modelling tradition that potentially addresses some of these concerns is the 'activity based approach', which emerged during the 1980s through the fusion of work on time-space geography, time-use research and travel behaviour (see, e.g., Axhausen and Polak, 1991; Axhausen and Gärling, 1992; Jones, *et al.*, 1983; Pas, 1990).

In contrast to the conventional 'trip-oriented' perspective, in which travel is conceived of principally as a set of disjoint trip-episodes with attached purposes, the activity-based approach emphasises the primacy of activity participation and sees activity participation and travel as forming linked and inter-dependent patterns in space-time that are the result of decision making at both an individual and household level. Axhausen and Polak (1991) comment that:

> "...[the activity based approach] argues that observed patterns of trip making should be seen as the consequence of individuals' and households' desire to participate in spatially and temporally distinct activities and that the analysis of travel behaviour should therefore be based on an understanding of the *linked sequence* of activities in which people engage during a day"

Pas (1990) points out another important aspect of the activity based approach, namely the emphasis it places on the importance of spatio-temporal, inter-personal and situation constraints in influencing travel behaviour:

> "…the [activity based approach] ...examines travel from a broad perspective that takes account of the demand for activity participation and motivations and interrelationships between trips. This perspective includes the scheduling of activities in time and space, the spatio-temporal and inter-personal constraints on travel and activity choices, the structure of the household and the roles of individuals in the household."

The concepts of the activity-based approach in principle provide an attractive framework in which to understand how the spatial, temporal, financial and situational constraints identified in the conceptual review interact to influence the opportunities of individuals and households to participate in activities.

A range of relevant modelling work has emerged from this activity based tradition. A number of studies (e.g., Daly *et al*., 1983; Polak and Jones, 1995) have extended trip-oriented models by replacing the trip as the fundamental unit of analysis by the *tour* (i.e., a sequence of linked trips beginning and ending at home). These tour-oriented models enable to analysis to capture the spatial and temporal interdependencies between different trips and, if complete tours are represented, to infer the amount of time spent at different stops. However, these models are still essentially oriented around (linked) trips, rather than the underlying activities. In particular, they do not attempt to model the selection of different activity types or the duration or scheduling of participation in different activities.

More ambitious models have attempted to explicitly model activity participation and scheduling decisions as a function of individual and household characteristics, the available activity opportunities and the characteristics of the transport system (e.g., Bowman and Ben-Akiva, 2001; Ettema *et al*., 1993, 1995; Recker *et al*., 1986a,b). Models of this sort in principle enable the analyst to estimate how changes in the spatial and temporal availability of activity opportunities and/or the characteristics of the transport system affect individuals' participation in different activities. However, one weakness of these studies from the perspective of analysing social exclusion is that their principal focus has been on discretionary activities such as shopping and recreation. Although some models do deal with the choice of work location (conditional on the assumption that the individual concerned is in employment) this stream of modelling work has not in general sought to address the issue of how the characteristics of transport provision affects individuals' basic participation in labour markets. This is an area in which further research may therefore be warranted.

Microsimulation Models

Over the last decade a number of researchers have sought to develop comprehensive transport planning model systems (comparable or exceeding in scope conventional 4-stage models) based on activity oriented principles (Arentz and Timmermans, 2001; Barrett *et al*., 1999; RDC, 1995; Kitamura *et al*., 1996; Miller *et al*., 1998). Most of these large scale activity based model systems have been designed as microsimulations i.e., model systems that operate by explicitly simulating the behaviour of synthetic populations of individual vehicles and travellers throughout the course of a day. Within such simulations, each agent (in this case a simulated traveller) is invested with specific characteristics (e.g., physical characteristics, household context and location, income, work status etc.), objectives (e.g., to arrive at work on time, to recreate, to undertake necessary shopping) and endowments (e.g., access to a shared household car or a public transport season pass) and also with certain behavioural rules that allow it to pursue its objectives and interact with other agents within the system. Often, but not always, the behavioural rules are formulated as discrete choice models, using the methods discussed in section 3.2.

During its operation the microsimulation model keeps track of the status of each agent in the simulation on a second-by-second basis, recording in particular when, where, and how each agent participates in different activities as well as the travel that it undertakes between activities. The simulation traces that are so generated can then be analysed to evaluate the benefits and costs (in terms of travel and activities) of alternative transport policies on any chosen segment of the population.

Another feature of this class of models that is directly relevant to the analysis of social exclusion is the level of detail in the spatial representation of demand. As we mentioned in

section 3.2, most existing 4-stage models use a rather crude representation of movements within zones (using the concept of a zone centroid and centroid connectors). Microsimulation models tend to use a much greater level of spatial detail, especially in the representation of intra-zonal activity. For example, TRANSIMS (Barrett *et al*., 1999) locates each household and activity opportunity (e.g., workplace, shop, recreational facility) at a specific geographical location and models movements between these specific locations, without recourse to the concept of zone or centroid connector. This means that the model is much better able to reflect variations in say, access to public transport, avoiding the averaging that occurs with zonal based approaches.

Clearly, provided that it is possible to fix an operationally tractable definition of a socially excluded individual, microsimulation models of the type described here offer substantial opportunities for the identification and evaluation of relevant effects.

3.4 Accessibility

An important conclusion of the conceptual review was to identify the need for an expanded concept of accessibility, specifically one that takes into account temporal as well as spatial dimensions.

The academic and professional literature on accessibility modelling is large and diverse with at least four identifiable streams of work (see, Handy and Niemeier, 1997):

- Approaches that define accessibility in terms of isochrones, based on skimmed network travel times, applied variously to car, public transport and pedestrian networks (e.g., Wachs and Kumanai, 1973; Vickermann, 1974).

- Approaches that define accessibility measures in terms of functions of the balancing factors of spatial interaction (gravity) models of trip distribution (e.g., Hansen, 1959; Huff, 1963).

- Approaches that define accessibility in terms of the inclusive value or logsum in discrete choice destination choice models (see, Ben-Akiva and Lerman, 1979; Neuburger, 1971; Williams, 1976).

- Approaches that attempt to integrate activity-scheduling concepts (such as timetable and other temporal constraints) into the computation of spatio-temporal accessibility measures (see, Arentz *et al*., 1994; Miller, 1999).

In addition to these approaches, which focus primarily on the accessibility of *potential destinations* by means of the transport network, there is also a complementary stream of work that focuses on the accessibility of the (public) *transport network itself*, principally in terms of pedestrian movements to bus stops and rail stations, often with a particular emphasis on the problems faced by those with mobility impairments.

Current Practice in the Modelling of Accessibility

Conventional accessibility modelling in the UK is largely based on the use of isochrones, using travel time, travel distance or generalised costs derived either from a GIS or from a conventional transport network model. For car accessibility this is a straightforward task that

can be carried out with most commercial software packages. For public transport, the skims must also take into account the frequency of the services used, and any access, egress or interchange penalties and more specialised data and software are required (see, Ashiru *et al*., 2000). The same approach can also be applied to pedestrian and cycle travel (including but not limited to access movements to public transport stops), although the data requirements (especially in terms of network descriptions) are substantial.

Most practical analyses in fact concentrate on a more limited concept of local accessibility to public transport stops (e.g., Kerrigan, 1992). This is typically is calculated by determining the access time as represented by combining the walk ime to a bus stop/rail station and the average wait time for a service at that facility. Facilities with a walk time above a certain limit (say, 5 minutes) are excluded.

Isochrone based accessibility measures are useful in comparing how easy it is for a given, spatially defined, population segment to reach a destination by different modes. However, it is rare in practice for the measures to be defined in such a way as to take account of the nature of the activity opportunities at the destination (either in terms of their type or size). Moreover, since the population is defined spatially, it is difficult to discriminate between population groups that are distinct with respect to socio-economic characteristics, but mixed geographically. Finally, it is worth pointing out that isochrone based measures do not account for the level of demand for the trips being – in other words, they measure a property of the opportunities offered but not the extent to which these are taken up.

Accessibility measures derived from gravity or discrete choice demand models, although not equivalent, have a number of theoretical and structural similarities, stemming from the fundamental theoretical similarities that exist between the entropy maximisation and utility maximisation formalisms underlying each approach (Anas, 1983). It is therefore convenient to consider them together. These measure are, for reasons that are not entirely clear, much less commonly used in UK practice than isochrone based measures. Yet they have a number of advantages, most particularly the fact that they (a) naturally take into account the joint effect of the characteristics of the transport system and the nature and scale of the available activity opportunities in determining accessibility and (b) are based on the patterns of behaviour actually estimated by the demand model, rather than notional potentials. A further advantage of the disaggregate discrete choice based measures, is that they can accommodate socio-economic as well as spatial heterogeneity within the population. However, the classical gravity/utility accessibility measures are, like classical 4-stage modelling, largely oriented around trips rather than activities and focus on spatial rather than temporal aspects of accessibility.

Spatio-temporal Accessibility Measures

A number of authors have recognised the desirability of extending the classical concept of accessibility. Early work by Richardson and Young (1974) has been followed up more recently a number of serious attempts to integrate activity-based concepts (principally the notion of trip tours and a recognition of the role of temporal as well as spatial constraints) into the development of accessibility measures. The most notable recent contributions contributions to this literature are Arentze *et al*. (1994), Burns (1979), Chen *et al*. (1997), Kwan and Hong (1998), Miller (1991,1999), Miller and Wu (2000), Recker *et al*. (2000) and Wang and Timmermans (1996). The methods proposed by Arentze *et al*. (1994) and Miller

(1991,1999) are of particular interest in the present context, since both have been practically implemented and applied (albeit in pilot form) within GIS frameworks.

The approach proposed by Arentze et al. (1994) is based on the (rather simple) idea that trip chaining occurs when an activity participation request cannot be satisfied at the particular destination (e.g., a shops does not have the product required). The probability of success is modelled as a function of the quality and diversity of opportunities offered at the destination. Routes through the network are constructed so as to achieve an acceptable probability of success. The expected costs of travelling the optimum route in the network are then determined and used as a measure of accessibility. More recently, Wang and Timmermans (1996) have generalised this approach, by separating the generation of trip chains from their evaluation. The Wang and Timmernans approach in principle allows the use of trip/activity chains that are generated by an appropriate model or directly observed in survey data and calculates a summary measure of accessibility via a modified logsum calculus.

The approach proposed by Miller (1991,99) and Miller and Wu (2000) is based on the concepts of time-space prisms originally proposed in the work of Hägerstrand (1970) and Lenntorp (1976, 1978). The fundamental concept of accessibility here is concerned with the set of opportunities that can be accessed by an individual from a particular destination conditional on the location of the opportunities, the location and duration of fixed activity commitments, the service provided by the transport system and the individual's time budget for flexible (discretionary) activities. The key development made by Miller (1991) is to show how these ideas (originally developed by Hagerstarnd and Lenntorp in the context of abstract geographical spaces with uniform speeds in all directions) can be applied in a discrete transport network with spatially varying performance characteristics. More recently Miller (1999) has explored the relationships between different measure of accessibility (including discrete choice logsum, micro-economic welfare and 'prism' based) and shown how it is possible to derive sets of mutually consistent results.

3.5 Conclusions

This chapter has presented a brief review of the relevant features of existing UK transport modelling practice and discussed a number of potential developments.

The overall conclusion of the review is that the transport modelling techniques commonly used by British local authorities do not in general deal well with the issues associated with social exclusion. Three key weaknesses were identified:

- They offer only very limited scope for socio-demographic and spatial disaggregation of the impacts of transport policy measures on different social groups.

- They do not provide an explicit treatment of the activities in which individuals take part and which are served by the trips individuals' make.

- They use partial and overly simplified concepts of accessibility, focusing principally on access to public transport stops and ignoring the access to ultimate destinations, the characteristics of these destinations and temporal constraints on access.

We have also briefly reviewed a range of current developments taking place in the field of survey methodology, synthetic sample development, activity based modelling and spatio-

temporal accessibility measures that offer the prospect of addressing these weaknesses. Several of these developments naturally converge in the development of microsimulation based models of activity participation, scheduling and execution.

However, it is clear that addressing all these weaknesses in a comprehensive and theoretically coherent fashion poses a considerable intellectual and theoretical challenge and that as such is a medium to long term solution. Fortunately, in the short term, useful developments based mainly on existing methods and data can also be made.

First, the opportunity exists to significantly improve the treatment of accessibility by making use of standard network skimming technologies to produce estimates of full door-to-door travel times. Beyond this, further short term improvements may also be possible by using more sophisticated (gravity/utility and spatio-temporal) concepts of accessibility, designed to accommodate such factors as trip chains and temporal constraints on transport system performance and activity opportunity availability. The methods would provide a staging post between the current situation and a fully configured activity based models.

Secondly, the opportunity also exists to make use of spatial datasets such as the census data and ID 2000 to perform comprehensive *ex-post* identification and disaggregation of the impacts of transport policy measures on spatially defined population segments. Although this approach has significant limitations relative to a more comprehensive *ex-ante* disaggregation approach, it nevertheless constitutes a useful and easily achievable advance on current practice.

Some of the issues associated with the application of these short term developments are discussed further in Chapter 5.

4 EVALUATION REVIEW

4.1 Objectives

Building on the work of the conceptual and modelling reviews, the aim of this chapter is to review of the NATA framework (DfT, 1998c,d) in the light of the requirements arising from the representation of social exclusion and the identification and specification of necessary modifications or extensions. The aims are:

- To determine to what extent existing approaches to appraisal are capable of appropriately reflecting the impact of transport policy interventions on social exclusion.

- To the degree that they are not, to propose ways in which they mighty usefully be improved.

The chapter first presents an overview of the NATA framework, highlighting sosm of the issues surrounding the assessment of transport schemes from the perspective of social exclusion impacts. This is followed by the identification of proposed changes to the existing framework so that social exclusion impacts can be adequately addressed.

4.2 Overview of the NATA Framework

The New Approach to Appraisal (NATA) was implemented in 1998 as a method for simplifying the task of decision makers in choosing between different transport scheme options and prioritising between them. NATA's primary objective is to summarise information contained in detailed cost-benefit (COBA) analyses of transport schemes and associated Environmental Impact Assessments. One of the key objectives is that the Appraisal Summary Table (AST) does not make any judgements about the relative weighting of the values presented. In theory, and hopefully in practice, the idea is to allow the decision-maker to balance the various trade-offs presented within the AST. Another key requirement is that the AST be displayed in a simple format on one page. The current required AST for multi-modal studies is displayed in Table 4.2

As currently structured, NATA seeks to identify the criteria of achieving the government's broad goals for transport. These goals, as originally identified in *A New Deal for Trunk Roads in England* (DfT, 1998b) and later refined in the *Guidance on Multi-Modal Studies* (DfT, 2000d) are listed as the objectives in Table 4.1. NATA requires detailed analyses on each of the sub-objectives.

The analyses of the sub-objectives currently tends to focus on aggregate impacts. For example, safety impacts are only the total number of fatalities, casualties and their total monetary value. In practice, this could mean that certain sub-populations (such as children or the elderly) may see an increase in fatalities while other sub-populations experience a decrease (perhaps leading to a net impact of zero). In this case, decision makers may assess the desirability of a scheme differently if, for example, fatalities to children increase (or fatalities to socially excluded groups) even if net impacts are zero.

The same could be said of other measures, such as local air quality and noise. As currently practiced, NATA reports the number of residential properties experiencing both an increase

and a decrease in these environmental impacts. No information is provided on which population segments may be facing a disproportionate negative impact.

With regard to various journey-specific measures, such as travel time and costs, NATA again aggregates these impacts without disaggregating these impacts on sub-groups. In addition, NATA provides no analyses of how direct income and welfare effects may vary between different population groups.

TABLE 4.1 Objectives and sub-objectives of NATA

OBJECTIVE	SUB-OBJECTIVE
ENVIRONMENT	Noise
	Local air quality
	Greenhouse gases
	Landscape
	Townscape
	Heritage of Historic Resources
	Biodiversity
	Water Environment
	Physical Fitness
	Journey Ambience
SAFETY	Accidents
	Security
ECONOMY	Transport Economic Efficiency
	Reliability
	Wider Economic Impacts
ACCESSIBILITY	Option values
	Severance
	Access to the Transport System
INTEGRATION	Transport Interchange
	Land-Use Policy
	Other Government Policies

Several sub-objectives touch on the issue of social exclusion. Regeneration attempts to identify whether the scheme will assist in the regeneration of economically deprived areas. In most cases, this could be similar to assessing whether the socially excluded (which often comprise lower income groups) will have future jobs in their local area. The accessibility sub-objectives also contain some elements of social exclusion analyses. Evaluating access by non-car modes (which are often utilized by lower income groups) can identify whether the socially excluded benefit. In general, the analyses, however, does not currently identify sub-groups in the population.

Severance is another sub-objective that can be applied to different population groups. While NATA identifies the likelihood of severance effects, it does not identify the demographics of the neighbourhoods affected.

The Guidance on the Methodology for Multi-Modal Studies (DfT, 2000d) contains a section discussing how social inclusion can be included in the appraisal framework (vol. 1, p. 61). It

is suggested that qualitative comments can be included to highlight the impacts on different social groups. However, qualitative summaries would not reveal the detailed information that may be necessary to more accurately assess impacts.

4.3 Social Exclusion and Assessment

The assessment of transport policies and schemes and their relationship to social exclusion has several dimensions. While geographical definitions are normally used to define social exclusion, we have argued that an alternative (and in several respects more satisfactory approach) is to define it as aa property of individuals, related to demographics, activity participation and travel behaviour.

Both geographical and individual measures of these concepts are amenable to analyses and incorporation in the NATA framework. Clearly, the actual scope of any specific analysis will be dependent both on the details of any transport policy or scheme and the specific nature of socially excluded populations that are likely to be affected.

