

**Matching networks to needs: Travel needs and the configuration and management of local
movement networks in South African cities**

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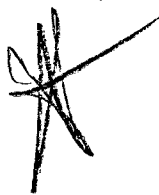
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MATCHING NETWORKS TO NEEDS

**Travel needs and the configuration and management
of local movement networks in South African cities**

Abstract



Motivated by disquiet that walking, as both a travel mode and as a segment of public transport trips, is not accommodated well in South African cities, this dissertation has two central aims. The first is to understand better the need for travel by non-motorised modes and within local areas. The second is to contribute to the improvement of local area movement network configuration and management practices. The research is primarily exploratory in nature and was conducted within a 'critical social science' paradigm – in which the research process was driven by a series of questions regarding the critical interrogation of these practices. It explores some of the implications for practice of a post-apartheid urban transport policy discourse that prioritises understanding travel need, managing road space, and accommodating public transport users and pedestrians. Reviews of literature, examination of codes of practice, and interviews with practitioners were conducted to trace the origins and nature of practices in the fields of travel analysis and local network planning and to investigate evidence of relationships between local network planning practices and improved local travel conditions. A household travel survey was administered in metropolitan Cape Town to gather data on travel behaviour across various income bands and in different residential locations. The survey employed an innovative activity-based method, with theoretical origins in time geography. With the use of computer-assisted personal interviewing technology, it involved members of 204 households recording their activity schedule over a 24-hour period. The data were analysed using conventional methods of filtered cross-tabulation, as well as time-space instruments. The research found, *inter alia*, that as a result of being routinely excluded or underestimated in past surveys, the importance of walking has not been fully understood. Walking would appear to be particularly important in satisfying the travel needs of middle- and low-income households, and walking distance findings would appear to refute assumptions regarding the introverted nature of pedestrian trips that underlie conventional local network configuration practices. In the light of these and other findings the dissertation argues for functionally 'fuzzy' local networks within which pedestrians and cyclists are accommodated on 'permeable' networks of footways, pathways, cycleways and shared roadways, while motor cars are accommodated on variously discontinuous roadway networks. The dissertation also argues for the strategic identification of local areas requiring priority attention, and the preparation of integrated local area plans incorporating co-ordinated and proactive pedestrian planning, bicycle planning and traffic calming.

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Summary

The topic of this dissertation relates to travel need and the configuration and management of local area movement networks in South African cities. It was motivated by three main concerns. The first was an observation that walking, as both a travel mode and as a segment of public transport trips, is not accommodated adequately. The second was that practices in the field of local network planning do not appear to be entirely consistent with a post-apartheid passenger transport policy that prioritises understanding travel need, managing road space, and accommodating public transport users and pedestrians. The third was that what constitutes appropriate practice in this field is subject to inter-disciplinary contestation. My primary aims in the dissertation are then:

- to investigate why travel by non-motorised modes and within local areas is not accommodated adequately in South African cities;
- to investigate whether practices in analysing travel need and configuring and managing local networks can be improved; and
- to explore the implications a new policy environment has for such practices.

To address these aims I investigate two main arenas of planning and management practice. The first of these arenas incorporates practices associated with the assessment of travel need, and the second incorporates practices associated with the design and management of local movement networks.

The research is primarily exploratory in nature, and was conducted within a ‘critical social science’ paradigm – in which the research process was driven by a series of questions regarding the critical interrogation of the arenas of practice mentioned above. Reviews of literature, examination of codes of practice, and interviews with practitioners were conducted to trace the origins and nature of practices in the fields of travel analysis and local network planning, and to investigate evidence of relationships between local network planning practices and improved local travel conditions. A household travel survey was administered in metropolitan Cape Town to gather data on travel behaviour across various income bands and in different residential locations. The survey employed an innovative activity-based method, with theoretical origins in time geography. This theoretical and analytical framework was selected on the grounds that it has been shown to lead to more accurate recall of local and non-motorised travel, and best enables an understanding of travel behaviour within the constraints of households’ daily lives. With the use of computer-assisted personal interviewing technology, the survey involved members of 204 households recording their activity schedule over a 24-hour period. I analysed the data using conventional methods of filtered cross-tabulation, as well as time-space instruments.

The dissertation is divided into six chapters. In *chapter 1* I introduce the motivation for, the aims of, and the method used to conduct the research, as outlined above. In *chapter 2* I review the development of methods of travel analysis and data collection internationally, identify which of these methods have been applied in South Africa, and discuss how travel need and behaviour has been represented as a result of their application. In the chapter I argue that the bulk of travel data collection and analysis methods applied in South Africa have been drawn from a stream of methods developed in the United States in the 1950s and 1960s in the context of a 'predict-and-provide' transport policy environment. While these methods – principally in the form of inter-zonal origin-destination surveys and aggregate four-step traffic forecasting models – have been refined and improved over time, by and large they remain, procedurally and substantively, the same as those first developed in the late 1950s in cities like Detroit and Chicago. They also remain centrally focused on the problem of traffic congestion, and the construction of highways in its alleviation. A focus on traffic congestion, together with the labour transportation requirements of urban apartheid, led to a focus on home-based work trips and morning peak periods in South African travel analysis, as a primary contributor to motorised trips during peak periods and the period when congestion is worst respectively. I contend that, as a result, little is currently understood of non-home-based, non-work, off-peak and non-motorised trip-making generally, and of how this behaviour varies across individuals and households in different situations. Of particular relevance to the focus of the dissertation, local travel – much of which is to non-work activities and by non-motorised modes – is thus either overlooked or poorly understood in travel analysis. I conclude that, as a consequence of the limited scope of past surveys, there are insufficient current data available with which to adequately understand the nature and relative extent of local travel behaviour. This necessitated the collection of primary data.

In *chapter 3* I set out the objectives of the primary research into travel needs and behaviour in Cape Town, describe the research method and theoretical framework used in conducting this research, and report on findings. My analysis of the primary data shows that travel needs diverge widely on the basis of a variety of financial, geographical, societal and demographic factors. Notwithstanding the relatively low confidence interval of the sample, my primary research indicates that income, as the primary determinant of private mobility, is the most significant variable in determining patterns of travel behaviour. The presence of children in the household, as well as neighbourhood form and location however, also have a significant impact on household travel behaviour, while age, gender and household responsibilities have a significant impact on personal travel. The data also indicate that the information gaps preventing a full understanding of the above diversity and complexity are large. Non-work and off-peak travel would appear to account for the majority of travel activity (80% and 54% respectively), and the focus on commutes and peaks in past surveys has therefore in all likelihood distorted perceptions of travel needs and patterns. In particular, as a result of being routinely excluded or underestimated in past surveys, the importance of walking trips – in terms of their roles in satisfying travel needs and in analysing road safety problems – has not been fully understood. Despite accounting for a relatively small share of commuter modal split, main mode walking trips would

appear to be particularly important in satisfying the travel needs of middle- and low-income households (accounting for 43% and 61% of all trip main mode use respectively). I argue that walking, more than any other mode in South African cities, rivals the motor car as a means of transportation. At best this exclusion or underestimation of walking trips in past surveys has introduced a routine bias in the way in which the urban transportation problem has been framed and has skewed the allocation of transport planning resources away from local network issues. At worst it has led to neglect in the planning and design of infrastructure improvement for the poor and vulnerable road users.

In *chapter 4* I then review the evolution of approaches to local network configuration and management internationally, describe South African practices, and discuss how these have been influenced by international approaches. I argue, in the case of network configuration, that South African codes of practice have promoted 'closed' 1.5-2 km square cells of collector and access road networks contained within delimiting grids of limited access arterials and freeways, which are supposedly introverted in terms of land use distribution and pedestrian movements. These practices have been drawn from British and American ideas concerning functional road hierarchies and through-traffic elimination developed in the 1940s and 1960s, and from ideas about introverted pedestrian movement developed in the 1920s and 1930s. In the absence of data, South African practices have shared, even if implicitly, the underlying assumptions of these ideas regarding the inevitability of universal access to private transport and the introverted or localised nature of walking trips. In reality, South African car ownership was and is significantly lower, reliance on non-motorised travel significantly greater, walking trip lengths considerably longer, and pedestrian road accident fatalities considerably higher. My data indicate that mean (main mode) walking trip lengths amongst low-income households exceed recommended parallel arterial frequencies (± 2.8 km vs. 1.5-2 km), which implies that pedestrians will often have to cross such arterial routes with concomitant road accident dangers. I argue that insufficient consideration has been given to how travel needs and behaviours differ in the local context. The evolution of South African codes of practice outlined in the chapter illustrates how the accommodation of the travel needs of low-income groups was essentially considered within the basic framework of a local network configuration idea developed out of a consideration of the travel needs of middle- and high-income groups.

In the case of network management I contend that South African practices have taken the form of procedures through which hazardous or inefficient locations within road networks are identified and warrants for pedestrian and bicycle facilities, transport system management and traffic calming measures are assessed, as well as access management and traffic impact assessment mitigation associated with new land use development applications. These practices have also by and large been drawn from the United States and United Kingdom. My review of South African codes of practice illustrates that, with the exception of those associated with transport system management procedures, they have tended to focus on the geometrics of paths and crossings, and on the circumstances under which different types of retrofitting management measures might be warranted at specific locations.

Recommended management practices as a result, and as a general rule, do not undertake causal analyses of problems beyond localised traffic engineering assessment of ‘road environment’ factors like driver visibility, skid resistance, crossing facilities and guardrails. Analytical questions associated with non-motorised trip purposes, timing, origin and destination, and route selection for instance, tend to be omitted, with the consequence that not much is said in the codes about important issues like land use distribution and how this gives rise to particular patterns of non-motorised trip-making, and pedestrian and bicycle network connectivity and the impact of parallel arterial frequency on severance. I argue that local network management practices have tended to be site-specific (in a spatial or network sense) and reactive (in the sense that management measures are considered on the basis of public request or hazardous location identification) – commonly described as a ‘black spot approach’.

Having established that local travel is of great importance in South African cities, and that local network planning practices have been imported without rigorous consideration of contextual difference, in *chapter 5* I go on to review evidence of relationships between local network planning practices and improved conditions of travel in local areas. I argue that the relationship between local network configuration and management practices and improved local travel conditions is neither always direct nor always consistent, and quite unremarkably, research has shown that numerous other systemic urban, social and economic factors influence this relationship significantly. Nevertheless, the weight of evidence indicates that grid-like ‘neo-traditional’ network configurations improve levels of accessibility to local destinations, and that despite generating more local trips, this accessibility does, in many if not most cases at least, reduce total vehicle kilometres travelled and increase walking and public transport share of modal split. The evidence also indicates that networks can be configured to prioritise direct and multi-directional pedestrian movement without compromising traffic congestion, and in fact, with the caveat that large volumes of extraneous traffic are avoided, ‘neo-traditional’ networks can offer real benefits in diffusing traffic and reducing volumes on arterial routes. With regard to road safety, studies that have included all accidents in network comparisons indicate quite conclusively that limited access networks have major benefits over gridiron networks, whereas studies that have included only injury or pedestrian accident data indicate far less benefit and in some instances in fact a greater accident rate. Studies of pedestrian accidents in South Africa show that distributors, as opposed to collectors and residential roads, represent the most hazardous locations for pedestrians, and, given higher levels of walking, are more important as a focus of pedestrian planning than in the developed countries from which most network configuration practices originate.

The reviewed evidence also suggests that, if an objective in network configuration and management is to manage travel demand and encourage mode switching – as indeed it should be – it needs to be included as one of a suite of co-ordinated measures with this objective. On its own, local movement network configuration and management can be expected to yield results which, at best, will be inconsistent. In the chapter I also review precedent for co-ordinated and proactive local network management. This review illustrates that there are practices elsewhere to draw from in the

development of local network management practices in South Africa that analyse problems on an area-wide basis, and that apply network management measures across local areas systemically and proactively.

I conclude the dissertation in *chapter 6* by exploring the possibility of a better match between travels needs and the configuration and management of local networks in South African cities through improved travel analysis and local network planning practices. With regard to the improvement of travel analysis practices, I argue that empirical observation aimed at improving understanding of current travel need is important and necessary, that this analysis needs to be inclusive of all travel undertaken by all people, and that travel patterns need to be observed over time in order to identify adaptations in behaviour. Of particular importance to my research motivation, walking needs to be analysed as a travel mode in its own right. To ensure consistency and to enable comparisons between geographical areas, it would make sense for surveys that collect these data to be conducted nationally, at the same time, using the same instrument. Such surveys could take the form of repeated cross-sectional surveys or panels. I argue that activity-based methods offer a suitable analytical framework, but that random household travel surveys are unable to provide adequate data on the needs of all travellers or on all trip-making activities. Other complementary surveys methods should therefore also be used.

I argue that improved network configuration practices will require a realignment of priorities in which networks are designed first to meet the travel needs of pedestrians, bicycles, public transport users and public transport operators, and then to accommodate motor cars. I contend that reorienting network configuration practices around non-motorised modes, not cars, will require the conceptualisation of local area movement infrastructure as topological grids of public rights-of-way, as opposed to road networks conceived simply in terms of motorised travel needs. Within such topological public right-of-way grids pedestrians and cyclists would be accommodated on a continuous network of footways, pathways, cycleways and shared roadways, while motor cars would be accommodated on a network of roadways deliberately designed to be discontinuous where necessary. The accommodation of inter- as well as intra-neighbourhood walking trips, will require a further conceptual shift from functionally introverted or 'cellular' neighbourhoods, to functionally 'fuzzy' and permeable neighbourhoods bounded by, not centred around, commercial strips and town centres. The pedestrian and bicycle networks of adjacent neighbourhoods therefore need to interconnect, and when unavoidably severed by high speed arterials or railways and warranted by pedestrian desire lines and volumes, connected by grade-separated crossing facilities.

I argue that improved network management practices will require co-ordinated and proactive pedestrian planning, bicycle planning and traffic calming, integrated within wider spatial development and travel demand management frameworks, and informed by analytical techniques that go beyond hazardous road accident, or 'black spot', identification. The planning frameworks emerging from

recent legislative change in South Africa however, focus almost exclusively on the metropolitan scale and provide little indication of how such co-ordinated and integrated practices might be implemented, and by whom. It is likely that resource limitations will prevent entire metropolitan areas from being covered by local plans. Local areas, and their geographical extents, will therefore need to be identified and prioritised strategically. Within such a strategic and integrated local planning framework, local transport issues will need to be central to the content of local area plans, as well as to the strategic identification of those parts of cities requiring localised integrated planning attention.

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Chapter 1

Introduction

1.1 BACKGROUND AND MOTIVATION

The transition to democratic government in South Africa in 1994 precipitated a perhaps unprecedented period of critical reflection across all disciplines and policy sectors associated with the planning and management of urban settlements, and the fields of town planning, transport planning and traffic engineering were no exception. This critical reflection led to the reformulation of policies, strategies and codes of practice across the fields of urban development and transportation, and it was a number of observations and issues that arose in my personal interaction with some of these processes in 1998 that motivated the research presented in this dissertation.¹ Primary among them was an observation that movement on foot is not accommodated particularly well in neighbourhood, or local area, planning in general, and in the configuration and management of local area transport systems more specifically.

*Back to
code of
practice*

The characteristics of walking trips in South African cities will be the subject of considerable investigation and discussion later in this dissertation. Suffice to note here that walking as a travel mode is widespread, accounts for large amounts of travel time, and the distances covered by pedestrians are considerably longer than those in cities of the developed world. That travel by foot is not accommodated particularly well in South African cities is fairly clearly evidenced by the efforts of pedestrians, and risks they take, to shorten their walking trips to destination activities.

The efforts pedestrians make to minimise their travel distance and time are apparent along freeways and arterials in and around metropolitan Cape Town for instance – in the form of breakthroughs in perimeter fencing at regular intervals to facilitate at-grade crossing, informal footpaths leading across roadways, and the assembly of makeshift stairs to climb over median barriers (de Beer and Davidson 2000, Stander *et al* 1997) (see figure 1.1).

¹ More specifically, I was involved as a consultant in the revision of the so-called 'new red book', the National Department of Housing's code of practice on site layout and service provision (see section 4.3.7). Together with Vanessa Watson and Paul Mann, I prepared the section of the code dealing with movement networks. In the process of finalising this section I became involved in an extended exchange with a subcommittee of the Committee of Land Transport Officials responsible for preparing codes of practices on transport planning. In this exchange it became clear that considerable debate existed on the appropriateness of different transport systems in the South African context, and that further research would be required if this debate was to be resolved.

Figure 1.1 *Pedestrian crossing activity along the N2 freeway in Cape Town*

fencing breakthrough and informal footpath



makeshift stairs to climb median barrier



children climbing over the median barrier to cross the freeway



continued overleaf ...



The risks pedestrians take to minimise their travel distance are reflected in the number and severity of road accidents involving pedestrians. National data on road accident fatalities between 1985 and 1995 indicate that between 9 000 and 11 000 people are killed on South Africa's roads every year, of which an alarming 40-48% are pedestrians (see figure 1.2). With the caveat that definitions and data collection methods differ in different countries, comparisons of road accident fatality rates across international cities indicate that rates in South African cities are particularly severe, and possibly the worst in the world (see figure 1.3). Data from 1997 to 1999 in the Cape Metropolitan Area (CMA) – the geographical focus of empirical research later in this dissertation – indicate a larger proportion (around 54-56%) of road accident fatalities are pedestrians (CMC 2000b). Figure 1.3 indicates that the CMA's pedestrian road accident fatality rate is in fact greater than the total fatality rates of most of the world cities for which data are available.