Analysis that focuses on individuals and their travel behaviour will necessarily be different from analyses that focuses on geographical areas. The extensions to the NATA framework presented below allow either method to be pursued. The decision on which method is best will naturally be dependent upon the details of the policies being analysed.

Another consideration is the impact of various policies on socially excluded areas or individuals. This will include whether there is an adverse environmental impact, or how any economic development impacts may affect these groups. A key consideration is the *relative* impact between different segments of the population. For example, a policy that reduces pollution impacts for a socially excluded group but reduces that impact to a much greater degree for those that are not excluded would be seen as having a disproportionate impact (although a positive one) on the socially excluded group. Depending upon the objectives of the project, this may (or may not) be important information for the decision maker to consider.

A more frequent occurrence may be when one group receives disproportionate benefits while the majority of the costs of the scheme are absorbed by another group. This may not be undesirable from a net social welfare perspective, but it is exactly these sort of distributional impacts that are important for the NATA framework to convey.

4.4 Revised Structure of NATA

Our review of modelling issues to account for social exclusion showed that there are both existing methods and some methods under development that will be able to assess the impacts of transport policies and schemes on socially excluded groups. These methods are inherently disaggregate, either at the individual level or spatially, such that the analyst can identify the impacts on disaggregate population groups or neighbourhoods. Given the lack of a clear definition for which population groups are socially excluded, our focus is on the ability to analyse different population sub-groups or neighbourhoods. This allows the decision maker to define socially excluded groups in the context of any specific assessment.

The analyses of disaggregate impacts will generally provide information on whether the transport scheme helps or hinders the access of various population groups to economic and

social activities. In addition, it should determine whether there are various adverse environmental impacts that disproportionately affect any specific sub-group. For example, are lower income communities more impacted compared to more affluent populations?

The NATA framework can be revised to display this type of analyses within the AST. Table 4.3 provides a proposed draft AST that includes the type of summary information that can be displayed for assessing the impacts on disaggregate groups. The key feature is to include a quantitative assessment based on the type of disaggregate analyses reviewed in our previous work. Therefore, various impacts need to be presented such that the decision maker can evaluate the impact on various sub-populations. The specific populations analysed would be dependent upon the nature of the specific scheme.

The proposed approach is basically to provide more information on each of the sub-objectives within the AST. This obviously adds additional complications to a framework intended to provide the decision maker with a simplified process. Attachment 2 describes the type of information that could be included to summarize potential disaggregate impacts. In addition, various additional sub-objectives are added.

The economic impacts of transport policies can vary widely between different sub-groups. For example, lower income groups (often including the socially excluded) may experience greater economic hardship from increases in transport costs. Analyses of these type of issues should be included within the Transport Economic Efficiency sub-objective.

Severance and its impact on community cohesion is one area that is critical to measuring the impacts of social exclusion. Traditionally this has not been analysed quantitatively. However, a number of methods of quantitatively measuring community cohesion do exist (Ohio Department of Transportation, 2000) and these make it possible, in principle, to include this issue in the AST. It should be noted that these methods are relatively new and could benefit from additional research.

An additional access sub-objective is critical for analysing what may be socially excluded groups such as the disabled and elderly populations. This is the type of access *within* the transport system (as opposed to access *to* the system). This would include consideration of the physical constraints within the system that may face various individuals in actually using transport systems (e.g. availability of wheelchair access at transport interchanges). These considerations may overlap with the transport interchange sub-objective, but the latter generally deals with less detailed design issues.

4.5 Conclusions

This proposed AST does not necessarily cover all the relevant issues related to assessing impacts on the socially excluded. However, it shows the direction in which such developments might most constructively be made. The key refinement is to present information that is derived from *disaggregate* analyses of transport demand, environmental impacts, and any other relevant factors. The only additional sub-objective that has been proposed is Access *within* the Transport System. Clearly, other potential elements may be revealed as the analyses of social exclusion impacts through disaggregate methods are practically applied.

TABLE 4.2 APPRAISAL SUMMARY TABLE FOR MULTI-MODAL SCHEMES

Option	**Description**	**Problems**	**Present Value Cost to Government (£m)**

OBJECTIVE	**SUB-OBJECTIVE**	**QUALITATIVE IMPACTS**	**QUANTITATIVE MEASURE**	**ASSESSMENT**
ENVIRONMENT	Noise			Net properties win/lose with scheme
	Local air quality			Concentrations weighted for exposure
	Greenhouse gases			Tonnes of CO_2
	Landscape			Score
	Townscape			Score
	Heritage of Historic Resources			Score
	Biodiversity			Score
	Water Environment			Score
	Physical Fitness			Score
	Journey Ambience			Score
SAFETY	Accidents			PVB £m
	Security			Score
ECONOMY	Transport Economic Efficiency			Users: NPV £m Private providers: NPV £m Public providers: NPV £m Other government: NPV £m
	Reliability			Score
	Wider Economic Impacts			Score
ACCESSIBILITY	Option values			Score
	Severance			Score
	Access to the Transport System			Score
INTEGRATION	Transport Interchange			Score
	Land-Use Policy			Score
	Other Government Policies			Score

TABLE 4.3 PROPOSED APPRAISAL SUMMARY TABLE INCLUDING DISAGGREGATE IMPACTS

Option		**Description**	**Problems**	**Present Value Cost to Government (£m)**
OBJECTIVE	**SUB-OBJECTIVE**	**QUALITATIVE IMPACTS**	**QUANTITATIVE MEASURE WITH DISAGGREGATE IMPACTS CONSIDERED**	**ASSESSMENT**
ENVIRONMENT	Noise		Number of residences affected by population groups.	
	Local air quality		Number of residences affected by population groups.	
	Greenhouse gases		NA	
	Landscape		Population groups most affected by landscape changes	
	Townscape		Population groups most affected by townscape changes	
	Heritage of Historic Resources		Are there unique heritage resources of any socially excluded populations?	
	Biodiversity		NA	
	Water Environment		Any disproportionate impact on socially excluded?	
	Physical Fitness		Any negative impacts on socially excluded?	
	Journey Ambience		What population groups experience a benefit?	
SAFETY	Accidents		Number of people by population groups / by mode	
	Security		Number of people by population groups / by mode	
ECONOMY	Transport Economic Efficiency		Disaggregate costs for users by population groups, and by mode, including direct income and welfare effects.	
	Reliability		Changes in reliability assessed by mode and likely users	
	Wider Economic Impacts		Economic effects on various population groups and neighborhoods.	
ACCESSIBILITY	Option values		Changes in option value by population groups	
	Severance / Cohesion		Are impacted neighborhoods socially excluded or will this contribute to isolation? What is measure of cohesion for different neighborhoods?	
	Access to the Transport System		Disaggregate spatial analyses of access by population groups, modes and neighborhoods	
	Access within the Transport System		Analyses of how scheme may make use of transport system more or less feasible for some population groups and modes.	
INTEGRATION	Transport Interchange		NA	
	Land-Use Policy		NA	
	Other Government Policies		NA	

5 APPLICATION STUDY

5.1 Objectives

The objective of this stage of the study is to demonstrate on a limited scale, the application of some of the short term modifications in practice identified by the project to better accommodate considerations of social exclusion in transport modelling and appraisal. The aims are:

- To identify whether the general approach can be used in application with existing modelling techniques.

- To appraise whether existing datasets generally available to local authorities in the UK are sufficient to support such applications.

- To investigate the results of such a sample application in terms of the calculated impacts of policy on socially excluded parts of the population.

The model approach centres on standard available datasets, accessibility tools developed by Mott MacDonald, and a real area of application in Birmingham.

5.2 Overview of the Modelling Approach

The modelling approach combines the consideration of four factors (see Figure 5.1):

- The use of a spatially-based definition of social exclusion, based on the Index of Deprivation.

- Assessment of access to the transport system through a detailed modelling of the walk and cycle network

- Assessment of the access provided by the transport system to essential facilities and services such as education, employment, shopping and healthcare

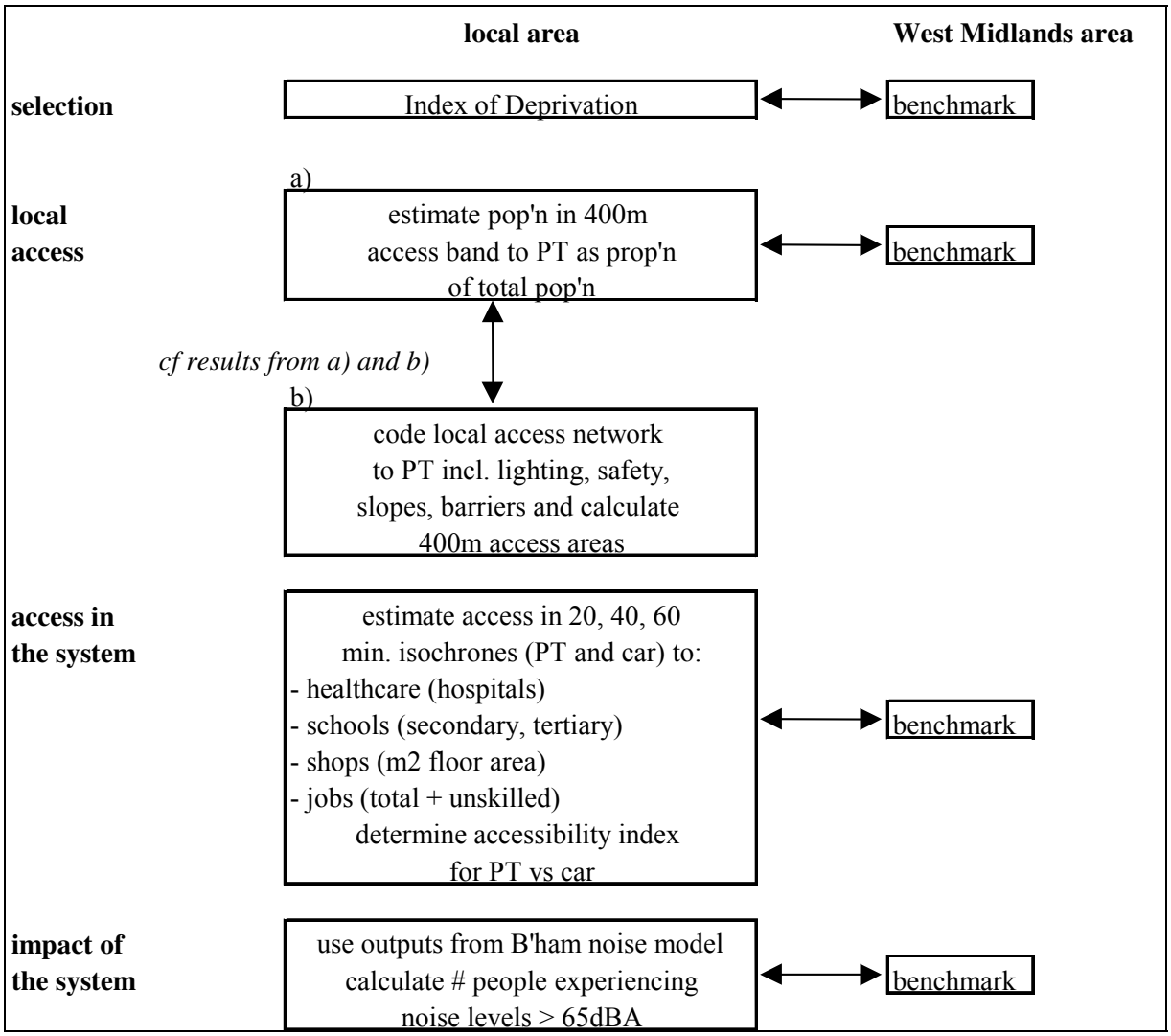
- The environmental impacts generated by the transport system

This builds on the work of Church *et al* (2000), but extends the approach through a more detailed consideration of local access and the environmental impacts of the transport system. There are a number of key stage in this approach.

The Identification of Social Exclusion.

The identification of socially excluded areas is based on the use of an Index of Deprivation. There are two relevant measures are available. The Index of Local Deprivation was defined for 1998 using Census and other Government data at the Enumeration District level. Following various methodological criticisms of the ILD (e.g., Connolly and Chisholm, 1999) a revised index – the Index of Deprivation 2000 – was defined at the Ward level. This integrates information from a variety of statistical sources and is updated annually. ID 2000 has the advantage of being more up to date and methodologically robust, but provides only coarser spatial detail.

FIGURE 5.1 The Modelling Approach



Although this approach based on Deprivation Indices provides a tractable and efficient means of identifying socially excluded areas, it should not be forgotten that a key disadvantage of the use of IMD or ID 2000 is that neither of these indicators are themselves sensitive to transport policy measures (see, section 2.3). This means that although we can use them to assess how socially excluded groups are affected by transport policy measures, we cannot, using these measures alone, draw any conclusions regarding whether transport policy measures reduce or increase social exclusion.

The definition of social exclusion implemented using the Deprivation Indices is a relative value – it is measured against averages (benchmarked). Hence, it is necessary to compare the access to, within and impacts of the transport system for the socially deprived areas with an average for the whole of the population considered. This may require national averages to be determined (possibly by area type). In the West Midlands application values for deprived areas have been compared with average values for Birmingham, where available – alternatively, they have been benchmarked against a non-deprived area.

Modelling Access to the Transport System

The principal interest was focused on access to the public transport system. This is generally not well modelled. In many accessibility applications access to the PT system is modelled through 400m circles (buffers) around bus stops, identifying the proportion of houses/population that fall within these minimum standards. In our application we have enhanced this area of quantification by detailed coding of access routes by slow modes to public transport stops, including physical barriers and the quality of the routes (safety, exposure, etc).

Modelling Access to Activity Opportunities within the Transport System

This has been tackled by means of constructing isochrones (separately by private and public transport) to a number of 'essential destinations (activity locations)'. The notion of essential destinations is one borrowed from recent American applications in the context of Environmental Justice. In our application we have included employment, shopping, education and health – further possibilities include religion, leisure and civic amenities. The databases of these essential destinations are generally in existence within a local authority's Geographical Information System (GIS) – or can be identified from external sources, and tools have been developed to calculate access times. We note, however, that careful consideration must be given to ensure an appropriate segmentation in destinations (e.g., to take account of type of leisure facilities, type of job (at least blue collar/white collar), etc).

Modelling the Environmental Impact of the Transport System

In this application, the environmental impacts of the transport system on different (spatially defined) population groups are quantified in terms of the exposure of resident populations. This form of *ex-post* disaggregation of impacts involves some degree of approximation (since people are exposed throughout the day, not just while at home), but has the significant attraction of being analytically tractable using existing modelling technology.

Most local authorities should have little difficulty in calculating resident population exposure, as the resident population databases from the Census and other sources contain the required information. However, the approach also requires spatially specific environmental impacts (e.g., estimation of noise, emissions propagation in built up areas), which implies significant additional modelling effort, which is likely to be beyond the current capabilities of some authorities.

5.3 Modelling Tools, Data and Policy Scenarios

Modelling Tools

Three key modelling tools were combined in the application:

- The West Midlands Strategic Transport Model (WMSTM), a multi-modal network-based model used to assess the impacts of policy and investment on transport flows and traffic conditions across the West Midlands. All roads with daily flows in excess of 2,000 vehicles, all public transport routes and flows are represented.

- Existing public and private transport accessibility models, able to calculate isochrones from any spatial point, distinguishing between peak and off-peak conditions.

- LIMA, a noise exposure model operated by Birmingham's Environmental and Consumer Services Department (BECSD), based amongst others on inputs from WMSTM. Noise levels are calculated per façade for each individual property.

Of these tools, only LIMA is exceptional (and unlikely to be available to the generality of authorities).

Datasets Used in the Application

The following datasets were used in the West Midlands application. Theses are data typically available in most UK local authorities.

- Population data from 1991 Census at Enumeration District level (approx 500 persons per 'zone')
- Local Index of Deprivation at Enumeration District level
- Index of Deprivation 2000 at the Ward level (approx 5,000 persons per 'zone')
- Full road network from the OSCAR database
- Location of individual properties from Landline data
- Council Tax data linked to properties (subject to client approval) for Birmingham
- Full public transport network (bus, metro and rail) including bus stops and service patterns

Determination of Application Area

A deprived area of Birmingham was selected, so as to maximise in our analyses the differences in terms of social exclusion from the area-wide average. On the basis of the Index of Deprivation 2000 one of the two most deprived Wards (in the worst 1% in England) was identified: Sparkbrook, to the South-East of the City Centre. Sparkbrook has a large ethnic Asian community, a large proportion of local authority rented accommodation and a considerably higher than average unemployment rate (32% in 1991 vs a 9.4% England/Wales average). In terms of social class many households belong to the partly skilled and unskilled categories, and the number of households without access to a car is twice as high as the national average.

Figure 5.2 shows the Index of Deprivation 2000 for a relevant part of Birmingham (at Ward level), also indicating the location of Sparkbrook. This is the most up-to-date information on Social Exclusion, but at a rather coarse spatial level of detail.

Figure 5.3 shows for Sparkbrook the Local Index of Deprivation at Enumeration District Level. Our further analyses concentrate on EDs CNGH28, 30 and 31, three of the worst EDs within an already deprived Ward.

FIGURE 5.2 Index of Deprivation 2000 Illustrating the Status and Location of the Sparkbrook Ward

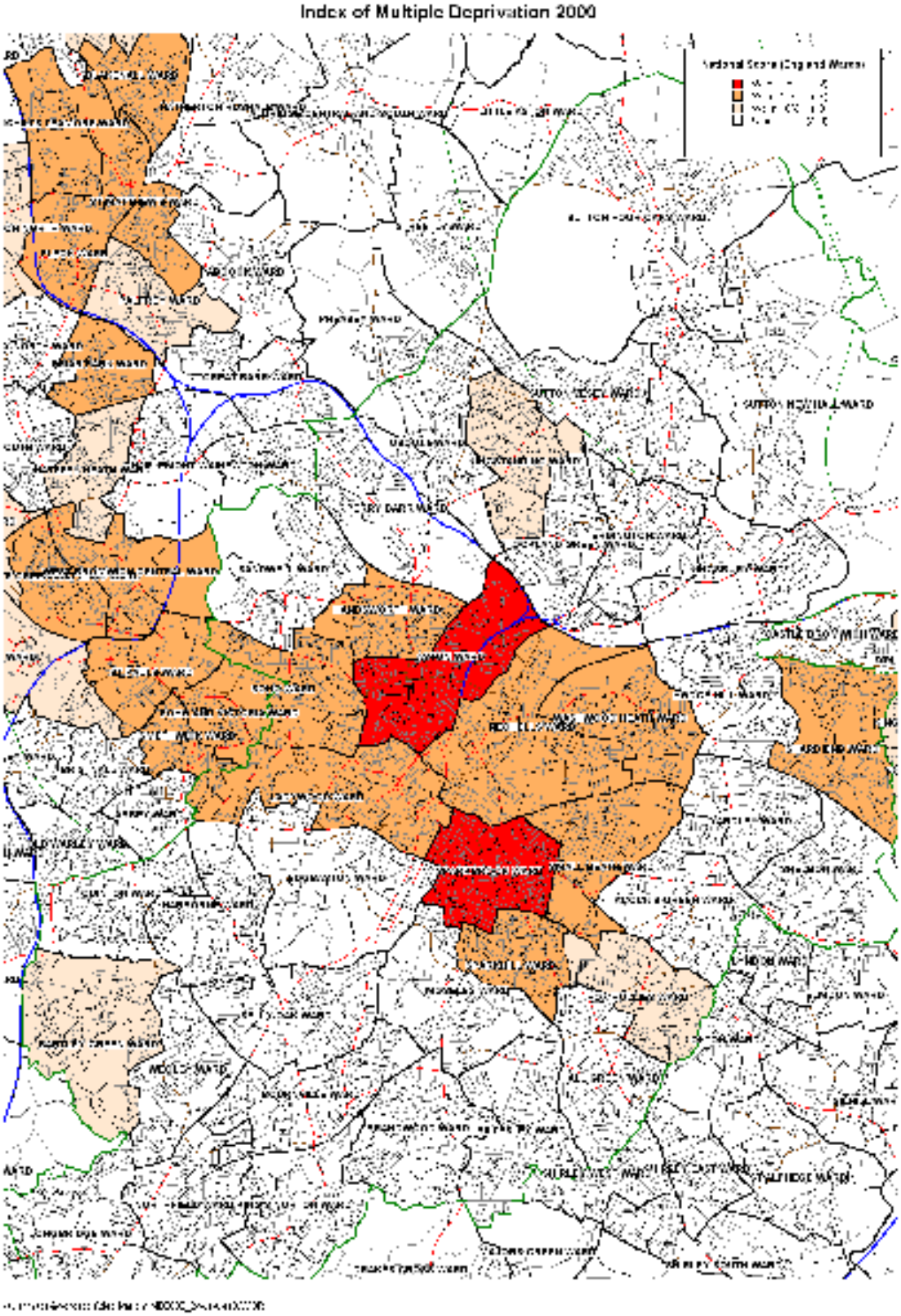
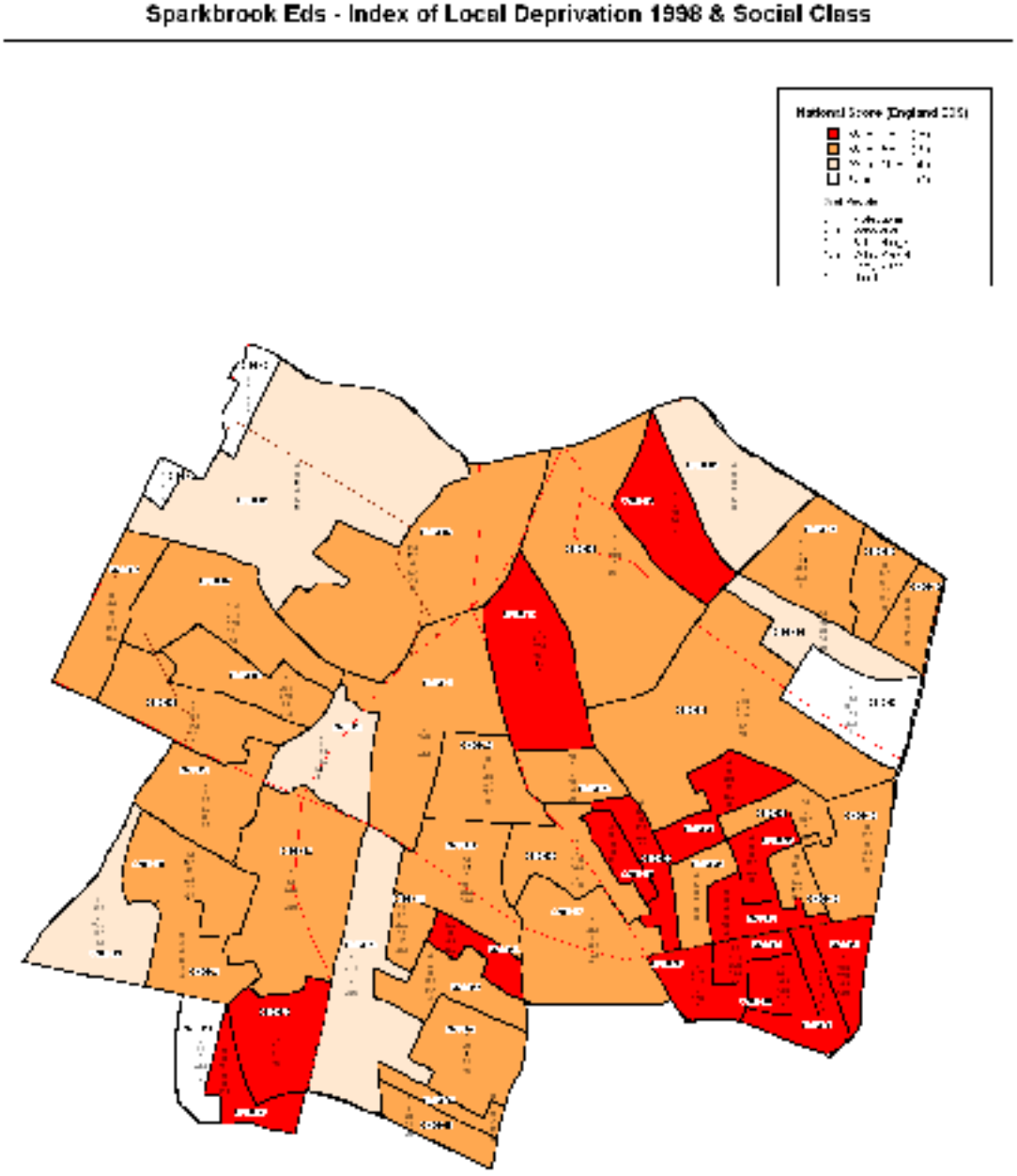


FIGURE 5.3 Distribution of Enumeration Districts by Index of Local Deprivation within the Sparkbrook Ward



Policy Scenarios

In an actual appraisal situation the above indicators (access TO and WITHIN the transport system, and impacts OF the transport system) would be compared in a before and after situation, to identify the impacts of the scheme on socially excluded groups. In our test case we have not explicitly aimed to investigate policies or schemes since access to the public transport system is good in the West Midlands, in general but certainly in socially deprived areas. Hence no realistic schemes could be identified that could be expected to have a noticeable impact on accessibility indicators.

However, it was possible to exercise the modelling methodology through test of the noise exposure impacts of traffic policies (through the availability of the LIMA noise immission model and outputs, which calculates the noise levels at house facades resulting from traffic flows and speeds from road, rail and air.).

A base case has been estimated and two policy scenarios have been tested:

- A speed reduction scenario, with all main arterial roads having a reduced speed limit of 30 mph and the motorways (M5 and M6) a speed limit of 50 mph;
- A charging scenario with all workplace parking spaces (PNR) charged at £10 per day.

5.4 Summary of Results

Accessibility to the Public Transport System

The local accessibility to the public transport system has generally been assessed by calculating the proportion of the population that lives within a 400m buffer area around bus stops. This is an easy measure to calculate, but ignores the availability of appropriate walk/cycle routes within the 400m buffer, and also ignores the safety and security of any such walk/cycle routes.

In the Sparkbrook application all relevant features have been coded, these include (see, Figure 5.4):

- The location of bus stops
- Safe walk routes, defined as routes along roads with streetlights and with passing traffic
- Less safe walk routes, defined as paths through parks etc

This has enabled us to assess the following:

- The proportion of population living within 400m radius of a bus stop (in Sparkbrook benchmarked against the Birmingham average).
- The proportion of the population living within a 400m safe / less safe walking distance of a bus stop (which can be compared with the proportion living within a 400m radius but cannot be benchmarked against the Birmingham average as the coding of walk routes across the whole of Birmingham has not yet been carried out).

Table 5.1 shows the proportion of the population living within acceptable walking distance (400m) from a bus stop measured (i) from concentric 400m radius circles (buffers) and (ii)

from actual route analyses. The buffer analysis enables us to compare the accessibility to pubic transport in Sparkbrook with the Birmingham average as a whole. This comparison shows that Sparkbrook has a slightly lower level of accessibility than Birmingham as a whole but that, despite that, levels of access to public transport are high. Hence, accessibility TO the public system in this deprived ward is not particularly bad. Interesting is the comparison between the 400m buffer analysis and the 400m walking distance analysis, showing the shortcomings of the widely accepted procedure in identifying TRUE accessibility to public transport facilities.

FIGURE 5.4 Location of Bus Stops, and Safe and Less Safe Walking Routes to These Bus Stops of up to 400m Length

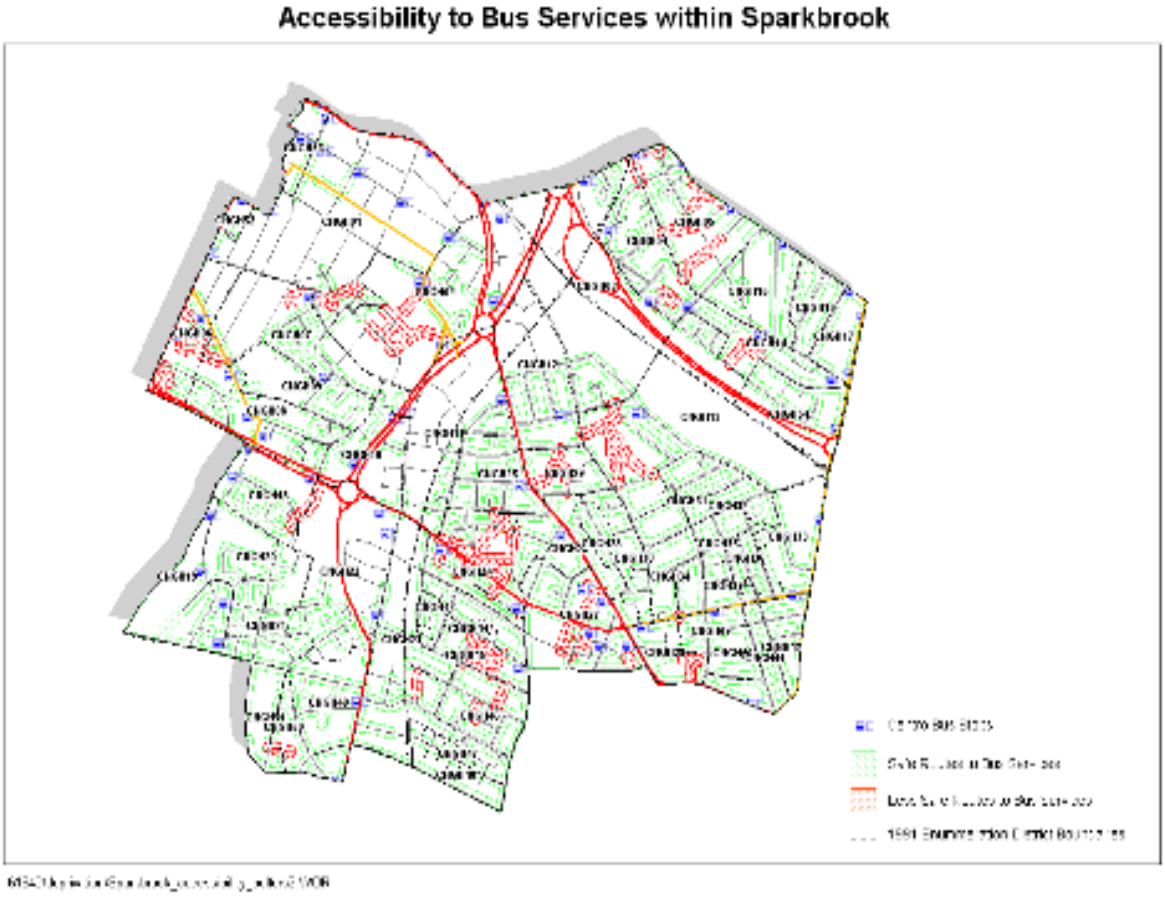


TABLE 5.1 Comparison of Accessibility TO the Transport System

	% of population in 400m buffer	% of population within 400m SAFE walking access	% of population within 400m walk access
Sparkbrook	98.1	68.1	70.4
Birmingham	99.1		

Accessibility Within the Public Transport System

This complementary assessment has been carried out by estimating the number of opportunities of each of four essential types, that can be reached at different levels of travel time. The four categories of essential opportunities are defined as:

- Work (all jobs / relevant jobs)
- Health (health centres/clinics/hospitals)
- Dducation (primary/secondary/tertiary)
- Shopping (retail >10,000 sq ft)

Isochrones of 20, 40 and 60 minutes have been determined for public and private transport separately, and overlaid over maps with details of the location of employment, health facilities, shopping facilities and education establishments. In this sample application it has not been possible to compare the within public transport system accessibility of Sparkbrook EDs with the Birmingham average, because of the computational effort required for such a large area. As an alternative, the Sparkbrook values are compared with those for the Acocks Green ward, a predominantly white area of Birmingham, with unemployment levels of around a third of those in Sparkbrook and considerably higher car ownership (45% of households without a car compared with 69% in Sparkbrook).

In addition to the total number of jobs that can be reached, the analysis has considered the number of *relevant* jobs, taking account of the social composition for the enumeration district in question as follows:

- Determine the composition of the Ward in terms of social class.
- Identify the number of jobs separated by social class that can be reached in total and weight these by the social profile of the enumerator district under scrutiny

Figure 5.5 shows the location of Sparkbrook, 20 minute isochrones by public transport in green and 20 minute isochrones by car in orange. Note the considerably larger distances that can be covered by car than by public transport; and hence the enormously larger area and number of opportunities that can be reached.

Table 5.2 shows the differences in (20-minute) accessibility within the public transport system between the different enumeration districts in Sparkbrook and Acocks Green, and also compares this accessibility by public transport with that by car.

A number of important observations can be made:

- The number of facilities that can be reached by car is substantially greater than can be reached by public transport, illustrating the differences in accessibility between car owners and those without.

- The accessibility to facilities (including employment) is actually less for the better-off ward Acocks Green than for Sparkbrook – Acocks Green is further removed from the City Centre and location is more important than service provision in a dense urban area.