more current data

Figure 1.2 National road accident fatalities by user group: 1985-1995

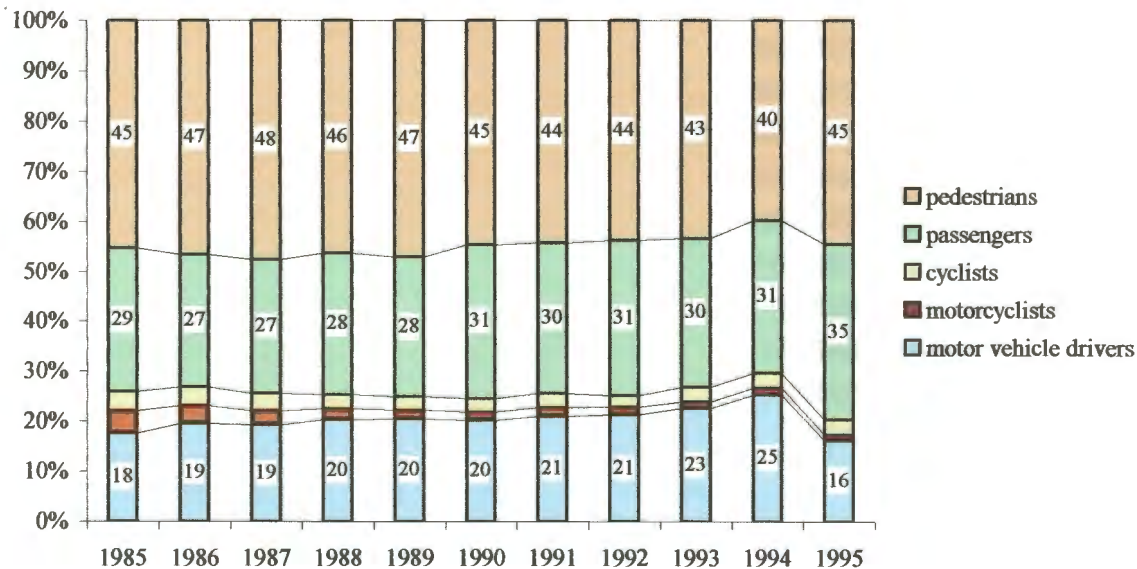
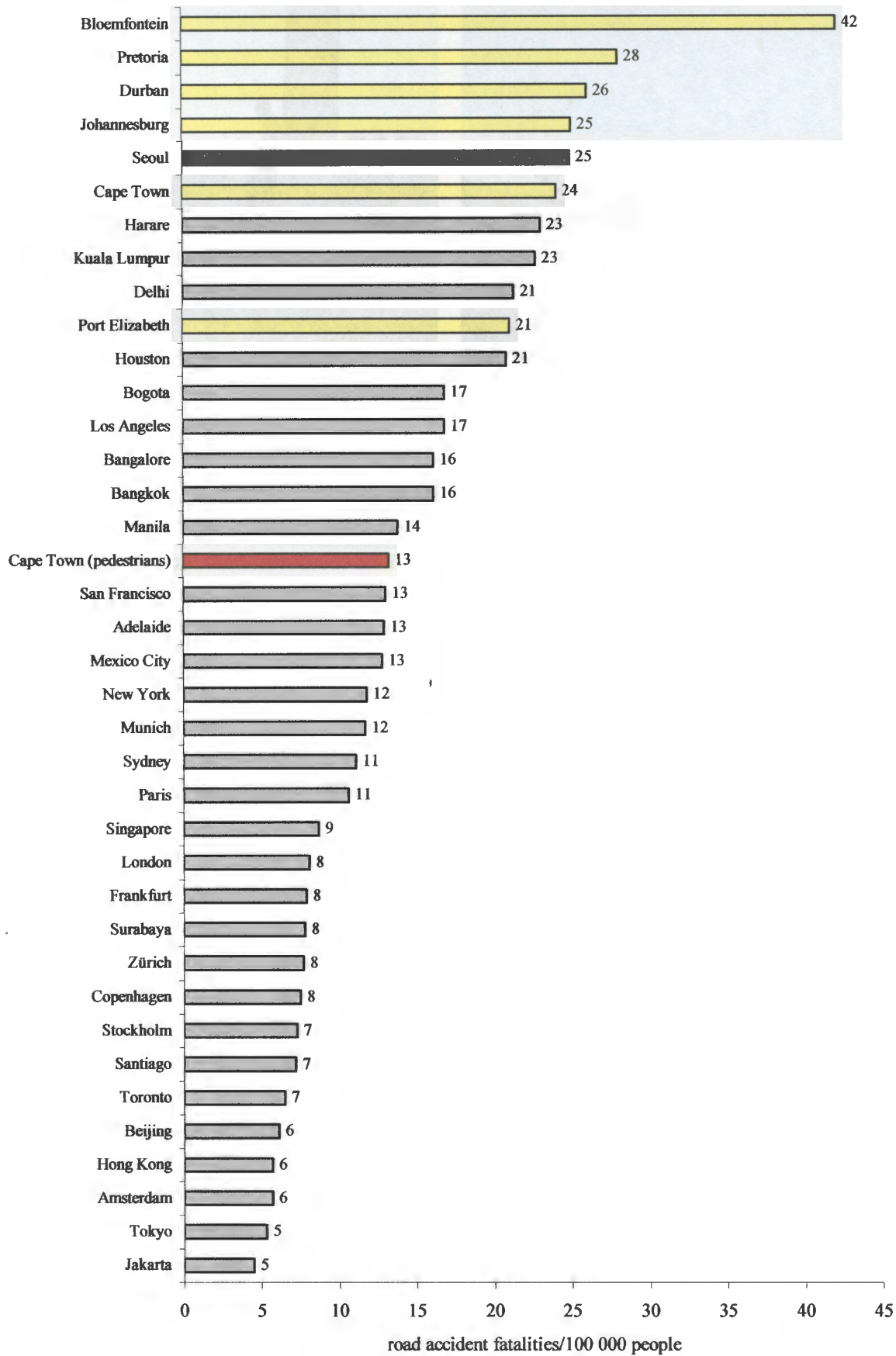
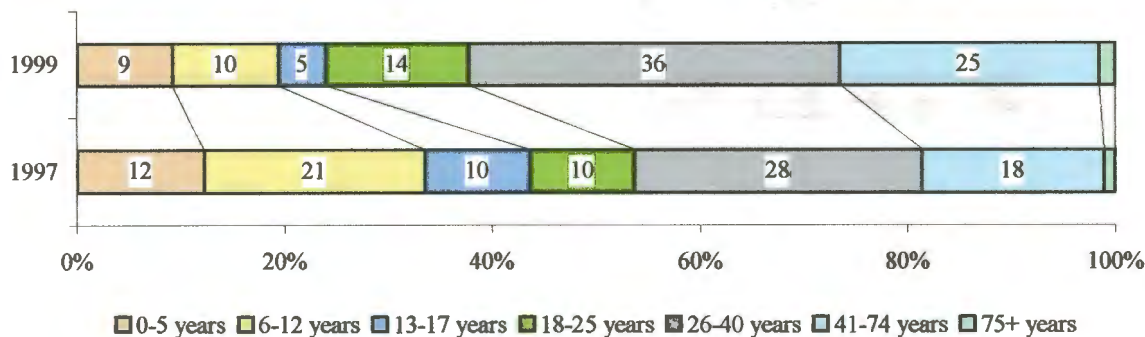


Figure 1.3 *International comparisons of city road accident fatality rates*



Even more alarming perhaps is the proportion of child pedestrian fatalities and injuries. National data for the period October to December in 1997 indicate that some 25% of pedestrian fatalities are children aged 16 years or less (NDoT *Arrive Alive* website), a proportion fairly consistent with 1998 data for the urban areas of the Western Cape which indicate that around 21% of pedestrian fatalities are children aged 14 years or less (de Beer 2000). Data from 1997 and 1999 in the CMA indicate around 19-33% of pedestrian fatalities and 31-38% of pedestrian injuries are children aged 12 years or less (and 24-43% and 41%-52% of pedestrian fatalities and injuries respectively, are children aged 17 years or less) (see figures 1.4 and 1.5). These figures are disproportionate with the total CMA population age distribution – 1996 census data indicate that 25% of the population are 12 years old or less, and 34% are 17 years old or less.

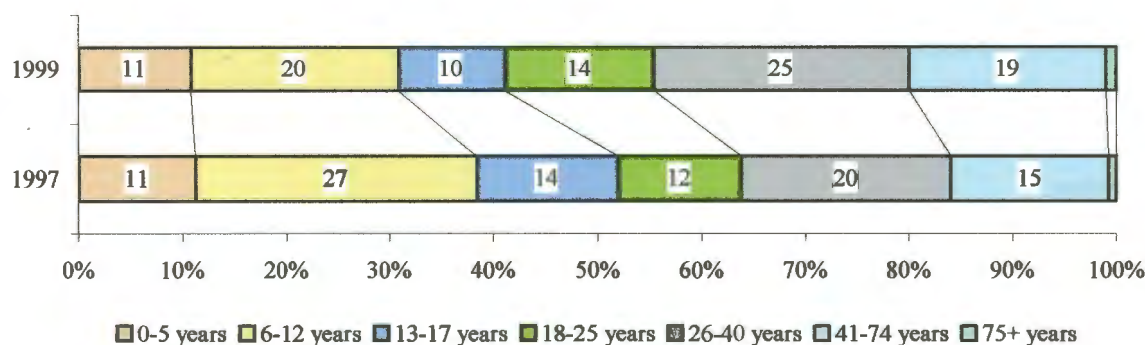
Figure 1.4 CMA pedestrian road accident fatalities by known age: 1997-1999



Source: CMC 1999:table 7, 2000b:34

Note: A fatal injury is defined as an injury that causes death, either immediately or subsequently, but not later than six days after the accident. (CMC 2000:5)

Figure 1.5 CMA pedestrian road accident injuries by known age: 1997-1999



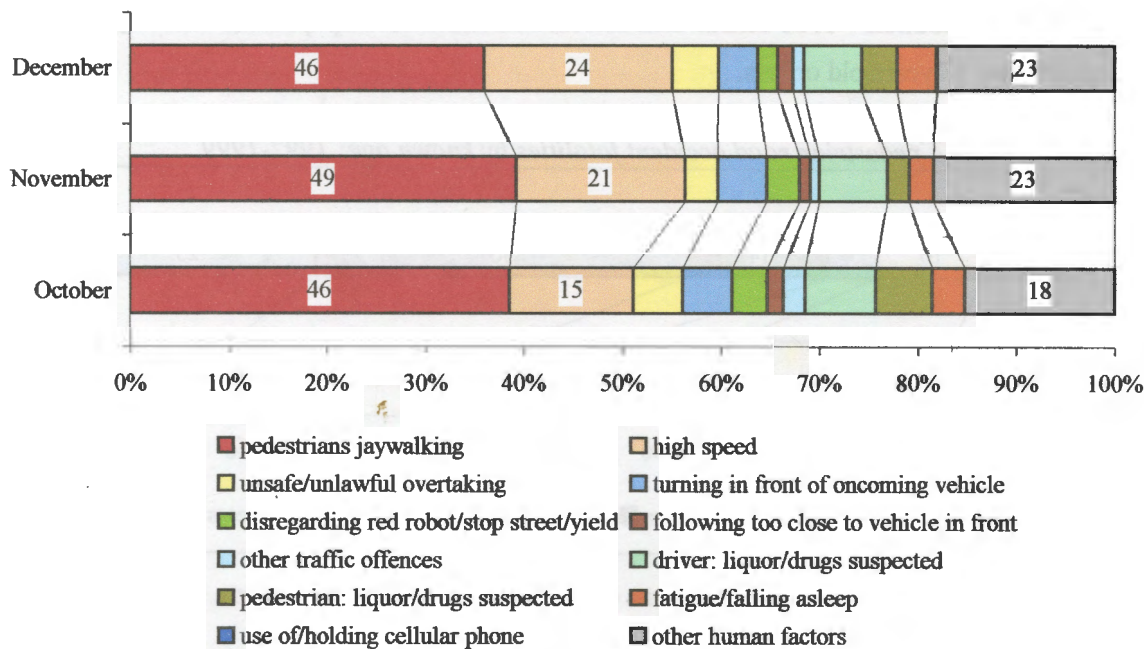
Source: CMC 1999:table 7, 2000b:34

Note: These data include both serious and slight injuries. Serious injuries are defined as including fractures, crushings, concussion, internal injuries, severe cuts and lacerations, severe shock requiring medical treatment, and any other injuries which necessitate hospitalisation or confinement to bed. Slight injuries include cuts and bruises, sprains and light shock not requiring hospitalisation. (CMC 2000b:5)

The factors contributing to fatal road accidents are typically broken into vehicle defects (e.g. tyre bursts), the road environment (e.g. poor visibility), and human factors (e.g. drunken driving). Of these, human factors are the most significant – accounting for around 75% of fatal accident contributing factors – vehicle defects and the road environment appear to be relatively less important, accounting

for about 17% and 8% of fatal accident contributing factors respectively (NDoT *Arrive Alive* on-line 1997/98 data). National data from 1997 indicate that pedestrians crossing the road without the use of crossing facilities account for between 46% and 49% of the human factors that contribute to fatal accidents (i.e. in the region of 35-37% of all contributing factors) (see figure 1.6). A simple matter of crossing the street is therefore the single most important factor causing road accident fatalities in South Africa.