FIGURE 5.5 20-Minute Isochrones from Sparkbrook by Car and Public Transport

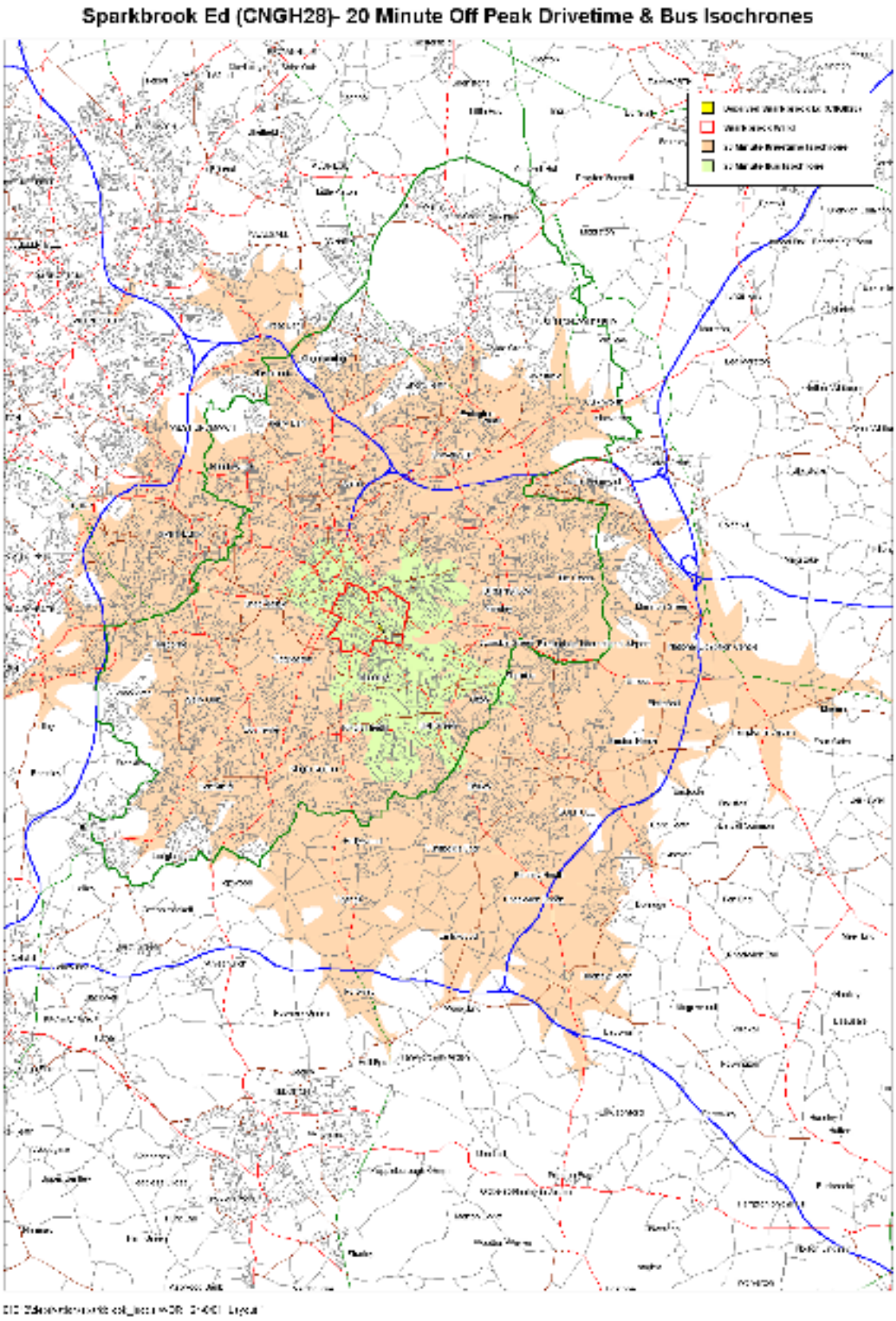


TABLE 5.2 Comparison of Accessibility WITHIN the Transport System

20 minute isochrones	no of jobs	no of relevant jobs	prop relevant jobs	health facilities	education			retail
by public transport					prim	sec	tert	
Acocks Green 22	53,304	11544	22%	16	39	14	7	38
Sparkbrook 28	149,927	25721	17%	32	45	20	15	50
Sparkbrook 30	130,439	22473	17%	22	39	16	8	45
Sparkbrook 31	96,292	16567	17%	11	24	12	7	35
by car								
Acocks Green 22	439,452	90972	21%	114	275	102	43	206
Sparkbrook 28	495,417	92774	19%	128	316	115	47	240
Sparkbrook 30	488,527	90893	19%	126	310	115	46	228
Sparkbrook 31	460,638	85148	18%	124	288	108	46	213

- The differences between the 3 enumeration districts are striking, with ED 31 consistently performing worse than the other 2 EDs – here there probably is an issue of locally poor public transport provision rather than location;

- Finally, the only measure in which Acocks Green Ward performs better than the 3 Sparkbrook EDs is in the proportion of relevant jobs that can be reached – this may indicate a structural shortage in the types of job that the deprived Ward's population can fill.

Environmental Impacts of the Transport System

The impacts of the transport system are generally environmental. They include emissions and air quality, noise and vibration but also visual intrusion and seggregation/barrier working. The approach in assessing the impacts of the transport system is to benchmark these for the deprived areas in question against the average, for the base situation, but also in terms of the effectiveness of the policies tested.

Figure 5.6 shows noise levels at the facades of each individual property in Sparkbrook. Yellow indicates acceptable noise levels (<65dBA, daytime) and red indicates excessive noise. Not surprisingly, many of the most affected houses are situated along main roads.

Because the application covers the whole of Birmingham, it has been possible to assess the impacts of the policies on noise exposure across the whole of the city, based on an aggregation of Enumeration Districts to bands (worst 1%, worst 5%, worst 10% and other).

Table 5.3 shows the distribution of enumeration districts in terms of noise exposure in the base case and also in terms of the effectiveness of the 2 policies, concentrating on the proportion of households/population experiencing daytime noise exposure in excess of 65 dBA and night time level exceeding 55dBA.

FIGURE 5.5 Noise Exposure Levels in Sparkbrook

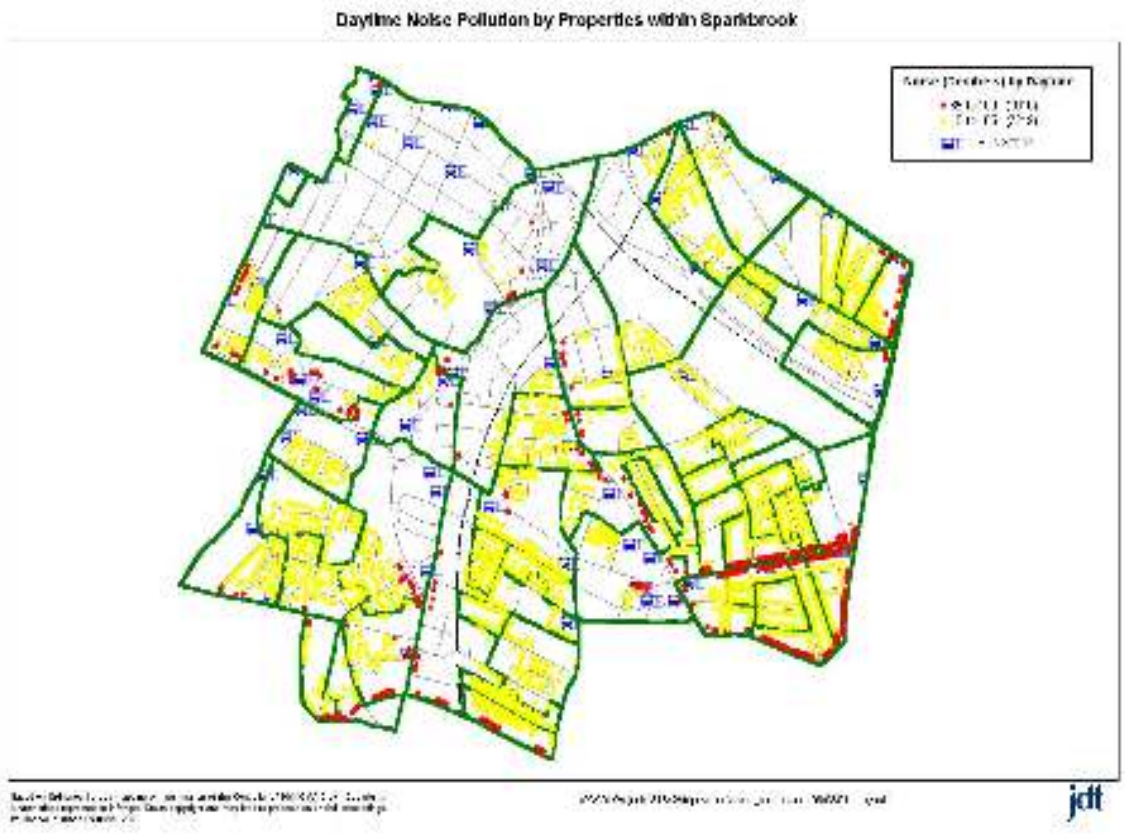


TABLE 5.3 Comparison of the (Noise) Impacts of the Transport System

Area	Pop'n	HHs	% HH >65dB Daytime - Base	% HH >65dB Daytime - Scen 1	% HH >65dB Daytime - Scen 2	% HH >55dB Night-time Base	% HH >55dB Night-time Scen 1	% HH >55dB Night-time Scen 2
B'ham	960,673	374,019	12.67	99%	55%	14.54	101%	63%
Deprived EDs								
Worst 1%	59268	17643	*10.49*	**105%**	**64%**	*11.32*	**105%**	64%
Worst 5%	148061	51754	13.70	97%	53%	15.63	98%	63%
Worst 10%	114296	46160	12.22	101%	51%	14.82	99%	55%
Other	639048	258462	12.69	99%	56%	14.49	102%	64%

The first thing to notice in Table 5.3 is that the proportion of households experiencing high levels of noise exposure in the most deprived areas is less than the average in the base case (10.49% and 11.32% for day and night respectively vs 12.67% and 14.54% for the whole of Birmingham). The second observation is that the effectiveness of the policies, however, is less for these deprived areas than on average: scenario 1 (speed reductions) actually increases the population/households in the worst 1% of deprived EDs both in the day and at night, whilst the reduction in daytime household exposure for scenario 2 (PNR parking charge) is less in these areas than the average (36% vs 45%). Although these values are clearly only

illustrative, they show the power of the identified approach to assess, in a NATA context, the distributed impacts of policies on social exclusion.

5.5 Conclusions

The application above has shown how with existing model techniques and generally available datasets it is possible to appraise the impacts of transport policies on social exclusion – but only through operating with area-based rather than population-based segmentations and with the *ex-post* (rather than *ex-ante*) disaggregation of effects. They also depend upon having an exogenously defined (spatial) measure of social exclusion – in this case ID 2000 – with which operate.

They enable to benchmark access to, within and the impacts of the transport system on areas that are identified as socially excluded, in the existing situation but also in terms of the effectiveness of policies.

Many of these analyses can be carried out now, as a matter of course for current projects. However, some extra coding work will be required, particularly for accessibility comparisons at the local level.

6 CONCLUSIONS

Despite the challenging nature of the modelling requirements associated with the representation of social inclusion, we have presented proposals that illustrate that useful progress can be made in the short term in providing practitioners with relevant guidance on how best to accommodate these considerations in the appraisal of transport projects.

Useful though they may be, we should remember that the short term fixes that we have proposed are properly considered as stop-gap measures, Ideally, they would be combined with a longer term research agenda aimed at addressing current shortcomings in a more comprehensive fashion. We see two main requirements in this respect. First, work needs to be done to define appropriate measurable indicators of social exclusion (or the lack of social inclusion), in particular measures that are sensitive to the effect of transport policy interventions. And second, new modelling techniques need to be developed that better reflect the emerging requirements of practitioners than do current techniques. We believe that activity-based modelling approaches have an important contribution to make to these developments.

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APPENDIX A: OVERVIEW OF THE AMERICAN EXPERIENCE WITH MODELLING TRANSPORT EQUITY

Brian J. Morton

Introduction

Metropolitan Planning Organizations and state departments of transport have slowly been responding to the Federal government's mandate, accompanied in some places by public pressure, to explicitly consider distributional impacts during development of transport plans and strategies. In the American context of interest in environmental justice and "just transportation," the populations of concern comprise low-income and minority persons.

This survey describes the measures and indicators of transport equity that are being used, or have been proposed for use, in regional transport planning and corridor planning. To the extent permitted by published documentation, the descriptions of the measures will provide specific information on: application (regional transport plan or corridor); parameter measured (accessibility etc.); analytical medium (thematic map, quantitative spatial analysis, consumer surplus, etc.); modelling platform (GIS, 4-step model, etc.); and data (decennial census/other, geographical unit of observation).

The survey is broad but not exhaustive. It reports on the efforts of large and small agencies, primarily Metropolitan Planning Organisations, advocacy groups, and transportation researchers. The included areas are: Atlanta, Baltimore, Iowa, Minnesota, National Capital Region, North Carolina, Ohio, San Francisco Bay Area, and Southern California.

The survey is organized by geographical area. The presentation of information by area will allow one to readily appreciate the views on transport equity analyses of the stakeholders interested in the area, including the transport planning agency, public interest advocates, academic researchers, and consultants. Public interest advocates are often very influential in the areas studied in this survey.

In most areas, the subject of an appraisal is a regional transportation plan. The appraisals conducted in Iowa and Wilmington, North Carolina, and some of the appraisals conducted in Sacramento are corridor studies.

All appraisals use socioeconomic data collected by the U.S. Census Bureau, but very few use data collected by a transport agency specifically for an appraisal. The smallest geographical areas for which the Census Bureau reports socioeconomic data are census blocks, block groups, census tracts, and traffic analysis zones (TAZs).[7] A census block is the smallest unit and generally corresponds to a city block. Data on race and ethnicity but not income are available for census blocks. A block group is a cluster of census blocks; a block group generally contains 600–3,000 persons, the optimal population being 1,500. Data on race, ethnicity, and income are available for block groups. Census tracts generally contain 1,500–8,000 persons, the optimal population being 4,000; they are intended to be homogeneous with respect to population characteristics, economic status, and living conditions when first defined; and they vary widely in spatial size depending on the density of settlement. Data on

[7] Definitions of terms appear in the online glossary "Census 2000 Geographic Definitions." http://www.census.gov/geo/www/tiger/glossary.html.

race, ethnicity, and income are available for census tracts. A TAZ is an area specifically delineated for tabulating data on journey to work and place of work; data on household income, ethnicity, race, and mobility limitation status are also tabulated at the TAZ level. A TAZ generally comprises multiple census blocks, block groups, or census tracts.[8] The choice of geographical unit of analysis and determining whether to supplement census data are among the most important data issues for transport equity appraisals.

For each area, the survey briefly describes the transportation equity measures and indicators and modelling techniques which are being used or have been proposed for immediate application. The survey reports in as much detail as is provided by the source of information. The survey concludes with a summary, critique, and recommendations for enhancing the ability—over the near- and intermediate-terms—of the NATA framework to encompass some of the most important aspects of the contribution of transport to social exclusion.

Atlanta

The Atlanta region in the state of Georgia is one of the most populous urbanized areas in the United States. In 1999, 3.2 million persons lived in the region's 10 counties, 64 cities, and 417 census tracts.[9] The Atlanta Regional Commission (ARC) is the Metropolitan Planning Organization for the Atlanta region and recently completed development of a long-range regional transport plan.

It is an understatement to say that ARC's long-range transport planning process and plan are controversial. Civil rights and environmental groups have filed administrative and legal complaints against the ARC to challenge its public participation process and compliance with the Clean Air Act. The U.S. Department of Transportation (USDOT) also has criticized ARC's failure to fully engage low-income and minority constituencies in planning.[10] Consequently, the experience in Atlanta with environmental justice involves a very interesting, ongoing exchange between an MPO and influential stakeholders.

Therefore, it is essential to acknowledge both groups' perspectives. ARC's approach to modelling environmental justice impacts is set out in the 2025 regional transport plan. The public interest groups' modelling approach is set out in their recommendations for the research project that USDOT is requiring of ARC as one remedy for procedural deficiencies in its transport planning process.

2025 Regional Transportation Plan

The stated objectives in the plan relating specifically to environmental justice are: to "[i]mprove connectivity between low income and minority populations and major employment and activity centers," and to "[i]mprove social and environmental equity for all

[8] The Census Transportation Planning Package provides information, obtained from the decennial census, at the TAZ level.
[9] Atlanta Regional Commission. *Transportation Solutions for a New Century*, vol. 1, p. 2-2. http://www.atlantaregional.com/transportation/. Atlanta, GA: ARC, April 2000.
[10] U.S., Department of Transportation. *Assessment of Environmental Justice and Public Involvement in the Atlanta Metropolitan Area: Draft Report*. N.p.: April 7, 2000.

the Region's citizens."[11] The ARC Board also directed staff to follow its environmental justice policy when developing the plan. The policy comprises two guidelines. [12]

- Ensure the equitable provision of transportation services on a geographic, demographic and modal basis to children and elderly, disabled, or transportation-disadvantaged persons. In addition, ensure access to jobs for minority and poor populations.
- When choosing locations of transportation improvements, especially for transit, consider the origins and destinations of low-income persons, the elderly, and persons who do not own automobiles.

Further, ARC's Board adopted a performance target expressing the intention to ensure that, by 2025, 30 percent of the persons (i.e., households) in low-income areas can reach an employment centre by travelling by transit for 60 minutes or less.[13]

The plan defines an environmental justice area as a census tract that contains an above-average proportion of persons who are either nonwhite, poor, elderly, or without an automobile.

- 50 percent nonwhite.
- 20 percent below poverty level.
- 20 percent 60 years or older.
- 20 percent without an automobile.

Regional maps show the locations of all environmental justice areas and overlay future employment concentrations on environmental justice areas.[14] Additional maps overlay major roadway-related and transit-related projects on each type of environmental justice area.

The potential impacts of the planned projects on the populations of concern are assessed in terms of job accessibility by transit, congested travel time, and travel times to selected activity centers.[15] The first two impacts are reported for the entire system, for four income groups, and for all households.[16]

- Share of jobs that are accessible by walking from a transit stop (at the destination end of the trip) and that are accessible within a specified duration by transit for each income group. The isochrones are for 40, 50, 60, and 75 minutes. The results are further broken down by walk to transit (≤0.4 mile) and drive to transit. TAZ-level results are available upon request from ARC's staff.
- Average, congested, home-based work travel time for each income group.
- Comparison of travel times to five activity centers for two low-income census tracts under two scenarios.

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[11] Atlanta Regional Commission. *Transportation Solutions for a New Century*, vol. 1, p. 1-4. http://www.atlantaregional.com/transportation/. Atlanta, GA: ARC, April 2000.
[12] ARC, *Transportation Solutions*, vol. 1, p. 1-13.
[13] ARC, *Transportation Solutions*, vol. 1, p. 1-15. Presumably, the travel time refers exclusively to a one-stop journey to work.
[14] An employment concentration is mapped as a point with 1500 jobs. In effect, those maps only provide highly aggregate information on the terminuses of potential home-based work trips for the populations of concern.
[15] ARC, *Transportation Solutions*, vol. 1, sections 3.9 and 4.5 and appendix V, pp. 9-11.
[16] The four categories of annual household income are: <20,000; 20,000-39,999; 40,000-59,999; and ≥60,000.