Figure 1.6 *Human factors contributing to fatal national road accidents: 1997*



Source: NDoT *Arrive Alive* website

In addition to the apparent mismatch between user needs and local area transport systems, the research was also motivated by a changing urban transport policy environment in which local area movement networks and non-motorised transportation have either explicitly, or by implication, assumed greater importance.

The changes in South African transport policy that followed the transition to democracy represent something of a watershed. Prior to the democratic transition, urban passenger transport policy can be broken into two main periods². The first period occurred between the late 1920s and the late 1940s, and was concerned primarily with the regulation of the transport industry and the protection of state-provided transport services (mainly in the form of the South African Railways and Harbours Administration). The second period occurred between the early 1950s and the late 1980s, and was concerned with the deregulation of the public transport industry to accommodate emerging informal minibus-taxi operators, and the subsidisation of the expanded passenger transport services necessitated by the imposition of apartheid. While not an explicit focus of transport policy during these periods, the

² For fuller discussion on urban passenger transport policy change in South Africa, see Cameron and Maeder 1995, Khosa 1995, Smith *et al* 1994, and Behrens and Wilkinson 2001.

approach adopted to traffic growth and road capacity expansion – a relationship that has defined transport policy watersheds in other parts of the world – was that of increasing road capacity supply to match forecast traffic demand, and in doing so, of facilitating increased motor car use. This policy approach, which was dominant internationally over this time, is referred to in the British literature as ‘predict-and-provide’ (Goodwin 1997, Owens 1995).

After the transition to democracy in the mid-1990s, South African urban passenger transport policy has been concerned with the introduction of ‘regulated competition’ with respect to public transportation (i.e. operator competition for a route rather than on a route) and the devolution of planning and management powers and functions to lower levels of government, while addressing issues of more equitable access to transport services in the post-apartheid context. With regard to the position adopted to traffic growth and road capacity expansion, the new policy environment – in the form of the White Paper of 1996, the *Moving South Africa* 20-year strategy of 1999 and the *National Land Transport Transition Act (No. 22)* of 2000 – represents a discursive shift from the earlier supply-side or ‘predict-and-provide’ approach to a demand-side or ‘demand management’ approach. Some of the key directives of the new policy environment include: the prioritisation of customer needs; the promotion of public transport over private car travel; the development of high density transport corridors; the optimal deployment of public transport modes to meet customer service requirements; the implementation of road space management in the form of a variety of charging and infrastructure measures; and the promotion of non-motorised transportation. Changed policy priorities thus necessitate that a new emphasis is placed on understanding the existing diversity of travel needs, travel demand management, and prioritising public transport users and pedestrians.

This policy watershed, while different in its circumstances, is not unique in international terms. The United Kingdom and the United States in particular underwent policy changes in the 1980s and 1990s that saw the emergence of travel demand and road space management measures, aimed at improving conditions for higher occupancy vehicles, public transport and pedestrians, as central to policy discourse. While there is a growing international literature on the disjunctures that have arisen as a result of the continued application, within the new policy environment, of a set of practices developed within past policy environments, and more specifically on the implications of policy change for local movement network configuration and management, these arenas of research have received very little attention in South Africa. Perhaps as a result of the concentration of transport planning capacity within metropolitan institutions, and of the particular transport planning requirements of the emergent legislation that focus on the metropolitan areas, in South Africa research into the implications that changed policy has for practice has been focused mainly at the metropolitan or city-wide scale. Little research has been undertaken in South Africa to investigate the implications the new policy environment has for local area transport planning practices, and certainly little consensus exists across disciplinary boundaries on what these might be.

Site layout, and the planning and design of movement networks as a part of this exercise, is a task that has been undertaken by professionals from various disciplines – including architects, urban designers, town planners, and civil and traffic engineers. As a result of the different philosophies and specialised concerns these disciplines have brought to bear on the task, it is arguably one of the most professionally contested arenas in the field of settlement planning, and at times very different perceptions on what represents appropriate practice have emerged. Two examples of such differences that I have often heard expressed by professionals in South Africa include the appropriateness of grid street patterns, and the appropriateness of access management policies. In the case of the former, I have often heard urban designers and planners argue the advantages of the grid in relation to ‘structuring’ urban space and accommodating change, while for many traffic engineers (as will be discussed later in chapter 4) this street pattern represents bad practice from the perspective of road safety. In the case of access management, similar disagreements exist between these two disciplines on the relative importance of, on the one hand, limiting interruptions to traffic flow and maintaining efficient traffic speeds along arterial routes, and on the other, creating linear ‘activity corridors’ with greater roadway and driveway accesses and mixed (motorised and non-motorised) traffic.

In summary then, three main aspirations motivated me to undertake this project. The first was a desire to contribute to the improvement of practices with regard to the planning and management of transport systems that fail to accommodate the needs of the poor and vulnerable. The second was a desire to examine the implications for practice of a changed policy environment. The third was a desire to reframe and clarify what seems to be at issue in the inter-disciplinary contestation referred to above, in the field of local movement network configuration and management.

1.2 AIM AND SCOPE OF THE DISSERTATION

Following on from these concerns then, the primary aims of the dissertation are:

- to investigate why travel by non-motorised modes and within local areas is not accommodated adequately in South African cities;
- to investigate whether practices in analysing travel need and configuring and managing local networks can be improved; and
- to explore the implications a new policy environment (that prioritises understanding travel need, managing road space, and accommodating public transport users and pedestrians) has for such practices.

To address the key research question articulated above it was necessary to investigate two main arenas of planning and management practice. The first of these arenas incorporates practices associated with

the assessment of travel need, and the second incorporates practices associated with the design and management of local movement networks.

Given the central importance that 'travel need', 'local travel' and 'local movement networks' assume in the dissertation it is important from the outset to provide definitions of these not unproblematic concepts.

I use the term 'travel need' quite simplistically to refer to the need for people to move from certain points in space to others, very often at prescribed times, in order to participate in a range of activities necessary for their sustained livelihood. Clearly some travel needs might be described as 'basic' – trips undertaken to acquire food or earn income for instance are essential to continued survival and are therefore in the same category of needs like sleep and safety. Other trips, like those to social and recreational activities, are less essential, and might be described as 'non-basic'. I do not however attempt to differentiate between these levels of travel need. For reasons that will become apparent later (in section 3.2.1), in my research I am interested in all travel undertaken by all people for all purposes. I also do not take into consideration those travel needs that are unfulfilled because the opportunity to undertake particular trips is denied the individual by a mobility impairment, a lack of resources, or an absence of transport services. As will be described in greater depth when discussing the objectives of my primary research (see section 3.2.2), I suggest that expressed travel behaviour provides a reasonable indication of the nature of relative travel need across different groups, but recognise the existence and importance of unexpressed travel need or 'latent demand'.

Regarding 'local travel', the current international literature has tended to define the geographical limits of a local 'neighbourhood', 'community', or 'village' (depending on the nomenclature) as a 5-10 minute, or (assuming a walking speed of 80 m/minute) a 400-800 m, maximum walking distance radius from a central public transport stop and/or neighbourhood centre. The extent of a 'local area', within which local trips are made and local road networks are configured, has therefore typically been defined as a roughly circular tract of land with a diameter of between 800 and 1 600 metres, and an area of between 50 and 200 hectares. This definition is embedded in the remarkably resilient town planning assumption that households can and do satisfy all their walking trip purposes within some form of local neighbourhood centre, which seems in turn to have led to the common practice amongst transport engineers of spacing intersecting grids of limited access arterials (the delimiters of local areas) at 1 500-2 000 m intervals (see figures 4.21 and 4.28).³ In South African cities however, as will be discussed later, average walking trip lengths amongst lower income groups are around 2 000 m, and it is not unusual for pedestrians to walk up to 4 000 m. The term 'local travel' is therefore used in this

³ In the review of South African codes of practice reported upon later (in chapter 4) I found no explicit rationale for this parallel arterial frequency. However, given that the minimum roadway or driveway intersection spacing required to maintain efficient traffic flow along arterials is typically considerably less than 1 500-2 000 m (around 500 m or less depending on the type of arterial and adjacent environment), I presume this practice was informed more by consideration of the pedestrian catchments that surround neighbourhood centres and a desire to avoid pedestrians crossing higher speed arterials to access them, than by a desire to avoid disruption of high speed traffic.

dissertation simply to refer to trips made to destination activities that are within walking distance of the point of origin (but not necessarily undertaken on foot), and for reasons that will become apparent later, the point of destination is defined as neither a public transport stop nor a neighbourhood centre and a quantitative specification of a local area is avoided. Thus defined, the 'local area' of a poorer community prepared to walk long distances would be larger than that of a wealthier community prepared to walk only short distances.

The term 'local movement network' is used then to refer to the links and junctions of fixed movement infrastructure that fall within 'public rights-of-way' or 'reserves' used for local travel (as well as obviously for a certain amount of through-movement). These links and junctions contain overlaid systems of 'ways' for different movement modes – including footways, roadways, pathways and cycleways. Importantly, the term movement network is used to refer to more than simply a network of local roads. This is another point that is returned to later.

It is also important from the outset to clarify the intended scope of application of my conclusions and recommendations regarding the nature of improved practices. My findings and recommendations are specific to the South African context. I leave any assessment of the relevance of this research to other parts of the 'developing world' to the reader. The populations of South African cities are at present characterised by their diverse array of household incomes and living conditions – ranging from the unemployed very poor living in high density informal settlements who extract a precarious living where they can from informal income generating activities, to the multiple car-owning very rich who live in expensive low density suburban housing, with a diversity of conditions in between. The stratification and clustering of the sample used in my primary research in Cape Town (see section 3.4.1) provides some indication of the range of conditions. Clearly the improvement of practices in the fields of local network configuration and management across this diversity of socio-economic and developmental situations will require the production of carefully considered codes of practice which specify to whom and to which type of development particular guidelines and standards apply. It is my intention to stop well short of the development of these kinds of highly specified codes of practice, and instead simply to develop a concept which offers a basic means of approaching the problem of how non-motorised travel needs can be accommodated adequately within movement networks. This concept (specified in section 6.3) might form the basis upon which more specific and detailed design guidelines and standards are developed at a later date. Clearly as poorer households depend more on non-motorised transportation than wealthier households, as will be illustrated later, this concept is directed at, but importantly is not exclusively relevant to, the needs of lower income groups.

Effecting changes in practice will however require more than simply the production of new design codes or management procedures. What might be regarded as best or appropriate practice at any point in time is influenced by decision-making power and political control in the offices of policy-makers,

professional practitioners, development assessors and financiers, and accordingly changes in practice are more possible at certain points in time than at others, as patterns of decision-making power and political control change. The analysis of the nature of this power and control, and of its influence, is an established field of study in its own right undertaken through complex theoretical and analytical frameworks. I will not endeavour to engage with this field or with these frameworks, beyond revisiting this issue in chapter 6 when I discuss the future research needs that are raised by my conclusions.

1.3 RESEARCH PROCESS

The literature on research method in the social sciences identifies three possible paradigms within which to conduct inquiry: 'positivism', 'critical social science' (or 'constructionism'), and 'interpretive social science' (see for instance Neuman 1997 and Terre Blanche and Durrheim 1999). Most previous research in the fields of travel analysis and transport planning has been conducted within the positivist paradigm. Positivist research assumes that human reactions to certain conditions are stable and law-like, and thus it searches for regularities in human behaviour. Legitimate knowledge of human behaviour is seen to be based on empirically observable and measurable facts, and the researcher is seen to be neutral or value-free in observing these facts. The emphasis on uncovering regularities (or 'social laws') is founded on a belief that the social sciences can and should be studied in the same way as the natural sciences. Consequently quantitative methods of inquiry have been imported from the natural sciences, and positivist social science methodology follows the same hypothetico-deductive route of constructing law-like explanations of reality through the testing of a hypothesis or hypotheses. Indeed, as will be discussed in the next chapter, some behavioural theory from the natural sciences has been used to explain and predict human actions as well (e.g. the gravity model of trip distribution).

Positivist social research has been criticised, *inter alia*, on the grounds that there are fundamental differences between the natural and social sciences, that the researcher is not a value-free objective observer, and that there is no single external social reality. In the field of travel analysis this critique revolves around an argument that travel behaviour does not exhibit the same rational and stable regularity as the behaviour of natural elements, and that the development of models from empirically observed social regularities to predict long term travel behaviour at ever increasing levels of accuracy – a central thrust of research activity since the 1960s – is somewhat misconceived (see for instance Gillespie *et al* 1998, Pas 1990 and Polak 1987).

The influence of this critique on the development of analytical methods in the field, and on the choice of my own analytical framework, is discussed later (in chapters 2 and 3). Suffice to say here that I elected to conduct my research loosely within a critical social science (rather than positivist) paradigm, on the grounds that my research aims did not sit comfortably within the latter. I hasten to

add that this was not a neat decision I took at the outset of the project. Rather, once my research interests and the broad nature of the tasks I needed to undertake to address them became clear, it became apparent that the research project fell within a particular paradigm. The research interests emerged first and fitted into a paradigm, not the other way round. The situation of different kinds of research within or across particular paradigms is a question that could be discussed at length. My purpose here is simply to situate my own project within the 'critical social science' paradigm, and allay any expectations that it might be positivist in approach.

According to Lawrence Neuman (1997), within the 'critical social science' paradigm, reality is seen to be socially constructed and multi-layered (sometimes dialectic), and the researcher is not seen to be neutral in his or her attempt to expose the versions of reality constructed by different interest groups.⁴ The research process is driven by a set of questions which are related to why socially constructed knowledge of reality is represented the way it is and by whom, and how the world can be made a better place by deconstructing practices in assembling and acting upon knowledge. My research process was therefore driven by a set of questions, as opposed to hypotheses. I did not dismiss the utility of positivist methods however, as some of the quantitative research techniques developed within this paradigm were used in my data collection and analysis.

The research process was also primarily exploratory in nature, but – insofar as it produced new data that extend existing knowledge of travel need, and examined evidence of casual relationships between local network planning practices and travel patterns – incorporated descriptive and explanatory elements.⁵ The exploratory and multi-disciplinary nature of the project necessitated that considerable effort was invested in reviewing and engaging with literature and developing analytical skills that spanned disciplinary boundaries. In particular, with a background in town planning, it was necessary for me to invest considerable effort in familiarising myself with transport system planning and management practices and travel survey methods that have emerged from other disciplines, notably traffic engineering and human geography.

The exploratory nature of the project inevitably also led to some shifts in course over the three year research period (1999-2001) as my understanding of current debates and the limitations of different research methods improved. It was initially my intention for instance to use multi-modal micro-simulation modelling software to test the ability of alternative local network configurations to

⁴ In the third paradigm, 'interpretive social science', social reality is seen to be constructed by human beings who interpret situations in particular contexts, and act in response to these situations. It involves making social reality intelligible and revealing its inherent meaningfulness. This requires studying how social reality is experienced, interpreted and understood. Qualitative research methodologies are frequently used. (Neuman 1997)

⁵ Consistent with Neuman's (1997) categorisation of types of research in the social sciences, I use the term 'exploratory' here to refer to research that is sufficiently open-minded and flexible to adjust fields of enquiry and research methods as new understandings of the research topic emerge and as important issues requiring investigation serendipitously come to light, and that identifies the appropriate future direction of research in a field and the methods that should be employed. In contrast, according to Neuman (1997), 'descriptive' research refers to the detailed depiction of a particular subject and possible contradiction of prior beliefs, while 'explanatory' research refers to the advancement of knowledge of underlying processes and theory building.

accommodate changing patterns of travel demand through the introduction of network management measures, and to develop and apply indicators of mode accessibility, efficiency and safety to measure network effectiveness. At the time my concern was to explore the ability, or flexibility, of different movement network and subdivision patterns to maintain convenient and safe non-motorised travel under changing levels of vehicular through-traffic and motor car mode share. While this is a theme that has endured throughout the research, my views on its relative importance to the project, and on the usefulness of this type of simulation research method, changed. It was also my intention initially to place greater emphasis on, and contribute to, debates surrounding the relationship between network configuration and travel behaviour. The body of literature that has emerged on this subject in recent years excited me tremendously as it is one of the few academic arenas in which town planners, transport planners and traffic engineers have engaged in meaningful scholarly debate. However, as I reviewed this literature and my appreciation of the limitations of explanatory research in this field grew, I elected to omit this issue as a focus of analysis in my primary research. In addition, during the course of the research, a book on the topic was published which obviated the need to assemble and present the available evidence as comprehensively as I had originally intended (Boarnet and Crane 2001).

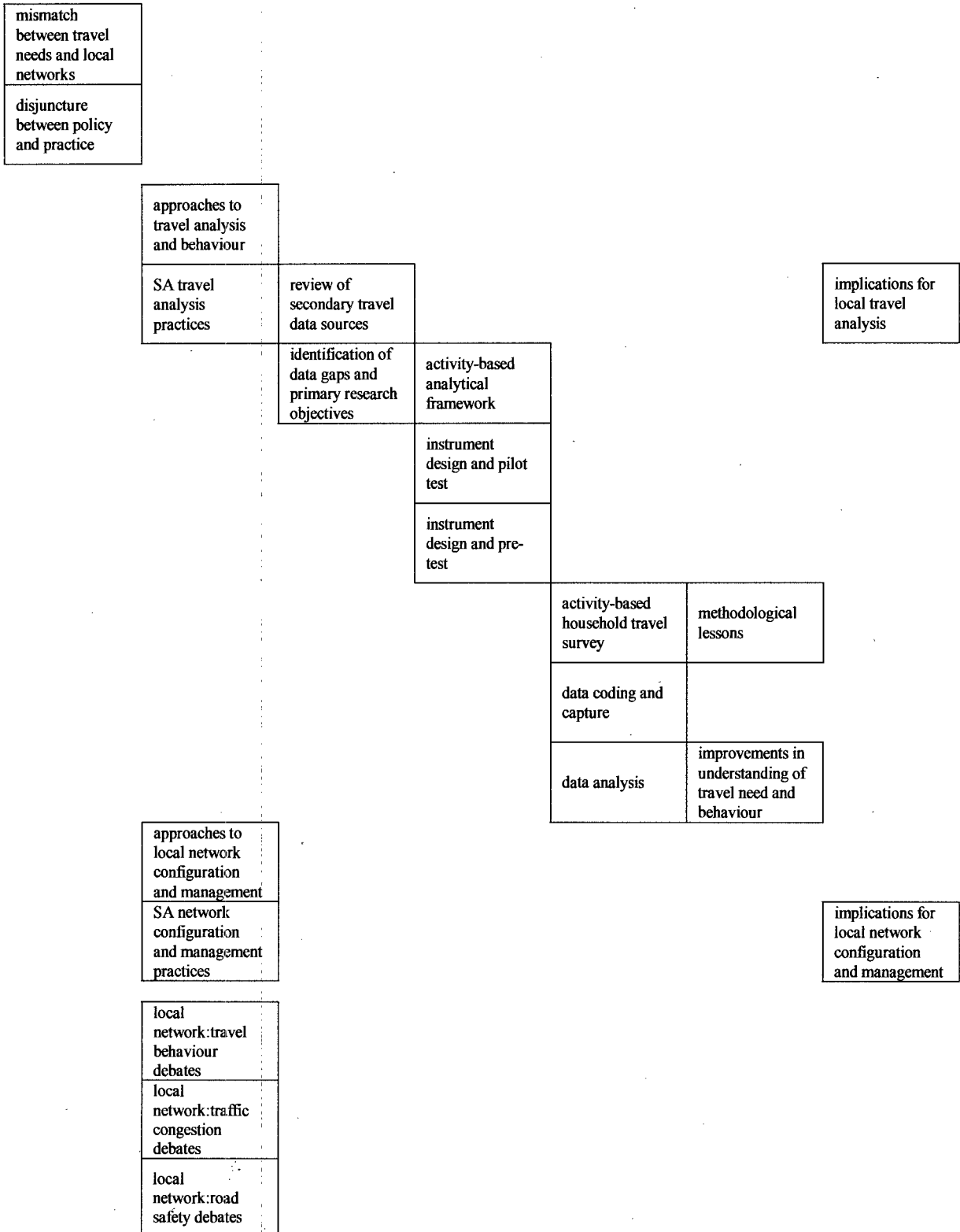
Extensions to my initial intentions, as opposed to the kind of narrowing of focus discussed above, took the form of greater emphasis accorded to network management issues, and an expansion of the scope of my primary research. The former resulted from a growing realisation of the futility of attempting to significantly improve conditions for non-motorised travellers in South African cities through concentrating on just (but still important) 'greenfield' development. Regarding the latter, while it was my intention at first to limit the presentation of primary research findings to those concerned with local travel behaviour only (with a particular but not exclusive focus on non-motorised travel modes), in the process of analysing my data it became apparent that by limiting the presentation of my findings in this way, much of the insight of travel need and behaviour in South African cities added by the research would be lost. I decided that these insights were sufficiently valuable to justify the expansion of my presentation of findings to include them. More importantly perhaps, as one of the objectives of the primary research was to test an innovative analytical method, I decided that this expansion was also necessary to demonstrate its utility in relation to the development of a richer understanding of travel need and behaviour than has previously been the case with other analytical methods.