Environmental Justice Coalition's Preferred Approach to Investigating Environmental Justice

The Environmental Justice Coalition developed specifications for a research project that will describe in detail the current (1990–2000) distribution of the benefits and burdens of the transport system in the Atlanta region on low-income communities and communities of color, i.e., racial and ethnic communities.[17] The intent of the project is to be descriptive and comprehensive within limits on existing data and transport models in use, thus providing as much information as possible to governmental agencies and interest groups, which will draw their own conclusions about the status of transport equity. The coalition did not describe how they intend to synthesize the vast amount of information that the project will generate.

The coalition's scope of work contains four major tasks involving information acquisition and analysis. The following summary emphasizes the tasks pertaining to travel patterns, benefits, and burdens.[18]

1. Describe socioeconomic characteristics and residential locations of the populations of concern, and employment and activity centers in the Atlanta region. Activity centers include educational institutions, regional shopping centers, passenger terminals, sports venues, and health care institutions.
2. Describe local travel patterns for residents of Atlanta.
   2.1. Obtain existing data from 1990 Census Transportation Planning Package, on-board surveys of bus and rail transit riders, and ARC's travel forecasts. Synthesize interzonal travel patterns stratified by race, ethnicity, and income.
   2.2. Summarize synthesized travel patterns for work travel.
   2.3. Summarize synthesized travel patterns for non-work travel.
   2.4. Describe transit ridership patterns by trip purpose (work and nonwork), mode, race/ethnicity, household-income class, and route.
3. Examine distribution of benefits of the transportation system and explain variation in average time spent commuting to work.
   3.1. Obtain data: transportation improvements programmed for implementation during the period under study; inventory of freeway interchanges and rail stations, major streetscaping projects, and off-street bicycle and pedestrian paths (i.e., facilities); modelled interzonal travel times; observed travel times on highway and transit systems; volume, capacity, and congestion by link; boardings and peak-load volumes by transit line; pavement conditions; and condition of rolling stock, bus shelters and rail stations.
   3.2. Develop inventory of actual transportation improvements.
   3.3. Describe residents near each facility.
   3.4. Measure mobility using zone-to-zone trip tables and travel times. For the populations of concern, measure accessibility of residential areas to employment, shopping, etc. using isochrones and weighting the scale of activity at the destination. The measures must distinguish between highway travel time and transit travel time.
   3.5. Describe traffic level-of-service for each link and tabulate results by location. Compute ratio of average peak-hour volume to seated capacity at peak-load-point for each bus and rail line.

[17] Environmental Justice Coalition. "Transportation Benefits and Burdens in Atlanta: Draft Scope of Work for the Phase II Equity Analysis." N.p.: n.d.
[18] Many tasks call for preparation of maps and other presentation materials.

3.6. Describe pavement condition and tabulate results by location and proximate population. Describe quality of maintenance of buses, bus shelters, rail vehicles, and rail stations and tabulate results by ridership profile.

4. Examine distribution of burdens of the transportation system.
   4.1. Examine vehicle, pedestrian, and bicycle crashes and tabulate results by socioeconomic characteristics of the victim and proximate population.
   4.2. Describe populations near transit vehicle maintenance facilities and compare those populations to the general population of the Atlanta region.
   4.3. Describe populations exposed to mobile source emissions.
   4.4. Describe populations exposed to noise from transportation facilities.
   4.5. Describe takings of dwelling units and businesses and reductions in park lands from transportation projects.
   4.6. Analyze incidence of transportation taxes and estimate out-of-pocket transportation expenses by population segment.

Baltimore

The Baltimore Regional Transportation Board (BRTB) is the MPO for the Baltimore metropolitan region in the state of Maryland. It develops transport plans for five counties and Baltimore City, a region with a 1990 population of 2.3 million.

BRTB adopted the following "accessibility" goal to guide preparation of the next (2002) Baltimore regional transport plan. "The BRTP shall strive to achieve a balanced transportation system that is accessible, equitable, and reliable for all system users and that provides for enhanced connectivity between modes and destinations, ease of use, service proximity, and user safety."[19]

BRTB commissioned consultants to recommend how to make environmental justice a more salient consideration during its planning process. The consultants' recommended options for indicators of environmental justice are: per capita net travel benefits, travel time, and composite cost disaggregated by city and county and by income, race, ethnicity, and disability status.[20]

BRTB's Equity Subcommittee, formed in January 2000, also developed recommendations on how to address environmental justice issues.[21] The Equity Committee recommended continued monitoring of efforts to develop models that can assess the transport benefits and burdens borne by specific subpopulations. The STEP Model, developed by Elizabeth Deakin and the late Greig Harvey, is of particular interest to the Equity Subcommittee because Environmental Defense sponsored a case study application of the model to the Baltimore region.[22]

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[19] Baltimore Metropolitan Council. Baltimore Regional Transportation Board. "2001 BRTP Goals, Policies and Strategies." September 14, 2000. http://www.baltometro.org/BRTPgps.htm. [Deletions and emphasis omitted.]

[20] Lemer, Andrew C. and Bonham, Gordon Scott. *Considering Equity in Regional Transportation Systems: Concepts, Current Practices, and Strategic Options: Final Report*. September 1999.

[21] Its membership includes representatives of community groups and Environmental Defense, a national environmental interest group with a keen interest in transportation.

[22] The STEP Model is a disaggregate microsimulation model that operates within TransCAD.

In the Baltimore case study, STEP estimates morning peak period, home-based work trips by mode, income class, race, and ethnicity.[23] Among other things, the output allows comparisons of mode shares and job accessibility (percent of workers who can travel to their jobs within 45 minutes of travel by transit) by income, race, and ethnicity.

The Equity Subcommittee also recommended that BRTB prepare various thematic maps and conduct accessibility analyses using the method developed by the National Capital Region's MPO (described below).[24]

- Map of low-income and minority communities in the region.
- Map of low-income communities and planned transport projects (20 years out).
- Map of low-income communities and employment centers (20 years out).
- Access to jobs.
- Access to health care.
- Access to schools and colleges.
- Access to retail shops.
- Access to community facilities.
- Access to recreational facilities.

Iowa

Forkenbrock and Schweitzer proposed methods for assessing the spatial incidence of exposures to air pollutants and noise near intersections and communicating the findings to environmental justice communities.[25] To estimate and map the emission and dispersion of fine particulate matter (PM_{10}) and carbon monoxide (CO), they linked the PART5 and MOBILE5 emission factor models, CAL3QHR Gaussian dispersion model, and TransCAD. [26] To estimate noise, Forkenbrock and Schweitzer used MINNOISE.[27]

For the air pollutant analysis, Forkenbrock and Schweitzer investigated the effects of existing traffic. They created a hypothetical scenario to investigate the effects on noise of a substantial increase in truck traffic such as might occur in response to industrial development.

Thematic maps overlay PM_{10} contours, CO contours, and maximum L_{10} contours on census blocks that are shaded to represent varying percentages of low-income or minority residents

[23] Slavin, Howard and Lam, Jim. "STEP: Microsimulation for Transportation Equity Analysis." Newton, MA: Caliper Corporation: February 1, 2001.
[24] Baltimore Metropolitan Council. Baltimore Regional Transportation Board. Equity Subcommittee. "Background & Recommendations to the Baltimore Regional Transportation Board." Draft. [December 2000]. Data Workgroup. "Summary Notes: Thursday, April 13, 2000."
[25] Forkenbrock, David J. and Schweitzer, Lisa A. "Environmental Justice in Transportation Planning." *Journal of the American Planning Association* (Winter 1999): 96-111. The sponsors of their work are U.S. DOT, Iowa Department of Transportation, and Minnesota Department of Transportation.
[26] Fine particulate matter is soot and dust with an aerodynamic diameter less than or equal to 10 microns. PART5 and MOBILE5 are models developed by U.S. EPA. CAL3QHR was developed by the California Department of Transportation. Dispersion is measured out to a distance of 150 meters from the source of emissions. TransCAD is the GIS-based modelling platform developed by Caliper Corporation.
[27] MINNOISE is the noise propagation model developed by the Minnesota Department of Transportation. The model it is an updated version of the U.S. Federal Highway Administration's STAMINA model. MINNOISE estimates L_{50} and L_{10}, the noise level in dBA that is exceeded 50 percent of the time and 10 percent of the time, respectively, and L_{eq}, a type of mean noise level.

near the intersections in the case-study city (Waterloo). GIS was also used to profile pollutant concentrations and noise levels over a transect.

The assessment shows that minority households but not low-income households are overrepresented among those exposed to noise levels at the Minnesota DOT's noise abatement criteria for residential areas. Over 40 percent of minority households are exposed to excessive noise but only 13 percent of Waterloo's population are minority, implying a disproportionate and hence unjust impact.[28]

Forkenbrock and Schweitzer directly address the aggregation issue that arises when selecting the geographical unit of analysis. They argue that environmental justice assessments require the fine grain represented by census blocks and that the desired resolution is lost at higher levels of aggregation, viz., census block groups, census tracts, and Traffic Analysis Zones. "People in one part of a [census] tract may be significantly affected, while those in another part are not. Another reason that smaller units of analysis are preferred is that generally they are more homogeneous."[29]

Nonetheless, a finely-grained assessment comes at a price because the U. S. Census Bureau withholds income data for census blocks to protect privacy. Forkenbrock and Schweitzer estimated the percentage of persons in households with incomes below the poverty level for block groups with predictor variables which are common to block groups and blocks (r^2=0.650). That procedure introduces an unknown amount and type of error into the environmental justice assessment.

Minnesota

The Minnesota Department of Transportation's Committee on Environmental Justice prepared general procedural guidelines to help staff in the department and MPOs.[30] The guidelines only provide very general recommendations on the modelling aspects. Environmental justice assessments should "rely on existing sources of data to the greatest extent possible," be quantitative "wherever possible," and use census tract data to identify low-income and minority populations.[31] The guidelines endorse Forkenbrock and Schweitzer's recommendations on how to identify environmental justice populations and characterize economic, social, and environmental impacts (which are summarized above in the section on the case study conducted in Iowa).

National Capital Region

The Transportation Planning Board, the MPO for the Washington, District of Columbia area, investigated the environmental justice consequences of its long-range transport plan with measures of job accessibility.[32] The primary analysis uses census-tract-level data (from the 1990 census) on these populations: Black, Asian, white, low-income, and Hispanic.

[28] This criterion is similar to the one used in the Baltimore study summarized above.
[29] Forkenbrock and Schweitzer, "Environmental Justice in Transportation Planning," p. 98.
[30] Minnesota. Department of Transportation. "Mn/DOT's Environmental Justice Draft Guidance." August 5, 1998. http://www.dot.state.mn.us/pubinvolve/pdf/envjustice_1.pdf.
[31] Mn/DOT, "Environmental Justice Draft Guidance," p. 2.
[32] Klancher, Wendy and Miller, Gerald. *A Regional Accessibility Analysis of the 1999 Financially Constrained Long-Range Transportation Plan and Impacts on Low-Income and Minority Populations*. Washington: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, May 2000.

Accessibility is defined as the number of jobs that can be reached within 45 minutes of travel by auto, transit, or the fastest of those modes.[33] The analysis accounts for projected changes in the transport system and employment; population size and residential locations are held constant.

The specific consequence of interest is the change over 20 years in the number of jobs within 45 minutes for each mode and socioeconomic group. The findings are tabulated by impact category: significant loss, moderate loss, minimal impact, moderate gain, and significant gain.[34] Changes are evaluated *en bloc* by comparing the profile of significant losses to the regional population profile, comparing the profile of moderate losses to the regional population profile, etc. For example, in the census tracts from which 300,001 or more jobs can no longer be reached within 45 minutes of travel by auto (a significant loss), 20 percent of the population are Black, 9 percent Asian, 70 percent white, 3 percent low income, and 5 percent Hispanic.[35] For purposes of comparison, the regional population is 27 percent Black, 5 percent Asian, 65 percent white, 6 percent low income, and 6 percent Hispanic. The methods for identifying significant differences between pairs of profiles and synthesizing the results of multiple comparisons are not identified.

For each mode, a triptych of regional maps shows the census tracts from which various numbers of jobs can be reached within 45 minutes travel time in 2000 and 2020, and changes in access to jobs. Additional maps provide background information on projected major highway improvements; major transit and high-occupancy vehicle lanes; change in employment; change in population; and the locations of the Black, Hispanic, and Asian populations in 1990.

Considering all comparisons of access losers or access gainers to the regional population, the TPB concludes: "the change in accessibility to jobs is not disproportionately affecting low-income and minority populations in adverse way," and therefore "the benefits and burdens of the transport investments appear to be distributed evenly across the regional demographic profile."[36]

A sensitivity analysis uses 1990 and 1999 tract-level household data obtained from Claritas, Inc., a commercial source of marketing data. The TPB again concludes that the consequences of the long-range plan are not differentially adverse for low-income and minority populations.

North Carolina

Wilmington Bypass

In response to accusations of racial disparity in planning the route of the Wilmington Bypass, the North Carolina Department of Transportation (NCDOT) consulted the members of Wrightsboro, an agricultural settlement which the 8.6 mile bypass would traverse.[37] The

[33] The study also examines 30- and 60-minute isochrones but reports the results of only the 45-minute isochrone because it most clearly portrayed changes in accessibility.
[34] A minimal impact may be a gain or a loss, an unfortunate conflation of opposite types of impact.
[35] Klancher and Miller, *Regional Accessibility Analysis*, p. 30.
[36] Klancher and Miller, *Regional Accessibility Analysis*, p. 29.
[37] Lane, Leigh Blackmon; Hoffeld, Scott; and Griffin, David. "Environmental Justice Evaluation: Wilmington Bypass, Wilmington, North Carolina." *Transportation Research Record* 1626 (1998). Paper no. 98-0423.

technical purposes of consultation were to determine the evaluation factors of greatest concern to the community and to obtain suggestions for minimizing and mitigating adverse impacts of the two alignments under consideration. For the members of the community, the significant factors were residential and business displacements, community impacts (anxiety relating to separation and isolation, relationship disruptions, and sprawl), community services (access to a church parking lot), safety, traffic, noise, air quality, land use and value, and aesthetics. The consultation thus determined the scope of the environmental justice evaluation.

The environmental justice evaluation defined the reference population as the residents in the census block groups within 1,000 feet of the centerline of the alignments under consideration. That distance was presumed to represent the extent of the impacts. The income characteristics of the population in any particular census block were assumed to be the same as that of the population in the encompassing block group. The racial characteristics of the population were taken directly from the most recent (1990) census. The income and racial composition of the population in 1990 was assumed to apply to the future years of interest, 2000 and 2016. The choice of extrapolation rather than projection reflects both resource constraints and concern that the errors in statistically-based projections would exceed the errors in extrapolation.[38] The reference population was 25.5 percent minority and 18.6 percent low income; the thresholds for determining income status were 150 percent of the census poverty thresholds.[39]

The Department's evaluation quantified residential and business relocations, traffic noise, and concentrations of pollutants subject to the U.S. Environmental Protection Agency's National Ambient Air Quality Standards, presumably ozone and carbon monoxide. For example, 34 percent of the persons whose residences will be displaced by the "Center Alternative" are minority, and 14 percent are low income. Residential relocation due to the Center Alternative will have a disproportionately greater effect on minorities because the affected population contains more minority persons (34 percent) than if the affected population's racial composition mirrored that of the study area's population (25.5 percent). Nonetheless, because of the countermeasures proposed to avoid and mitigate adverse effects, NCDOT concluded that neither alignment would have, after mitigation, a disproportionately high, adverse effect on the populations of concern.[40]

Triangle Transit Authority's Regional Rail System

The second North Carolina case is the environmental justice analysis in the draft environmental impact statement for the first phase of a proposed regional rail system in the Research Triangle area that would serve Durham, Morrisville, Cary, and Raleigh.[41] Self-propelled diesel vehicles in two- and three-car trains would provide service 18-hours a day, seven days a week, with headways of 15 or 30 minutes.[42] The rail line would require some construction of track and construction of 16 stations and the yard and shop facility. Feeder bus service would also be provided.

[38] Had projection been attempted, the predictors evidently would have included existing and proposed land uses, existing and proposed infrastructure improvements, past population trends, and public services. Lane et al., "Wilmington Bypass," p. 135.
[39] This definition of low income is more conservative (generous) than the U.S. Department of Health and Human Services poverty guidelines which are employed in USDOT guidance on environmental justice.
[40] Lane et al., "Wilmington Bypass," p. 137.
[41] Triangle Transit Authority. "Environmental Justice Excerpts from Draft EIS." N.p.: n.d.
[42] Triangle Transit Authority. *A Guide to Phase 1 Regional Rail System: Durham to Raleigh to North Raleigh: Preliminary Engineering/Environmental Impact Statement*. Research Triangle Park, NC: TTA, November 1998.

The Triangle Transit Authority (TTA) identified the populations of concern by using 1990 census data and GIS to locate concentrations of very low-income, low-income, and minority persons within one mile of the rail corridor. The geographical unit of analysis is the census block group or census block. Very low income means a median family income less than or equal to 50 percent of the median family income for a household of average size in the Raleigh-Durham-Chapel Hill Metropolitan Statistical Area; the threshold for low income is 80 percent.[43] A concentration of minority persons is present when at least 50 percent of the population in a census block comprises one or more of the racial and ethnic groups listed in the environmental justice Executive Order.[44] The minority populations in the study area are primarily African American.

The appraisal investigated transit service equity and impacts on the environment, natural resources, and the social and economic conditions in the areas containing the populations of concern. The TTA investigated the following specific types of adverse impact on environment, natural resources, and community.

- Air pollution.
- Noise and vibration.
- Water pollution.
- Soil contamination.
- Destruction of man-made resources.
- Destruction of natural resources.
- Diminution of aesthetic values.
- Detriment to community cohesion.
- Diminution of economic viability.
- Detriment to private and public facilities access.
- Detriment to private and public services access.
- Traffic congestion and impairment to mobility.
- Diminution of employment opportunities.
- Displacement of businesses and residences.
- Exclusion, isolation or separation.
- Diminution of benefits provided by U.S. Department of Transportation.

Many impacts are obviously related to social exclusion. Almost all impacts, including transit service equity, are treated qualitatively or with minimal quantification.[45]

The TTA's appraisal qualitatively investigates *en bloc* several factors that are highly significant for social exclusion: community cohesion; access to facilities and services; and exclusion, isolation or separation. Community cohesion is analyzed as a function of displacements and whether the proposed corridor contains an existing facility used for freight and passenger rail. Because the number of displacements is small (see below) and the

[43] The criteria are similar to the income limits used by the U.S. Department of Housing and Urban Development to determine eligibility for housing subsidies. U.S. Department of Housing and Urban Development. Notice PDR-2001-03.

[44] The threshold (50 percent) for identifying a minority population is consistent with recommendations made by the Council on Environmental Quality, which is in the Executive Office of the President of the United States. Council on Environmental Quality. *Environmental Justice: Guidance Under the National Environmental Policy Act*, p. 25. Washington: CEQ, December 10, 1997.

[45] Air pollution, noise and vibration, job losses, and displacement are investigated quantitatively. The documentation that is available at this time provides sufficient information only on job losses and displacement.

corridor contains an active rail line, TTA concludes that community cohesion will not be adversely affected. The issue of exclusion, isolation, or separation is treated as an issue of access. Thus, because the regional rail system increases regional access to goods and services and does not affect local access, it will not adversely affect exclusion, isolation, or separation.

Economic viability and employment opportunities are also closely related to social exclusion. In TTA's appraisal, they are analyzed as a function of displacement of businesses and the effects of the regional rail system on the region's economy. The appraisal predicts displacement of 13–44 businesses.[46] Less than half the displaced businesses have a work force that is mostly minority, and none of the businesses are in minority or low-income areas. Depending on the project alternative, 236–487 jobs would be created in the region in the opening year.

The TTA concludes that the regional rail system would not adversely affect economic viability or economic opportunities, and that the predicted business displacements would not be inequitable. "The economic and employment benefits and disbenefits of the project," taking into account direct and indirect job creation, "would not be disproportionate since there will be additional employment access benefits, the project's business displacements would not inequitably focus on businesses with high minority employment, and the owners of most displaced businesses have indicated that they can relocate."[47]

The appraisal estimated the number of residential displacements (4–16), and concludes that the impact may be inequitable. Four dwellings that may be displaced by station construction are in areas with a concentrated minority population, and seven dwellings are in an area with a concentrated low-income population. TTA concludes that the regional rail system "could result in a disproportionate impact on low-income and minority neighborhoods, relative to displacements elsewhere along the project corridor."[48] The conclusion is interesting for two reasons. First, unlike the environmental justice assessment of the Wilmington Bypass, TTA's finding of disproportionate impact is based not on net effects (net of relocation) but on gross effects (displacement per se). Second, the investigation does not examine whether the proposed avoidance strategy—relocation of the yard and shop facility and a station in a popular retail district—would reduce the employment access benefits which help offset the harm done by business displacements.

Transit service equity is investigated primarily by an examination of the proximity of the populations of concern to the planned rail stations. Because most low-income communities and most minority communities are within 1 mile of a planned station, and because feeder bus service is planned for many areas in the region, TTA concludes that the mobility options and hence the potential for regional access would be improved for the populations of concern. Although the inference is not explicitly made, it is straightforward to conclude that the proposed system is neutral or positive with respect to transit service equity.

Ohio

The Ohio Environmental Justice Task Force developed (draft) guidance for the state department of transport, local governments, and MPOs to promote a uniform approach to

[46] The documentation does not report employment at the displaced businesses
[47] TTA. "Environmental Justice Excerpts," p. 9.
[48] TTA. "Environmental Justice Excerpts," p. 10.

addressing environmental justice.[49] The guidance recommends the "methods and approaches for ensuring that the interests of minority and low-income populations [and elderly and handicapped persons] are considered and the impacts on these populations are identified and addressed within the current transport decision-making processes."[50]

The guidance describes procedures for identifying the area of potential impact for a regional transport plan or individual project, identifying locations of the populations of concern, and conducting disproportionate-impact tests. Regarding data and the spatial unit of analysis, the guidance recommends use of U.S. Census data to identify populations and conducting assessments at the TAZ level. Impact assessments should quantitatively and qualitatively investigate each of the types of impact listed in USDOT's environmental justice orders (see below). Assessments should compare impacts with and without the proposed plan or project and report results in a matrix that provides information on current and future states, whether the estimated change is beneficial or adverse, and short- and long-term impacts. The results should be reported separately for the target populations/locales and the larger area that is relevant to the plan or project.

This list gives the quantitative indicators that the guidance recommends for each type of impact described in USDOT's environmental justice orders.

- Bodily impairment, infirmity, illness, or death.
  - Traffic speed, traffic volumes, and nonlocal traffic within the target area.
- Air, noise, and water pollution and soil contamination.
  - Traffic noise and traffic-induced air pollutant emissions and water pollution.
- Destruction or disruption of man-made or natural resources.
  - Number of trees and other plants.
  - Quantity and quality of waterways.
  - Number and size of parks, parklands, and outdoor recreational opportunities.
- Destruction or diminution of aesthetic values.
  - Addition, relocation, and removal of public art and statues.
  - Expenditures on "enhancements" such as pedestrian and bicycle facilities, landscaping, historic preservation, etc.[51]
  - Amount of open space.
- Destruction or disruption of community cohesion or a community's economic vitality.
  - Number of new dividers (4-lane highway etc.) in existing communities that will cause segmentation.
  - Numbers of businesses and locally-owned businesses in the target area.
- Destruction or disruption of availability of public and private facilities and services.
  - Time to travel to public and private facilities and services (schools, medical facilities, shops, community centers, libraries, etc.).

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[49] Ohio. Department of Transportation. Office of Urban and Corridor Planning. *Guidance and Best Practices for Incorporating Environmental Justice into Ohio Transportation Planning and Environmental Processes*. May 30, 2000. http://www.dot.state.oh.us/planning/Environ-Just/env-jus.pdf. The members of the task force are representatives of ODOT, MPOs, regional councils, FHWA, and FTA.

[50] OH DOT. *Guidance for Environmental Justice*, pp. 2-3.

[51] The Transportation Equity Act for the 21st Century defines "transportation enhancements activities" (23 U.S.C. 101(a)(35)).

    - Number of impediments, including bus transfers, to reaching public and private facilities.
    - Number and location of public and private facilities.
- Vibration.
    - Vibration caused by traffic and transit.
- Adverse employment effects.
    - Time to travel to jobs in the target area and region.
    - Increases and decreases in number of jobs in the target area and region.
- Displacement of persons, businesses, farms, or nonprofit organizations.
    - For the populations of concern, numbers of persons, businesses, farms, and nonprofit organizations that will be displaced.
    - For the rest of the population, numbers of persons, businesses, farms, and nonprofit organizations that will be displaced.
- Increased traffic congestion.
    - Traffic congestion level.
- Isolation, exclusion, or separation of minority or low-income individuals within a given community or from the broader community.
    - Number of severed roads that provide ingress and egress to target area.
    - Travel time from target area to schools, churches, shops, employers, recreational facilities, etc.
- Denial of, reduction in, or significant delay in receipt of benefits.[52]
    - Are populations of concern denied access to or use of transport improvements?
    - Are populations of concern effectively limited in access to or use of transport improvements?

Sacramento

Rodier and Johnston developed a technique for expressing the information on consumer surplus implicit in the aggregate, multinomial logit mode choice models used by transport planning agencies in the United States.[53] Their computer program generates the compensating variation for transport changes from the home-based work, shop, and other models used by the MPO for the Sacramento area in California.[54] Thus they measure the monetized change (policy scenario minus base case scenario) in the logsum of the denominator of the logit equation.

Because those models distinguish among household incomes, the compensating variation of a proposed transport strategy or plan may be reported by income class as well as for all households.[55] They have applied the technique to evaluate the benefits of light-rail transit, high-occupancy vehicles lanes, pricing policies, and advanced public transport systems.[56]

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[52] Contrary to the intent of the guidance, the indicators of this type of impact are not quantitative.

[53] Rodier, Caroline J. and Johnston, Robert A. "Method of Obtaining Consumer Welfare from Regional Travel Demand Models." *Transportation Research Record* 1649 (1998): 81-85.

[54] For a realized change that is beneficial to a consumer, the compensating variation is the maximum amount of money that the consumer would be willing to pay while leaving him/her just as well off as he/she was before the change.

[55] Their income classification would need adjustment for use in environmental justice assessments because the lowest-income class (<$10,000 net income) does not conform to the Federal definition of poverty.

[56] Rodier and Johnston, "Consumer Welfare." Rodier, Caroline J. and Johnston, Robert A. "Travel, Emissions, and Welfare Effects of Travel Demand Management Measures," *Transportation Research Record* 1598 (1997):

San Francisco Bay Area

The Metropolitan Transportation Commission's environmental justice analysis of the 1998 regional transport plan for the Bay Area investigated the potential (in 2020) for disparate impact discrimination with two types of cumulative-opportunities accessibility measures.[57] The isochronal measures depict the total number of jobs within 35, 45, 50, or 75 minutes by mode and by zone of residence. The "weighted accessibility" measures depict the total number of jobs in destination zones weighted by the difficulty of access by mode and zone of residence; difficulty of access is expressed by the inverse exponential function of travel time in which the exponent is the best-performing friction factor used in the Bay Area's model of trip distribution. The total number of jobs is a proxy for the number of activities and hence the accessibility measures correspond not to the availability of employment per se but the availability of goods and services. For all accessibility measures, the modes of interest are transit, drive alone, and carpool.

The Metropolitan Transportation Commission (MTC) drew on a sociodemographic study prepared by a public-interest group to identify "disadvantaged neighborhoods" and the 142 census tracts in the disadvantaged neighborhoods.[58] The MTC then identified the 133 (out of 1,099) TAZs that correspond to those census tracts. Thus the geographical unit of analysis for the accessibility measures is the TAZ.

It appears that the only projected socioeconomic variable used directly in the accessibility measures is total employment by industrial sector (projected at the census tract level).[59] Projections were not made for population by race, ethnicity, or disability status. Even though the latter socioeconomic variables are central to environmental justice analyses, the MTC staff evidently believed it could not responsibly project their values. "Mechanical, computer procedures can always be developed to produce numbers, yet simplified mechanical procedures cannot be used to realistically or accurately assess neighborhood-level population dynamics."[60]

The MTC conducted statistical tests to determine whether transport investments significantly affect accessibility for each mode, isochrone, and type of neighborhood (i.e., disadvantaged or other). It conducted additional statistical tests to determine whether the post-investment accessibility (also assessed with the isochronal measures) of disadvantaged neighborhoods would differ from the accessibility of the other neighborhoods. Thus the statistical tests were the tools the MPO used to conduct the disproportionate impact test of the planned transit and highway investments that could be modeled.

18-24. Rodier, Caroline J.; Johnston, Robert A.; and Shabazian, David R. "Evaluation of Advanced Transit Alternatives Using Consumer Welfare." *Transportation Research*, Part C (1998): 141-156.

[57] Purvis, Charles L. "Data and Analysis Methods for Metropolitan-Level Environmental Justice Assessment." 80th annual meeting of the Transportation Research Board, Washington, DC. 2001.

[58] Disadvantaged neighbourhoods are defined by a median household income 80 percent or less than the encompassing county's median household income. That definition is similar to the definition of low income used by the U.S. Department of Housing and Urban Development.

[59] Projections of many other variables were made for the travel demand model.

[60] Purvis. "Methods for Metropolitan Environmental Justice Assessment," p. 12.

Southern California

Michael Cameron and the late Greig Harvey developed a formal cost-benefit model to appraise the effects of economic incentives such as a mileage fee on the transport system in Southern California.[61] The model is remarkably comprehensive. It encompasses and quantifies in monetary terms the mobility benefits enjoyed by persons travelling by automobile or public transit, costs incurred when obtaining transport services, and costs of air pollution and traffic congestion. Benefits and costs are reported by income quintile. The transport demand model underlying the investigation employs a household-level simulation framework.[62] The benefit measure is willingness-to-pay. That approach to characterizing benefits later became problematic for some stakeholders because of the need to quantify income effects and the nearly eight-to-one difference in the value of time for the highest and lowest income quintiles.

The 1998 regional transport plan for Southern California, "Community Link 21," was the first plan prepared by the Southern California Association of Governments (the region's MPO) that included environmental justice in the plan development criteria.[63] Development of the plan occurred during resolution of the landmark class-action civil rights law suit filed in 1994 against the Los Angeles County Metropolitan Transportation Authority, the region's largest transit agency, by the National Association for the Advancement of Colored People on behalf of a multiracial and multi-ethnic coalition of bus riders and their advocates. In addition, in 1997, a broad coalition of public interest groups gave notice of intent to sue the MPO over its handling of environmental justice issues in the preliminary (1997) version of Community Link 21. It is an understatement to say that those legal actions helped motivate the MPO to give greater attention to environmental justice and to increase public participation in plan development. Among other public involvement processes, the MPO established an expert Peer Review Committee to advise staff on how to include equity in the transport appraisal process. Thus the MPO's environmental justice criteria reflect the interaction of a highly-attentive staff with transport researchers, consultants, and environmental justice advocates.

Looking at both the preliminary and adopted versions of Community Link 21, the MPO used several indicators of the effects of proposed transport investments on environmental justice, some of which were not received well by stakeholders. The MPO initially proposed to quantify the distribution of benefits by calculating the value of travel time saved by income group; the unit value of time for any particular group was half its average hourly wage. For the preliminary plan, the least affluent quintile would experience 9 percent of the total travel time saved and 2 percent of the monetary value of time saved; the most affluent quintile would experience 25 percent of the total travel time saved and 48 percent of the monetary value of time saved.[64] Expression of the benefits in monetary terms was controversial because of some stakeholders' discomfort with making judgments about the value of time for different income classes.

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[61] Cameron, Michael W. *Efficiency and Fairness on the Road: Strategies for Unsnarling Traffic in Southern California*. Oakland, CA: Environmental Defense Fund, 1994.

[62] This model is known as the STEP model. It is being further developed by Caliper Corporation, which recently used it in an environmental justice assessment in Baltimore (see above). Slavin and Lam, "STEP: Microsimulation for Transportation Equity Analysis."

[63] U.S. Department of Transportation. *Community Link 21, Regional transportation Plan: Equity and Accessibility Performance Indictors: Southern California Association of Governments*, p. 4-9. Environmental Justice Case Studies. N.d. http://www.fhwa.dot.gov/environment/ejustice/case/index.htm#4.

[64] U.S. DOT. *Community Link 21 Indicators*, p. 4-11 (Table 1).

The issues with the monetary evaluation of time savings led the MPO to base its assessment of environmental justice on an isochronal measure of accessibility to jobs and an isochronal, cumulative-opportunities measure of access to "essential services."[65] The indicator of job accessibility measures the percent of jobs in the region within 30 minutes of travel by auto, all forms of transit, or transit other than express bus and rail. The indicator of essential-service accessibility measures the percent of various service opportunities in the region within 30 minutes of travel by auto, all forms of transit, or transit other than express bus and rail. The essential services are provided by commercial banks, savings institutions, credit unions, personal services, automotive repair shops, miscellaneous repair services, amusement and recreation services, health services, educational services, social services, religious organizations, private households, police protection, and fire protection.[66] The accessibility indicators are reported separately by income class, mode, ethnicity (Hispanic), and race (Black).

The geographical unit of analysis for both indicators is the TAZ, of which there were 1,527 in the planning region. The historical data on income, race, and ethnicity were obtained from the 1990 Census for each census tract. The MPO's staff projected the racial and ethnic composition of the population in 2020. The number of households in each of 30 categories (five income classes and six race or ethnicity categories) were apportioned to the TAZs. The number of jobs at service establishments was used as the surrogate for magnitude of opportunity. Historical employment data were obtained from the 1990 Census for each census tract, employment projections at the county level were made by the state Employment Development Department, and counts and estimates were apportioned to the TAZs.

Historical and projected data on trip-making by income and mode, trip distribution, and travel times were obtained from the 1990 Census (PUMS) and the MPO's 4-step model of the region's transport system. Because PUMS data are reported at the county level, trip-making rates by income and by mode for any particular TAZ must be assumed to equal the respective rates for the county containing the TAZ. Further, trip-making rates are assumed to be determined by income; therefore, for any income class, the number of trips for a racial or ethnic group is proportional to the group's population in the income class.

A technical appendix to the regional transport plan provides supplementary information on access to jobs and services.[67] Job accessibility is measured in several additional ways: 1) the percent of jobs in the region within 45 minutes of travel by transit, 2) the percent of employment opportunities (jobs) in the region within 30 minutes of travel by auto, 3) the percent of employment opportunities in the region within 30 minutes of travel by transit, and the percent of employment opportunities in the region within 45 minutes of travel by transit. Access to essential services is also measured with a 45 minute isochrone. Access to retail shopping opportunities is also measured using the same three combinations of travel time and mode. In the evaluations reported in this appendix, income classes are reduced from six to three (low-, middle-, and high-income).

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[65] U.S. DOT. *Community Link 21 Indicators*, p. 4-11.

[66] Southern California Association of Governments. *98 Regional Transportation Plan: Technical Appendix*, p. IV-110. Los Angeles: SCAG, n.d. The categories of services are standard industrial classifications used in statistical reports.