Two intentions that remained unchanged throughout the research process however were my desire to understand better travel need and behaviour in South African cities, as well as the origins and underlying philosophies of local network planning practices. Consequently relatively large portions of this dissertation are dedicated to documenting the results of my efforts to come to terms with design codes, methods of travel analysis, the available travel data, as well as the collection and analysis of my own travel data. The exercise of primary travel data collection proved to be the most fraught and time-consuming aspect of the research, and partly for this reason, an original intention to undertake a

subsequent complementary qualitative survey of local travel patterns and perceptions was deferred for later research.

Figure 1.7 *Research process*

Identification of research problem and questions	Critical review of relevant literature and debates	Identification of new information needs	Development of theoretical and analytical frameworks	Collection and analysis of information	Reflective discussion on research findings	Identification of implications for the field
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While interrupted and not necessarily sequential in nature, the research did follow what might in essence be regarded as the conventional path for dissertation study (Holt 1998, Phillips and Pugh 1987): the identification of a research problem and key motivating research question(s); a critical review of what others have said about this problem and the schools of thought that have emerged; the identification of what information needs to be gathered to explore and address the research questions identified; the development of theoretical and analytical frameworks with which to collect and interpret information; the collection and analysis of information; a reflective discussion on how the research findings add to existing knowledge and address the research questions; and an identification of the challenges and implications the research findings present for, and what still needs to be explored in, the field. Figure 1.7 illustrates the broad research process followed and the various tasks undertaken in each phase.

1.4 STRUCTURE OF THE DISSERTATION

While the research process went through the various phases discussed above, these have not been used as a basis for structuring the dissertation, as might be regarded as conventional. Instead – in line with the ‘critical social science’ paradigm within which the research was conducted – the dissertation has been structured around the sequence of questions that drove the research process. It is divided into six chapters (including this introductory chapter), followed by a set of appendices.

Chapter 2 (the next chapter) addresses the question of how travel need has been analysed and represented, and how adequately available data enable a thorough understanding of local travel need in particular. The chapter, in essence, reviews the development of methods of travel analysis and data collection internationally, identifies which of these methods have been applied in South Africa, discusses how travel need and behaviour has been represented as a result of their application, and identifies gaps in existing knowledge. While tracing the evolution of international travel analysis and data collection methods is an exercise that has been undertaken elsewhere – although for different purposes, with different emphases, and with more specific geographical foci (see for instance Bates 2000, Bates and Dasgupta 1990, Fischer 1987, Pas 1990 and Weiner 1997) – it is presented here at some length to provide a basis from which the origins of South African practices can be identified, and the contextual differences between South Africa and the countries of origin can be understood. Travel analysis was also a field in which I had no prior training or experience, and it was necessary for me to undertake this literature review to provide a foundation from which I could engage with later aspects of the research. In the absence of published reviews of the origins, policy contexts and application of analytical methods in South Africa, beyond those dealing simply with modelling software, it was necessary to undertake a series of practitioner interviews to develop an understanding of local approaches. The review of available travel data in Cape Town and other South African cities was also a task that had not been undertaken before, and in order for me to substantiate my

conclusions regarding the limitations of current travel data, this too had to be undertaken in some detail. By tracing the origins and development of South African travel analysis practices in a way that has not been done before, I attempt to make, in this chapter, the first of what are intended to be a number of contributions to the field.

One of the conclusions drawn from the review of earlier representations of travel need in chapter 2 is that there are insufficient current data available with which to adequately understand the nature and relative extent of local travel behaviour, and more specifically that the scope of most past surveys (typically restricted to commutes or morning peaks) has been too limited for this purpose. This gave rise to the need to undertake a travel survey of my own, and to broaden the scope of conventional travel analysis to enable a more comprehensive view of local travel to be developed and the relative importance of local travel to be viewed in perspective. As discussed earlier, this resulted in an expansion of the core research focus. Chapter 3 documents this survey, and addresses the question of what travel need is in its fuller diversity and complexity, and what the relative importance of local travel need is in particular. Metropolitan Cape Town was selected, for pragmatic reasons, as a case study of a South African city for the purposes of addressing this question. The chapter, in essence, sets out the objectives of the primary research, describes the method and theoretical framework used, and reports on findings.

In a field dominated by prediction and mathematical modelling, and in a context of increasing economic uncertainty and demand-side and equity-oriented transport policies, I argue at this point that travel analysis studies focussed on improved understanding of existing need and behaviour through empirical observation are important in and of themselves. Consequently I regard the collection and analysis of data to improve our understanding of current travel need and behaviour as an end in its own right, and make no attempt to develop a predictive model.

For reasons that will become apparent later I selected time geography and activity-based analysis as the theoretical and analytical framework within which to develop the survey instrument and explore the data collected. Because this survey method is to a large extent untested in South Africa, and because an anticipated contribution is the application of this analytical framework under South African conditions, the preparation for and administration of the survey is documented in some detail. Despite a constrained sample size and associated large confidence intervals, I believe the analysed data do extend current understanding of travel need and behaviour through the application of this framework, and I anticipate that a further original contribution to knowledge is made here. My personal experience from the project is that household time-space paths – one of the tools developed by time geographers – illustrate to the travel analyst the plight of the poor in a far clearer and more forceful way than other analytical techniques.

The findings of the survey are discussed in terms of the influence of household income, neighbourhood form and location, household life-cycle stage, and personal circumstances on travel behaviour. The data indicate that gaps in our understanding of travel need and behaviour in South African cities are large, and that walking as a form of local travel is indeed important – particularly so amongst poorer households, and individuals within wealthier households that do not have access to the household car(s) – and significantly more important than earlier travel surveys focussed on commutes and peaks might have led us to believe. An overarching implication of the research is argued at this point to be that, given the hitherto poorly understood importance of local networks in satisfying travel need, greater resources need to be allocated to transport planning in local areas and for non-motorised modes generally.

Chapter 4 then shifts the focus of the dissertation away from travel need to local network configuration and management. Local network *configuration* is defined as the arrangement of footways, roadways, pathways and cycleways in ‘greenfield’ development to delimit street blocks and open spaces, and to facilitate local travel by various modes between the different land use activities they accommodate. Local network *management* is defined as the addition or extension of footway, pathway and cycleway systems, the provision of additional driveway or roadway accesses, the provision of roadway crossing facilities, and the control of vehicular traffic through roadway retrofitting, subsequent to ‘greenfield’ construction.

The chapter addresses the question of how local networks have been configured and managed, and the extent to which practices have been developed to match actual local travel needs in South African cities (as best they have been understood). The chapter, in essence, reviews the evolution of approaches to local network configuration and management internationally, describes South African practices, and discusses how these have been influenced by international approaches. While the task of tracing the evolution of international approaches to local network planning has been undertaken in great detail elsewhere (see for instance Hall and Ward 1998, Hass-Klau 1990 and Southworth and Ben-Joseph 1997), in much the same way that approaches to travel analysis are reviewed in chapter 2, this progression of ideas is presented here at some length to provide a foundation from which the origins of South African practices can be identified and the contextual differences between South Africa and the countries of origin can be understood. South African practices are reviewed through the examination of design codes (as opposed to, for instance, case studies) and supplemented with practitioner interviews where necessary. By tracing the origins and development of South African network configuration and management design codes in a way that has not been done before, this is an area in which I expect another contribution to the field will be made.

Chapter 5 then addresses the question of what evidence there is of local network planning practices improving the conditions of travel within local networks – a form of travel revealed to be of great significance in chapter 3 – and the question of what implications this evidence has for transforming

current South African practices in this field. Among the conclusions drawn from the review of design codes in chapter 4 are that putative 'best' local network planning practices have been imported from developed world contexts without rigorous consideration of contextual difference, and that management practices have tended to be site-specific and reactive. I postulate at this point that closer examination of and response to actual travel need, and a co-ordinated and proactive approach to local network management, would surely improve practice. With regard to the former, while the findings of chapter 3 in relation to travel need in its fuller diversity and complexity have implications for numerous transport planning matters, including those relevant at the larger city-wide scale, the focus of the dissertation necessitates that chapter 5 concentrate on local network configuration and management matters in particular. The chapter, in essence, reviews evidence of the relationship between local network planning practices and travel behaviour, traffic congestion and road safety. It also reviews, briefly, precedent for co-ordinated and proactive local network management. The literature review in this chapter therefore represents the third of three presented in the dissertation as a whole, with the first two dealing with travel analysis and local network planning practices respectively. As mentioned earlier, for a number of reasons, my ambitions with regard to this particular body of literature were tempered during the course of the project. I hope nonetheless that the multi-faceted nature of the review represents a contribution. Similar reviews in the past have focused on either travel behaviour, traffic congestion and road safety, and seldom all three.

Chapter 6 concludes the dissertation by addressing the question of whether travel analysis and local network planning practices can be improved in South Africa, and what future research would be necessary to assist this process. Following a brief reflection on the dissertation's aims, I explore the implications of the research for improved travel analysis practices, local network configuration practices in new land development, and local network management practices within existing settlements (and in broad terms the planning frameworks and processes their implementation would necessitate). I conclude with a discussion on the dissertation's intended contribution to knowledge.