[67] Southern California Association of Governments. *Draft 1998 RTP: Technical Appendix: Issue #4: Equity - Distribution of Benefits from Transportation Investments Among Different Population Groups*. Los Angeles: SCAG, n.d.

Implications for Appraisals of Effects of Transport on Social Exclusion

In several important ways, the American experience with modelling transport equity is directly applicable to the appraisal of the effects of transport plans and policies on social exclusion. The evaluation of the American experience presented here focuses on the most basic modelling-related components of the appraisal process and the organization of appraisals, particularly involvement of the populations of concern.

- Populations of concern and reference populations, current and future.
- Impacts on social exclusion and transport system performance measures.
- Involvement of socially-excluded persons in the appraisal process.

The latter significantly influences the selection of impacts to appraise and determines whether the appraisal process inadvertently reproduces relations of governance that intensify social exclusion.

Populations of Concern and Reference Populations

The primary populations of concern in American transport equity (environmental justice) analyses are characterized by income, race, and ethnicity. The review of the definitions of social exclusion and transport poverty in the conceptual review prepared for this project demonstrates that although some environmental justice populations may also be socially excluded, the two types of populations in general are not identical. Therefore the interesting methodological issues apparent in the survey pertaining to the definitions of the populations of concern and reference populations are not the specific meaning of "low-income" and "not low-income" but: the criteria of an adequate operational definition of the populations, choice of the geographical unit of analysis, and approach to projecting the locations of the populations 20 years into the future. At that level of generality, those issues are salient for analyses of social exclusion and transport. A theme of the methodological recommendations emerging here is that it is important to test the robustness of conclusions concerning transport poverty and equity with respect to the assumptions made about the future socioeconomic characteristics of neighborhoods and the location of the reference population.

The survey finds that different investigations use different definitions of low income (a surprising finding in light of the U.S. Department of Transportation's definition of a low income as the household incomes equal to or below the U.S. Department of Health and Human Service's poverty guidelines.) [68] In the context of social exclusion, the methodological issue that arises is one of robustness. Are the conclusions dependent on the specific definition of low-income? If appraisals of social exclusion and transport use population characteristics that cannot be unambiguously defined—which is certainly true—then a sensitivity analysis should be conducted to determine the robustness of the findings.

Forkenbrock and Schweitzer (1999) have raised a valid, theoretical concern about the errors that may result from analyzing some of the adverse environmental impacts of transport at the more aggregate geographical unit, i.e., block group or census tract.[69] The distance of a person

[68] At least for analyses using 1990 census data, race and ethnicity are unambiguous because the definitions are universally accepted.

[69] The data from the decennial census on race and ethnicity are reported at the census block, block group and census tract levels; the census data on income and disability status are reported at the block group and census tract levels.

(receptor) from a source of carbon monoxide emissions, particulate matter emissions, or noise, and the direction of the person relative to the source, affect the intensity and frequency of exposure.[70] For those pollutants, block groups are large enough relative to the range of influence of mobile sources that exposure to air pollution or noise is unlikely to be adequately represented by assuming uniform exposure throughout a block group. Therefore, considerable error may be introduced in block-group or census-tract level analyses of the population characteristics within pollutant or noise contours. It is also true that exposure is unlikely to be uniform throughout a census block, but the error should be less.

The census-block-level analysis of environmental impacts entails making inferences about the income characteristics of census blocks. Forkenbrock and Schweitzer (1999) regressed the percentage of impoverished persons in a block group on predictor variables that are available for block groups and census blocks. The regression was somewhat successful, explaining about two-thirds of the variation in the dependent variable. They did not take the next step of calculating the upper and lower bounds on the estimate of the percentage of impoverished persons in each block group. Their argument for census-block-level analysis would have been more compelling if presented with an uncertainty/sensitivity analysis that reveals whether the conclusion made about disparate impacts varies with the geographical unit of analysis or use of estimated values of the income variable other than the point estimate.

All but one of the empirical assessments reviewed in the survey assume that income distribution and the ethnic and racial composition of the population do not change during the period covered by the 20-year planning horizon, i.e., they assume a constant "ecological" structure of the region. The exception is the assessment made by the Southern California Association of Governments, which predicted change in the ethnic and racial composition, but held income distribution constant.[71] Obviously, the assumption of a constant ecological structure simplifies the assessment, reduces the cost of preparation, and, as Purvis observes,[72] avoids the difficulties and errors in making small-area projections of sociodemographic attributes. "Old data from the 1990 Census is [sic] quite valuable in depicting the geographical distribution of low-income, minority, elderly and disabled persons - as of 1990! Current estimates of population by these market segments is hard-to-impossible to come by, and future year projections of these attributes are rare and of questionable accuracy."[73]

Unfortunately, the assumption of a constant ecological structure probably is invalid not only over periods of 20-years but also shorter periods. One case study must suffice to document the substantial structural changes that occur over 10- or 20-years.

Morenoff and Tienda studied neighborhood change in Chicago during the late 20th century; Chicago is an interesting case study because the city arguably is representative of other industrial cities.[74] Working with census-tract data from the three decennial censuses of 1970–1990, they used cluster analysis to identify urban neighborhoods with similar socioeconomic status, residential stability, family structure, and age composition. They developed a four-part typology comprising middle class, yuppie, working class, and underclass neighborhoods.

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[70] For example, the concentration gradients for CO and PM_{10} can change substantially over 100 feet or less.
[71] The published documentation does not describe the method used to project racial and ethnic composition.
[72] Purvis. "Methods for Metropolitan-Level Environmental Justice Assessment."
[73] Purvis. "Methods for Metropolitan-Level Environmental Justice Assessment," p. 4.
[74] Morenoff, Jeffrey D. and Tienda, Marta. "Underclass Neighborhoods in Temporal and Ecological Perspective." *Annals of the American Academy of Political Science*, 551 (May 1997): 59-72.

Because of their relatively high racial and ethnic composition and relatively low incomes, changes in working class and underclass neighborhoods provide insight into the evolution of environmental-justice and socially-excluded populations. The number of working class neighborhoods declined from 374 in 1970 to 217 in 1980.[75] The number of underclass neighborhoods increased from 22 to 187 during the first decade studied. Between 1970 and 1980, 50 middle-class neighborhoods became working-class, and 14 became underclass. Thirteen yuppie neighborhoods became working class, and two became underclass. Working-class neighborhoods made upward and downward transitions: 71 became either middle class or yuppie and 151 became underclass. Only two of the underclass neighborhoods in 1970 changed, becoming working class. Over the 20-year period, the number of working class neighborhoods declined by 258, and the number of underclass neighborhoods increased by 234. Although underclass neighborhoods tend to be stable, relatively few becoming working class, yuppie, or middle class, substantial change in the ecological structure of Chicago—and hence the locations of environmental justice and socially-excluded populations—has occurred over periods as short as a decade.

The difficulty of precisely predicting neighborhood transitions and the unreasonableness of ignoring them provide the rationale for additional efforts to depict ecological structure from a spatial as well as temporal perspective.[76] The statistical analysis conducted by Morenoff and Tienda documents the occurrence of change in the locations of the populations of concern over time without showing how change occurs spatially. Thus it does not attempt to answer questions having to do with, for example, whether emergent underclass neighborhoods abut existing underclass neighborhoods. Direct information on the spatial characteristics of neighborhood change would assist with developing procedures for predicting such change or, in the absence of such predictions, shaping the sensitivity analysis of the assumption that the locations (relative to the geographical unit of analysis) of the populations of interest are fixed.

Another modeling response to the findings on urban ecological trends is to adapt Morenoff and Tienda's method for identifying neighborhoods to the task of identifying socially-excluded populations and non-socially excluded populations. A multidimensional clustering technique is a rigorous approach to classifying neighborhoods. The historical understanding of urban structure that would be obtained by using Morenoff and Tienda's method would also provide important contextual information relevant to developing transport strategies and plans because, among other reasons, it may be able to reveal the advantages, if any, of the forms of transit capable of highly flexible routing such as buses.

Reference populations are relevant to social-exclusion assessments because the question of the contribution of transport to social exclusion implicitly assumes a contrast with the non-socially-excluded population. The reference populations for a corridor study must be defined with respect to not only social-exclusionary status but also proximity vis-à-vis the project under consideration to determine who they are and where they live. The choice of the latter is not obvious because different meanings can be given to living "near" a project.

The survey found two approaches to determining the residential location of a reference population: the "project study area" or impact area (identified with a buffer around the

[75] All figures in this paragraph are from Morenoff and Tienda, "Underclass Neighborhoods," Table 2, p. 68.
[76] The same could also be said about the locations of significant destinations. Metropolitan planning organizations in the United States commonly project employment by TAZ but not the locations of new schools, parks, etc. Nonetheless, discussion of improvements in projecting nonresidential activity centers is beyond the scope of this modelling review.

proposed facility) and the metropolitan area (City of Watterloo). The assessment of the Wilmington bypass locates the reference population within 1,000 feet of the centerline of any feasible corridor, the assessment of regional rail in the Triangle area locates the reference population within one mile of the rail corridor, and the assessment of traffic noise at an intersection in Waterloo (Iowa) locates the reference population in the city.

Neither assessment justifies the adopted approach to locating the reference population, and the impact-area approach selects an excessively small domain. An example illustrates the flaw in the impact-area approach. Consider a freeway that will be built through the exclusively African-American neighborhood Hayti; no entry or exit ramps will be built in Hayti. The purpose of the freeway is to connect an affluent white neighborhood, Governor's Club, and the Silicon Piedmont Office Park, which lie on either side of Hayti. Application of the impact-area approach would locate the population of concern and reference population entirely within Hayti. It would be impossible to demonstrate a disproportionate impact on the African-American population even though it suffers the adverse impacts of the freeway.

When the metropolitan area is the domain for the reference population, the assessment correctly finds an adverse, disproportionate impact because the adversely affected population is 100 percent African-American and the reference population is less than 100 percent African-American. Indeed, in this example, it would be crucial to document the distribution of benefits—which are 100 percent enjoyed by the white population—and adverse effects—which are 100 percent suffered by the African-American population.

Impacts on Social Exclusion and Transport System Performance Measures

Our conceptual review reached these conclusions about the contribution of transport to social exclusion. Transport poverty is understood within a conceptual framework that encompasses impacts on activity participation, well-being (safety, security, health, and affect), and coping strategies. Transport poverty occurs, and hence social exclusion intensifies, when the transport system: interferes with participation in normal social roles; provides unsafe or insecure travel by transit, cycling, or walking; exposes socially-excluded persons to elevated concentrations of carbon monoxide or airborne toxins; reinforces low self-esteem; or diminishes the effectiveness of coping strategies. Viewed politically within the transport context, token or placative processes for public participation also intensify social exclusion.

The survey of the American experience with modelling transport equity brings to the fore three major issues that are germane to modelling the impacts of transport on social exclusion: the scope of quantitative assessment, the measurement of accessibility and other use values pertaining to mobility, and whether inquiry into potential impacts should provide information only on incremental changes, thus ignoring historical context. The first issue entails an observation on the status of analytical techniques which leads to broad recommendations for improved modelling that may be achieved in the near- and intermediate-terms. The survey permits the making of more specific recommendations pertaining to the appraisal of the effects of transport strategies and plans on accessibility. The third issue raises a fundamental question about the importance of grounding social-exclusion oriented assessments in an historical context.

Many impacts included in the surveyed assessments and guidance documents are also germane to social exclusion. Noise, vibration, and air pollution are among those impacts although the preferred modelling approach is often unstated. For the reasons given in the

conceptual review, specific attention should be given to emissions of diesel particulate matter. The *Guidance on the Methodology for Multi-Modal* Studies contains specific recommendations for modelling and appraising noise and local air pollution with the exception of diesel particulate matter; review of those recommendations is outside the scope of this survey.[77]

The Ohio Department of Transportation's draft environmental justice guidance offers recommendations for measuring the social impacts included in USDOT's environmental justice orders, and all are germane to social exclusion. They are reiterated below,[78] and each is followed by general remarks on the appropriate quantitative indicators.[79]

- *Disruption of public outdoor recreational sites*.

Disruption occurs through either actual physical destruction or diminution of the quality of the recreational experience. Two indicators are necessary: number of parks, gardens, and soccer fields and number of sites with annoying traffic noise.

- *Diminution of aesthetic values*.

Appraisals of proposed corridor-level projects would be enhanced with renderings and/or computer-aided visualization and simulation techniques.[80] When coupled with preference surveys, such as those developed by Anton Nelessen, [81] they provide quantitative information on stakeholders' attitudes toward the aesthetics of facilities.[82] The journey ambience sub-objective under the environment objective in *GMMS* requires an assessment by technical staff of whether travellers' views of the landscape or townscape will improve.[83] In conjunction with public participation, use of visualization techniques would enhance the ability of appraisals to obtain the stakeholders' evaluations of changes in aesthetics.

- *Disruption of community cohesion*.

Ohio's guidelines recommend measurement with the number of new, high-capacity highways that will segment an existing community. An increase in the number of such highways (a physical characteristics of a community) is postulated to correlate with decreased community cohesion (an affective state of residents). Thus measured, disruption of community cohesion appears to be functionally equivalent to severance, a sub-objective under the accessibility objective in *GMMS*.[84] Therefore severance is the preferred indicator of disruption of community cohesion.

- *Disruption of availability of public and private facilities and services*.

In effect, Ohio's guidelines recommend measuring the accessibility of schools, medical facilities, and other destinations, and the supply of jobs and other goods and services. That approach begs the more fundamental question of whether accessibility should be measured with respect to a single-stop trip or a trip chain. The question is taken up in the general discussion of accessibility measures which appears below.

- *Adverse employment effects*.

The Ohio guidelines recommend two indicators of adverse employment effects: increased time to travel

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[77] U.K. Department of the Environment, Transport and the Regions. *Guidance on the Methodology for Multi-Modal Studies*. http://www.detr.gov.uk/itwp/mms/index.htm. 11 May 2000.

[78] Terms have been edited for clarity and to eliminate redundancy.

[79] Some of the recommendations differ from the recommendations in Ohio's guidelines and *GMMS* for similar objectives and sub-objectives. The intent is not to criticize but to propose for further discussion indicators that may be more appropriate in the specific context of social exclusion.

[80] A brief catalogue of visualization tools is available online at http://sustainable.state.fl.us/fdi/fscc/news/state/0004/tools2.htm.

[81] Nelessen, Anton C. and Constantine, James. "Understanding and Making Use of People's Visual Preferences." *Planning Commissioners Journal*, no. 9 (March/April 1993).

[82] *GMMS* addresses the appraisal of options against the townscape sub-objective under the environment objective but does not refer to this specific technique for visual preference surveys.

[83] U.K. DETR. *GMMS*, volume 2, chapter 4.

[84] U.K. DETR. *GMMS*, volume 2, chapter 7.

to jobs and reduction in jobs. Further discussion of how to measure accessibility to jobs appears below. Any reduction in the number of entry-level jobs is obviously relevant to the well-being of socially-excluded persons. The studies of the spatial distribution of jobs in large metropolitan areas conducted by Rich and Coughlin and Lacombe provide methodological guidance on identifying and projecting the number and location of entry-level jobs.[85] Engineering analysis of a proposed facility would allow one to determine the employers that will be displaced, and conventional economic impact analysis would allow one to estimate the effects of the transport investment on jobs.[86]

- *Displacement of persons from residential units*.

The elimination of housing opportunities due to acquisition of right-of-way and facility construction is a serious adverse effect that may not be entirely mitigated with relocation assistance. Engineering analysis of a proposed facility would allow one to determine the number of destroyed housing units and/or number of displaced persons.

- *Isolation, exclusion, or separation of minority or low-income persons within a given community or from the broader community*.

The Ohio guidelines recommend measuring isolation by determining the reduction in the number of roads that provide ingress and egress and by determining travel time to schools, churches, shops, etc. It is the impact in the American lexicon of environmental justice and just transportation that comes closest to social exclusion. For the many reasons adduced in the conceptual review, the specific indicators recommended in the Ohio guidelines cannot adequately summarize the influence of transport on social exclusion.

Because of the obvious importance of mobility and access to highly-valued destinations such as employment centers, all environmental justice assessments and related guidelines pertaining to regional transport plans (transport strategies) use some measure of accessibility. They measure accessibility either according to the user-benefits approach developed within random-utility travel demand models (consumer surplus by income class) or with attraction-accessibility measures. The most common indicator of the latter is access to employment centers, which, for example, is measured by the Southern California Association of Governments as the percent of jobs in the region within 30 minutes of travel by auto, all forms of transit, or transit other than express bus and rail—reported separately by income class, mode, ethnicity (Hispanic), and race (Black).

The unique advantage of consumer surplus is that it is a monetary measure. Therefore only the consumer surplus of a proposed transport investment, but none of the other measures of transport performance, can inform a cost-benefit analysis of the investment, including, in particular, the distribution of benefits and costs. The survey reveals that an important disadvantage of consumer surplus is that stakeholders may object, as they did in Southern California, to making assumptions about different groups' value of time, which is essential because consumer surplus cannot be quantified without capturing income effects. Another disadvantage is that transport demand models are disaggregated by income, race, or ethnicity, but those characteristics have not been demonstrated to be strongly correlated with social exclusion. Another is its highly technical and abstract nature and hence the difficulty it poses for communication with socially-excluded persons. The most important disadvantage is that it does not provide insight into specifically how a transport investment may affect the ability of

[85] Rich, Michael J. and Coughlin, Joseph. "The Spatial Distribution of Economic Opportunities: Access and Accessibility Issues for Welfare in Metropolitan Atlanta." Atlanta: Emory University, March 28, 1998.
Lacombe, Annalyn. *Welfare Reform and Access to Jobs in Boston*. BTS98-A-02. Washington: U.S., Department of Transportation, Bureau of Transportation Statistics, 1998.