The three appendices that follow the list of references at the end of the dissertation include a list of related doctoral research products, the survey instruments used in primary research, and a comparison of surveys findings.

Chapter 2

The analysis and representation of travel need and behaviour

2.1 INTRODUCTION

This chapter addresses the question of how travel need has been analysed and represented, and how adequately available data enable a thorough understanding of local travel need in particular. The chapter reviews how methods of travel analysis and data collection have evolved internationally. It goes on to identify which of these analytical methods have been applied in South Africa, and how travel need and behaviour has been represented as a result of their application. Finally it discusses gaps in existing knowledge.

The chapter is divided into six sections, including this introduction and a concluding summation. Section 2.2 (the next section) reviews the evolution of approaches to travel analysis and data collection internationally, in terms of a number of broad periods, from the emergence of the transport planning and traffic engineering professions in the 1930s to the present day. The contexts in which different approaches emerged and the factors that initiated methodological change are discussed, as well as the assumptions made in each period that often became the focus of challenge and motivation for subsequent development. While this is a review that, with different emphases and geographical foci, has been undertaken elsewhere (see for instance Bates 2000, Bates and Dasgupta 1990, Fischer 1987, Pas 1990 and Weiner 1997), as mentioned earlier, it is undertaken here at some length to provide the necessary foundation upon which South African practices can be situated, and upon which decisions regarding the later primary research can be made. Section 2.3 then identifies the origins and application of approaches to travel analysis and data collection in South Africa. Section 2.4 reviews the representations of travel needs and behaviour, or existing knowledge, that have resulted from these analyses in South African cities and in Cape Town, as the focus of later empirical research, in particular. Secondary sources of data are discussed in terms of a set of variables that broadly represent the scope of previous analysis. This is a task not done before, and in order to be able to properly substantiate later conclusions regarding the limitations of current travel data, is undertaken in some detail. Section 2.5 identifies the gaps and restrictions that occur in our existing understanding of travel needs and behaviour.

2.2 EVOLUTION OF METHODS OF TRAVEL ANALYSIS AND DATA COLLECTION

A review of the international literature suggests that, on the basis of the contexts to which they responded, the emergence of methods of, and approaches to, travel analysis can be broken into the following five overlapping periods⁶ (see figure 2.1). The policy environment, academic critiques, analytical methods and underlying assumptions of these periods are discussed in turn.

- approaches that emerged in the 1930s to 1950s in response to increased private motor car ownership and use, and associated intra-urban traffic problems;
- approaches that emerged in the 1950s to 1960s in response to accelerated highway construction and technological innovation in the computer industry;
- approaches that emerged in the 1970s to 1980s in response to critiques of aggregate methods and the observed limitations of traffic forecasts of the 1960s;
- approaches that emerged in the 1980s to 1990s in response to critiques of static, trip-based travel analyses and their underlying behavioural theory; and
- approaches that emerged in the 1990s in response to environmental pollution and shifts from supply-side (i.e. 'predict-and-provide'), to demand-side (i.e. travel demand management) transport policies.

Figure 2.1 *Periodisation of the emergence of approaches to travel analysis*

	19	00s	10s	20s	30s	40s	50s	60s	70s	80s	90s	
Responses to increased private car use and traffic problems					█							
Responses to rapid highway construction and technological innovation							█					
Responses to critiques of aggregate methods									█			
Responses to critiques of static, trip-based travel analyses and their behavioural theory											█	
Responses to pollution and shifts from supply-side to demand-side transport policies												█

⁶ An alternative periodisation can be found in a conference paper presented by Eric Pas (1990). Pas identified five eras on the basis of analytical method: (1) the 'social physics era' (mid 1950s-late 1960s), (2) the 'econometric era' (late 1960s-late 1970s), (3) the 'psychological measurement era' (mid 1970s-early 1980s), (4) the 'human activity analysis era' (mid 1970s-mid 1980s), and (5) the 'dynamic analysis era' (mid 1980s-late 1980s). A further periodisation of travel demand modelling systems often referred to in the transport planning literature, takes the form of: (1) 'first generation models' (from the late 1950s onwards) in which aggregated trips between traffic zones were the focus of demand analysis, (2) 'second generation models' (from the 1970s onwards) in which trip choices at a disaggregated individual level were the focus of demand analysis, and (3) 'third generation models' (from the 1980s onwards) in which the constraints associated with household activity behaviour were the focus of demand analysis.

2.2.1 1930s-1950s: Responses to increased private car use and traffic problems

The first period of travel analysis emerged in response to the rapid increases in private motor car ownership and use that occurred during the 1920s to 1940s in the developed world. According to Oi and Shuldiner (1962) the resultant growth in intra-urban (as opposed to interurban or rural) traffic that occurred at this time led to a realisation that conventional attempts to solve traffic congestion and intrusion problems, through the provision of urban bypasses, were futile, because a large proportion of traffic was internal or not 'bypassable'. During this period, innovations in travel analysis therefore focused on obtaining travel information regarding the volume and distribution of intra-urban traffic.

Techniques of analysing urban travel, developed prior to the 1930s-1950s period, essentially took the form of traffic volume counts⁷. These studies involved the enumeration of vehicles moving at a particular intersection, bridge or roadway link, and were typically used for selecting appropriate pavement surfacings or evaluating the effect of traffic on street cleaning. They were rarely used as a tool in the selection of road alignments or the design of road cross-sections, and they made little attempt to understand the underlying causes of traffic generation. Because of the emerging complexity of urban road systems and the shifting of traffic from route to route, simple traffic volume counts were increasingly recognised as inadequate for the purposes of understanding or anticipating intra-urban travel behaviour. (Oi and Shuldiner 1962, Pas 1995)

Two key analytical methods emerged during this period – 'roadside interview origin-destination surveys' and 'home interview origin-destination surveys'.

2.2.1.1 Roadside interview origin-destination surveys

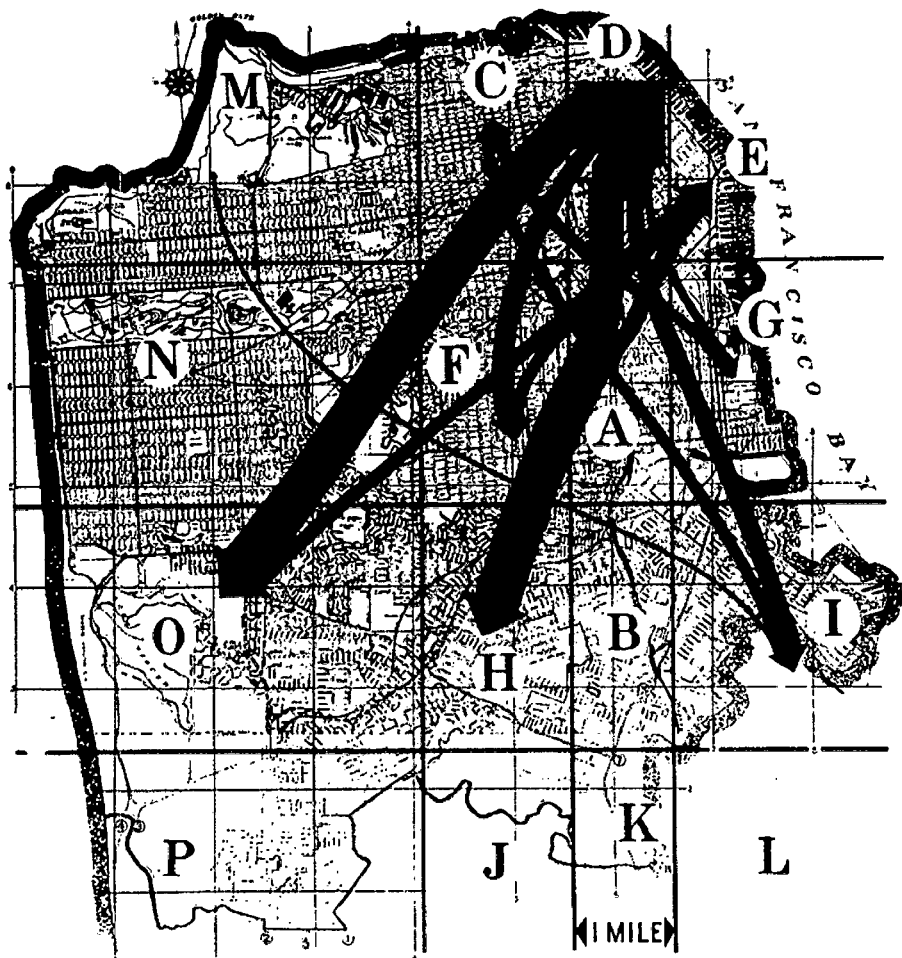
Roadside interview origin-destination (O-D) surveys took the form of either 'external cordon' surveys in which traffic crossing an imaginary line surrounding a study area is surveyed, or 'screenline' surveys in which traffic crossing a selected 'screenline' or boundary is surveyed. Prior to the second world war, external cordon surveys were typically conducted at the peripheries of urban areas (at entrance and exit points known as 'cordon stations') to determine the proportion of traffic that would be circumvented if a bypass were to be constructed. This analytical technique involved stopping vehicles and asking drivers for information on trip origin, destination and purpose. Typically all the vehicles passing through the cordon station were counted, but only a sample of drivers were interviewed. (Oi and Shuldiner 1962, Salter and Hounsell 1996, Wright 1996)

⁷ The first traffic volume counts were conducted in France and the United States of America in the mid-1800s. (Oi and Shuldiner 1962)

2.2.1.2 Home interview origin-destination surveys

Home interview O-D surveys were first developed by the Public Roads Administration (PRA – later known as the Bureau of Public Roads) in the United States in 1944⁸. The PRA produced a procedural manual for O-D surveys in 1944 (later modified in 1946), entitled *Procedures for the metropolitan areas traffic studies*. Unlike roadside surveys which only indicated the use of a particular existing link, home interview surveys enabled the existing area-wide demand for travel to be studied. Home interview O-D surveys entailed selecting a sample of dwellings within a study area, and interviewing households to obtain information on the number, purpose, mode, origin, and destination of all trips made during a prescribed time period. The results of these surveys were used to create ‘desire line’ maps which indicated, schematically, the major spatial distribution of trips (see figure 2.2). Future urban travel volumes were sometimes predicted by simply extrapolating the past traffic growth rate into the future. (Oi and Shuldiner 1962, Pas 1995, Weiner 1997)

Figure 2.2 Example of a ‘desire line’ map



Source: Papacostas and Prevedouros 1993:295

⁸ According to Oi and Shuldiner (1962), the relatively large amounts of money for urban highway planning and construction made available by the Federal Aid Highway Act of 1944 in the United States of America, enabled more extensive travel surveys, like home interview origin-destination surveys, to be undertaken.