[86] Weisbrod, Glen and Weisbrod, Burton. *Assessing the Economic Impact of Transportation Projects: How to Choose the Appropriate Technique for Your Project*. Transportation Research Circular no. 477. Washington: Transportation Research Board, 1997.

socially-excluded persons to pursue coping strategies, knowledge of which is essential to understanding the contribution of transport to social exclusion. Nonetheless, when cost-benefit analysis is desired, the consumer surplus, disaggregated on the basis of a variable that correlates best with social-exclusionary status, of a transport investment must be measured; it is equally important to provide additional information on the specific dimensions of social exclusion (activity participation, well-being (safety, security, health, and affect), and coping strategies).

The cumulative-opportunities accessibility measures found in the survey are readily calculated and probably are easily understood by socially-excluded persons, but those measures fail to simulate the multi-stop activity patterns that are an essential component of socially-excluded persons' coping strategies. The conceptual review reached the conclusion that transport modelling must represent the search behaviour that is an essential coping strategy for socially excluded persons and hence must go beyond the simplistic modelling of proximity to transit and employment accessibility that is predicated on single-stop trips instead of trip chains.

At least three measures of multistop accessibility have been proposed in the transport research literature: the "linked-trip accessibility" measure developed by Richardson and Young;[87] the multistop, multipurpose measure of accessibility ("MP method") developed by Arentze et al.;[88] and, most recently, the "space-time accessibility measures" (STAMs) developed by Miller and Wu.[89] The latter two measures have been implemented in common modelling platforms and therefore are of greatest interest.

The MP method defines accessibility as the minimum travel cost incurred over the course of a week to purchase a set of heterogeneous goods when the traveller may patronize multiple shops in any one trip. It is a type of attraction-accessibility measure and does not incorporate the coupling constraints imposed by the traveller's schedule. Arentze et al. have implemented the MP method as a procedure in TRANSCAD and have applied it to characterize the accessibility to retail shopping of the residential areas in Maastricht in the Netherlands. Because the MP method handles multistop, multipurpose trips, it simulates the search behavior—comparison shopping—that is an essential element in the coping strategies that socially-excluded persons use. The MP method has potential for realistically measuring access to food stores, which the conceptual review concluded is very difficult for excluded persons and an important component of exclusion. Experimentation with the MP method in an empirical setting is merited.

The STAMs define accessibility as the benefit accruing to a traveller of the opportunities at specific locations that may be accessed within the velocity constraints imposed by a transport system and the traveller's coupling constraints. The STAMs provide ratio of measures of accessibility, allowing meaningful interpersonal comparisons of access. They synthesize the three major approaches to measuring accessibility: Hägerstrand's constraints-based approach,

[87] Richardson, A. J. and Young, W. "A Measure of Linked-Trip Accessibility." *Transportation Planning and Technology*, 7 (1982): 73-82.
[88] Arentze, Theo A.; Borgers, Aloys W. J.; and Timmermans, Harry J. P. "Geographical Information Systems and the Measurement of Accessibility in the Context of Multipurpose Travel: A New Approach." *Geographical Systems* 1 (1994): 87-102.
[89] Miller, Harvey J. and Wu, Yi-Hwa. "GIS Software for Measuring Space-Time Accessibility in Transportation Planning and Analysis." *GeoInformatica*, 4 (2000): 141-159. (http://www.geog.utah.edu/~hmiller/papers/GIS-STAM_software_paper.pdf)

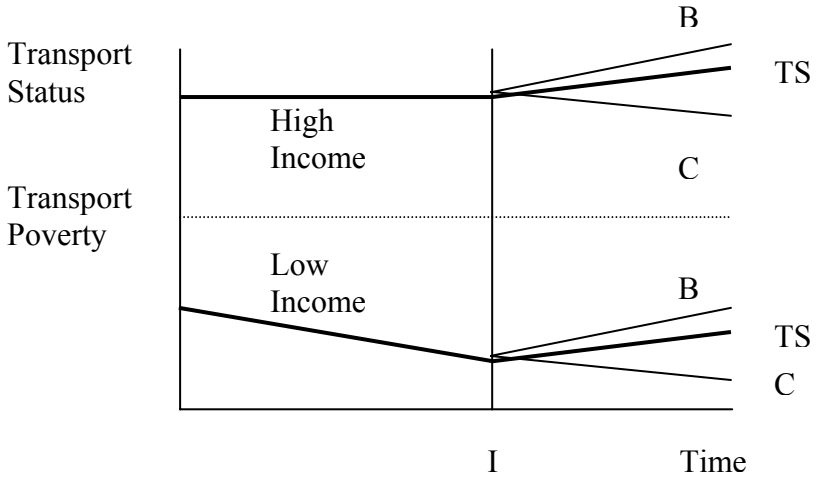
attraction-accessibility measures such as the cumulative-opportunities measure of accessibility, and random-utility travel demand models.[90] Miller and Wu have developed GIS software for ArcInfo that calculates STAMs and generates coverages showing the accessible places for trip chains with three stops, two mandatory activities, and one discretionary activity; an example of such a trip chain is the journey from home to work with shopping in between which must be made in three hours or less. At this time, the implementation of STAMs does not encompass multiple travellers and activity schedules. Nonetheless, experimentation with STAMs is merited because they are elegant tools, for example, for measuring the accessibility of a particular residential location to a particular employment center when the traveller makes an intermediate stop (such as daycare) and, obversely, for identifying all residential locations with "acceptable" accessibility based on stopping at a daycare center during travel to a particular employment center.

If appraisals of the effect of transport strategies or plans on socially-excluded persons were to follow the basic pattern of environmental justice assessments, the appraisal would estimate only the incremental change in the transport status of those persons. This focus on incremental concern, and the implied inattention to historical context, has been criticized by the Environmental Justice Coalition in Atlanta because it may obscure the most important effect of the transport investment: whether it will achieve just transport for low-income African-Americans or, in the language of social exclusion, whether it will end their transport poverty. This issue is another kind of question about the scope of analysis.

The following figure represents the ahistorical, context-free approach characteristic of environmental justice assessments as a comparison of two derivatives (indicated by the slopes of line segments labelled with "C"): the adverse impacts (reduction in transport status) borne by the high-income population and the adverse impacts borne by the low-income population after an investment made at time I. The derivatives are equal and the assessment would conclude that the investment would not inequitably favor the high-income population. However accurate, the assessment is incomplete because it fails to observe that the investment would not end transport poverty because the transport status (TS) of the low-income population, including both costs (C) and benefits (B), would still be below the poverty threshold. None of the surveyed environmental justice assessments work with a concept of transport poverty and, with only one exception (Atlanta), none present historical information on transport status. Without contextual information, evaluation of the equity of a transport strategy or plan is incomplete.

Context matters. Appraisals should describe the historical transport status of socially-excluded persons and estimate the incremental change in status due to the investment under consideration, determining whether they experience transport poverty before and after the investment. Although an obvious point, it is nonetheless worth mentioning that the appraisal process must be grounded in an operational concept of transport poverty.

[90] Miller and Wu, "GIS Software for Measuring Space-Time Accessibility."



Involvement of the Populations of Concern in the Appraisal Process

The processes of social exclusion operate in the political arena and, consequently, token or placative processes for public participation in transport planning intensify social exclusion. Lane et al. indirectly make that point in connection with an observation on the limitation on quantitative methods and the ensuing need for public participation in the planning process.

Despite the strides made toward quantifying environmental justice impacts, problems with evaluating qualitative environmental justice effects of projects (community cohesion, quality of life, community values, and other social effects) remain. Most often, these are the contested issues and the issues that are most laborious and expensive to evaluate. Case-study databases are an answer to this type of impact projection; however, further analysis is needed to develop a list of parameters that should be investigated for such impact projections. Studies that investigate the effectiveness of various public involvement methods for determining community values and goals within the framework of environmental justice analyses would also be of great benefit.[91]

In the context of the contribution of transport to social exclusion, public participation in the appraisal process would be invaluable for obtaining information on the effect of an investment on neighbourhood aesthetics and information on the destinations, trip chains, and tours that are most important and on which information is needed to most meaningfully evaluate accessibility. To avoid reinforcing social exclusion in the appraisal process, the technical analysts should work with socially-excluded persons on the design of the appraisal and development of a communication strategy about the appraisal.

Public participation is also essential to the process of determining whether a transport strategy or plan is equitable because the making of such judgments requires the discovery of "local" and thus context-dependent principles of equity. H. Peyton Young makes the distinction between "distributive justice in the large, that is, with the question of what constitutes a just social order," and "distributive justice in the small, that is, how institutions divide specific types of benefits and burdens."[92] The varied attempts to operationally define environmental justice found in the survey, and the absence of attempts to apply the classical

[91] Lane et al., "Wilmington Bypass," p. 138.
[92] Young, H. Peyton. *Equity in Theory and Practice*, p. 6. Princeton, NJ: Princeton University Press, 1994.

principles of justice,[93] provide evidence that just transport is a kind of allocation problem that is solved by principles of distributive justice "in the small."

The apposite local principles of justice emerge only through the dialogue and conflict of the persons in the vicinity of the transport strategy or plan.

The key to resolving a distributive bargain is not to make self-serving demands, but to make a proposal that the *others* find plausible and justifiable. This is precisely where equity arguments come in: they *coordinate* the expectations of the bargainers by establishing a plausible basis for the agreement….Equity principles are the *instruments* that people use to resolve distributive bargains.[94]

Recommendations

The American experience with modelling the impacts of transport strategies and plans on transport equity provides many insights into the methodology that should be used in the United Kingdom to assess the contribution of transport to social exclusion and determine the equity of the distribution of the benefits and costs of transport strategies and plans. The methodological recommendations drawn from the survey of environmental justice pertain to all the basic technical components of the transport appraisal process. The following list synopsizes the recommendations.

- Characterizations of exposure to carbon monoxide and particulate matter require a very small geographical unit of analysis.
- Sensitivity or uncertainty analysis should be conducted to determine the robustness of the findings of an appraisal:
    - with respect to the geographical unit of analysis,
    - when the appraisal relies on population characteristics that cannot be unambiguously defined,
    - when the appraisal uses statistical procedures to estimate population characteristics,
    - with respect to the residential location of populations of interest.
- Use cluster analysis and historical data to identify the residential location of populations of interest.
- For corridor studies, the domain of the reference population should be the metropolitan area that contains the project.
- The measures and thresholds in *GMMS* for noise and local air pollution are germane, although emissions of diesel particulate matter should also be quantified.
- Multiple types of social impact recognized in environmental justice assessments are germane to appraisals of the contribution of transport to social exclusion. Those impacts and the appropriate quantitative indicators are the following.
    - Disruption of public outdoor recreational sites.
        - Number of parks, gardens, and soccer fields.
        - Number of sites with annoying traffic noise.
    - Diminution of aesthetic values.

[93] The classical principles are the difference principle (Rawls), greatest good principle (Bentham), and the proportionality principle (Aristotle).
[94] Young, *Equity*, p. 18. Emphasis in original. Footnote omitted.

        - Renderings and/or computer-aided visualization/simulation techniques, coupled with preference surveys to elicit quantitative information on stakeholders' attitudes toward the aesthetics of facilities.
    - Disruption of community cohesion.
        - Severance, measured according to the guidance in *GMMS*.
    - Disruption of availability of public and private facilities and services.
        - Accessibility to public and private facilities and services (multistop measure preferred).
    - Adverse employment effects.
        - Accessibility to employers (multistop measure preferred).
        - Reduction in the number of entry-level jobs.
    - Displacement of socially-excluded persons from residential units.
        - Number of destroyed housing units and/or number of displaced persons.
- When cost-benefit analysis is desired, the consumer surplus, disaggregated on the basis of a variable that correlates best with social-exclusionary status, of a transport investment must be measured; it is equally important to provide additional information on the specific dimensions of social exclusion (activity participation, well-being (safety, security, health, and affect), and coping strategies).
- The method developed by Arentze et al. to measure accessibility in the context of multipurpose travel (MP method) simulates the search behavior—comparison shopping—that is an essential element in the coping strategies that socially-excluded persons use. The MP method has potential for realistically measuring access to food stores, which the conceptual review concluded is very difficult for excluded persons and an important component of exclusion. Experimentation with the MP method in an empirical setting is merited.
- Experimentation with the space-time accessibility measures developed by Miller and Wu is merited because they are elegant tools for measuring the accessibility of a particular residential location to a particular employment center when the traveller makes an intermediate stop (such as daycare) and, obversely, for portraying all residential locations with "high" accessibility based on stopping at a daycare center during travel to a particular employment center.
- Appraisals should describe the transport status of socially-excluded persons and estimate the incremental change in status, determining whether they experience transport poverty before and after the investment. Although an obvious point, it is nonetheless worth mentioning that the appraisal process must be grounded in an operational concept of transport poverty.
- To avoid reinforcing social exclusion in the appraisal process, the technical analysts should work with socially-excluded persons on the design of the appraisal and development of a communication strategy about the appraisal. Public participation is also essential to the process of determining whether a transport strategy or plan is equitable.

Several performance measures highlighted in the recommendations may be applied now without, it would seem, inordinately increasing the resources devoted to transport appraisal while still providing valuable information on the impacts of transport on social exclusion. The Southern California Association of Governments' equity assessment represents the current best-practice characterization of access within the transport system. It uses trip-based isochronal measures of accessibility to employers, and trip-based, isochronal, cumulative-

opportunities measures of accessibility to employers, essential services, and retail shopping.[95] Access is measured separately by income class, race/ethnicity, and mode of travel for each Traffic Analysis Zone (TAZ) and the entire region. [96] A technical appendix to the Southern California Association of Governments' regional transport plan provides detailed information on the analytical procedures used in the accessibility evaluation.[97]

The Southern California Association of Governments' evaluation of accessibility is remarkable for the effort made to project racial/ethnic composition, employment opportunities (including entry-level jobs, which are assumed to be the only employment opportunities open to low- and middle-income persons), essential services, and retail shopping. The evaluation is also remarkable for the breadth of coverage of destinations and thus trip purposes, and segmentation by auto or transit travel. The conceptual review of the contribution of transport to social exclusion draws particular attention to the importance of generating information on accessibility for different trip purposes and understanding modal differentials in accessibility.

The accessibility evaluation produces fifteen suites of performance measures, which SCAG prepared for both the future base case and an alternative strategy.

1. Percent of commuters within a particular socioeconomic group who are projected to travel to work in 30 minutes or less by transit.
2. Number of commute trips that take 30 minutes or less by transit for each socioeconomic group.
3. Percent of commuters within a particular socioeconomic group who are projected to travel to work in 45 minutes or less by transit.
4. Number of commute trips that take 45 minutes or less by transit for each socioeconomic group.
5. Percent of commuters within a particular socioeconomic group who are projected to travel to work in 30 minutes or less by auto.
6. Number of commute trips that take 30 minutes or less by auto for each socioeconomic group.
7. Percent of employment opportunities (jobs) that are projected to be reached in 30 minutes or less by transit.
8. Percent of employment opportunities (jobs) that are projected to be reached in 45 minutes or less by transit.
9. Percent of employment opportunities (jobs) that are projected to be reached in 30 minutes or less by auto.
10. Percent of essential services that are projected to be reached in 30 minutes or less by transit.
11. Percent of essential services that are projected to be reached in 45 minutes or less by transit.
12. Percent of essential services that are projected to be reached in 30 minutes or less by auto.

[95] The essential service sectors are commercial banks, savings institutions, credit unions, personal service providers, automotive repair services, miscellaneous repair services, amusement and recreational services, health services, educational services, social services, religious organizations, private households, police protection, and fire protection.
[96] The socioeconomic categories are Hispanic, Black, other race/ethnicity, and low-, middle-, and high-income.
[97] Southern California Association of Governments, *Draft 1998 RTP: Technical Appendix: Issue #4: Equity - Distribution of Benefits from Transportation Investments Among Different Population Groups*.

13. Percent of retail shopping that is projected to be reached in 30 minutes or less by transit.
14. Percent of retail shopping that is projected to be reached in 45 minutes or less by transit.
15. Percent of retail shopping that is projected to be reached in 30 minutes or less by auto.

Those performance measures are probably easily understood by all stakeholders and probably are more meaningful to the public than weighted accessibility measures. Thematic maps illustrating the accessibility of selected neighborhoods would be helpful, especially for members of the public with limited ability to read English.

It is not clear how or whether SCAG accounted for the time taken to reach transit. To be most accurate, the measurement of accessibility should include both the time required to travel to the nearest transit stop (at both trip ends) and the time required to travel by transit. Accessibility should be measured separately for walk to transit and drive to transit.

The amount of information provided by SCAG may seem overwhelming, but it does provide comparative insights into the access within the transport system of persons who must use transit, of low-income populations, and of people of color. When the information is generated for the base case and an option under consideration, one can also compare the changes in accessibility that would be experienced by the different socioeconomic groups. For example, the transit enhancements in the alternative evaluated by SCAG increase the number of persons who may commute to work in 30 minutes by transit: 23 percent are low-income workers and 56 percent are high-income workers. Those distributional effects inform evaluative judgments about the equity of the benefits or damages generated by the transport option (relative to the base case).[98]

The new approach to appraisal of transport strategies and plans in the United Kingdom encompasses access to the transport system but not access within the transport system. The practical modelling techniques used by the Southern California Association of Governments to measure access within the transport system have the potential for significantly enhancing the ability of the NATA framework to encompass some of the most important aspects of the contribution of transport to social exclusion and to inform judgments about transport equity.

[98] It would be interesting to investigate empirically whether conclusions drawn about the equity of a transport strategy are sensitive to the use of trip-based or multistop measures of accessibility.