2.2.1.3 Assumptions

The approaches to travel analysis that emerged during this period made the following basic assumptions:

- that the observation of origin to destination movements provided an adequate basis for understanding travel behaviour – which meant that these approaches had limited explanatory ability, with roadside surveys in particular providing little information about the social and economic characteristics of the people undertaking trips; and
- that an understanding of existing travel patterns or ‘desire lines’ provided an adequate basis for future transport planning – which meant that these approaches had very limited predictive ability.

2.2.2 1950s-1960s: Responses to rapid highway construction and technological innovation

The second period of travel analysis emerged in response to the accelerated private motor car use, highway construction and technological innovation in the computer industry that occurred during the 1950s to 1960s in the developed world, primarily in the United States. Perhaps the most important factor in the development of analytical methods during this period was the availability for the first time of computers capable of manipulating relatively large quantities of data. It was believed at the time that if certain relationships between land use, population and travel could be measured, these relationships could be used as a means to predict future travel. Computers enabled the use of mathematical equations describing these relationships to calculate large quantities of data (collected by the survey methods developed in the previous period), and enabled the examination of travel patterns across large geographical areas. The early computer models were developed in a *milieu* of ‘positivism’ and ‘rational comprehensiveness’, in which it was believed the earlier 20th century successes in the natural sciences would extend to the social sciences, and into the planning of urban settlements more specifically. The idea of urban planning as ‘architecture-writ-large’ therefore declined, as systems, models and computers became the focus of research attention (a stream of planning research that became known as ‘regional science’). The analytical methods of the previous period, on their own, were seen to be insufficiently predictive and explanatory for the purposes of rational comprehensive planning. (Batty 1994, Dimitriou 1992, Pas 1995, Taylor 1998, Weiner 1997)

The key analytical method to emerge during this period was the ‘aggregate four-stage model’.

2.2.2.1 Aggregate methods

In his record of the history of transportation planning in the United States, Edward Weiner (1997) identifies a number of theoretical research papers as being particularly seminal in the development of computer models to predict urban travel behaviour. One was a paper in 1956 by Alan Voorhees,

entitled *A general theory of traffic movement*. Voorhees advanced the gravity model as a means to link land use with urban traffic flows.⁹ Research had been proceeding for a number of years on a gravity theory for human interaction, with the gravity analogy being applied by sociologists and geographers to explain population movements generally. Voorhees used O-D survey data with travel time as the measure of spatial separation, and developed a three trip purpose gravity model. In 1957 two further papers were published that discussed a minimum impedance algorithm for assigning trips to networks. One was entitled *The shortest path through a maze* by Edward Moore, and the other *The shortest route problem* by George Danzig. With such an algorithm, travel could then be assigned to minimum time paths using the newly developed computers. These theoretical developments led to the first practical applications of computerised travel analysis. Pioneering studies were undertaken in Detroit (Michigan) and Chicago (Illinois) in the 1950s.¹⁰

The Detroit Metropolitan Area Traffic Study (DMATS), conducted from 1953 to 1955 under the direction of Douglas Carroll, put together the elements of what was to become a conventional urban transportation study for the first time. It developed a procedure for: collecting data, forecasting travel demand, preparing road network proposals, and testing and evaluating these proposals. In 1955 the Chicago Area Transportation Study (CATS), also under the direction of Douglas Carroll, set the norm for later metropolitan transportation studies in the 1960s and 1970s. While the Detroit study was the first to develop travel forecasting procedures, the CAT study was more influential in informing computerised procedures used to forecast trip patterns. In the study transportation networks were developed to serve travel generated by projected land use patterns. It used a simple land use forecasting procedure to predict future land use and activity patterns. Basic 'trip generation', 'trip distribution', 'modal split', and 'network assignment' models were used for travel forecasting – which became the basis for the so-called 'four-stage' model. (Dimitriou 1992, Oi and Shuldiner 1962, Weiner 1997)

The emphasis in the DMAT and CAT studies was on planning a road network that could cater for the large increases in private motor car travel in urban areas that were expected at the time. Both the natural and financial resources necessary to achieve this were seen to be abundant. The resulting plans were therefore heavily oriented toward long-term, capital-intensive expansions of transport system capacities. The planners were concerned primarily with technical questions of how to link trip origins

⁹ This general form of model derives its name from its analogy with the Newtonian formula for the gravitational force between two masses. In this analogy, the masses are the populations of different geographical zones, and the gravitational force is the amount of travel between zones. Human beings were assumed to behave in the same way as particles – hence this period of theoretical development became known as the 'social physics era'. As in the Newtonian formula, the amount of travel between zones is considered inversely proportional to the square of the distance between them. Later variations of the gravity model used 'generalised cost' (i.e. a combination of travel time and cost) instead of distance, to account for interaction effects. (Bates and Dasgupta 1990, IHT 1996, Pas 1990)

¹⁰ An earlier transportation study was undertaken in San Juan (Puerto Rico), which began in 1948. The San Juan study was one of the earliest to use a trip generation approach to forecast trips. Trip generation rates were developed for a series of land use categories stratified by general location, crude intensity measures and type of activity. These rates were applied, with some modifications, to the projected land use plan. Later transportation studies included the Washington Area Traffic Study in 1955, the Baltimore Transportation Study in 1957, the Pittsburgh Area Transportation Study in 1958, the Hartford Area Traffic Study in 1958, and the Penn-Jersey (Philadelphia) Transportation Study in 1959. (Weiner 1997)

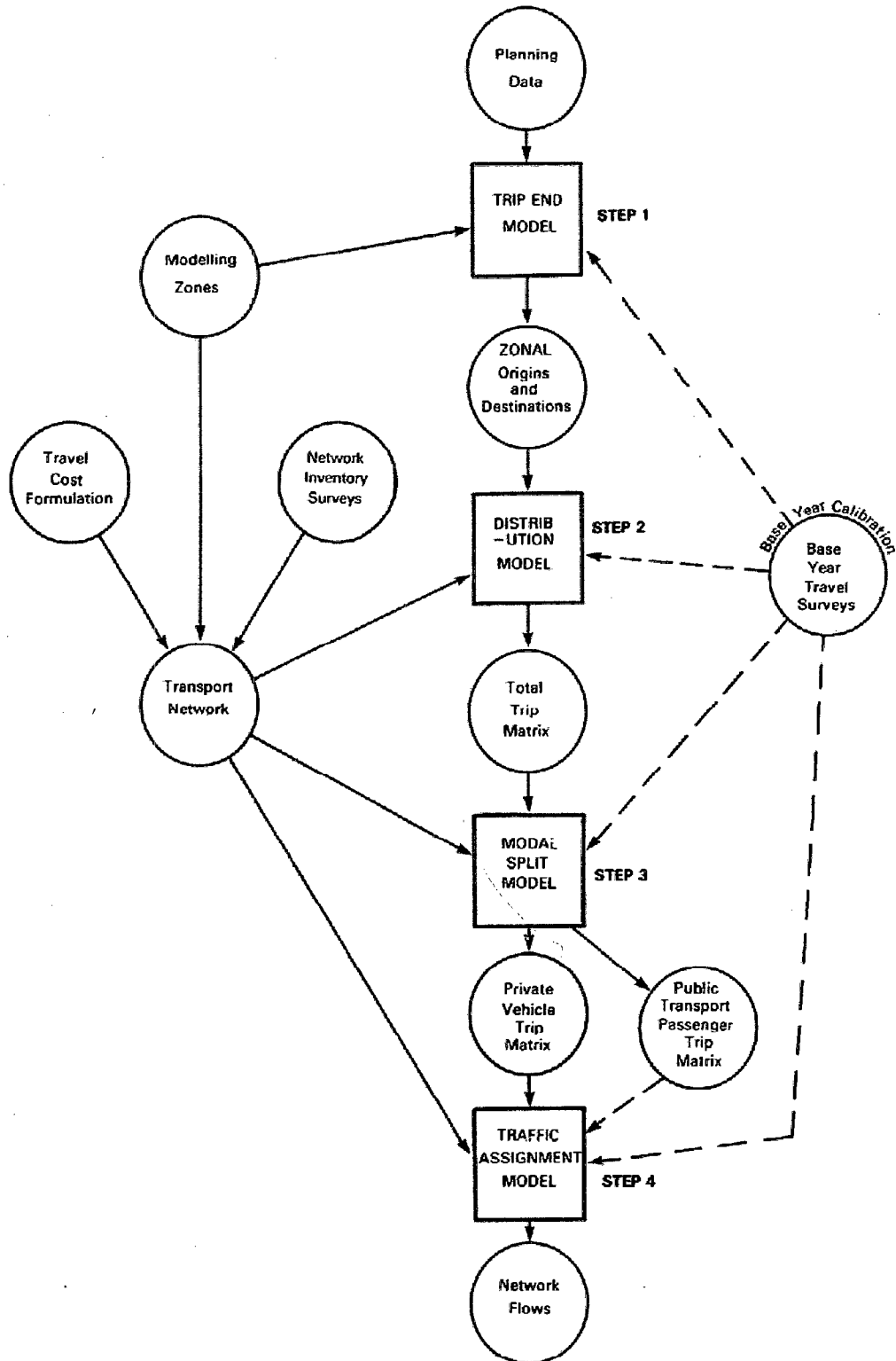
and destinations with an optimum road network – the alignment and capacity of limited access arterials were therefore the foci of planning and improvement. Public transport and non-motorised modes received little, if any, attention in analysis. These pioneering studies of the 1950s established a procedural norm (see figure 2.3), and provided the basis for an institutionalisation of analytical methods in the United States in the 1960s.¹¹ (Allen 1985, Garrett and Wachs 1996, Pas 1995, Weiner 1997)

The application of aggregate four-stage models to particular urban areas necessitated that these areas be represented as a series of small geographic areas, called ‘travel analysis zones’ (TAZs). TAZs were typically around 100-400 ha in area – demarcated on the basis of their population, employment and land use (amongst other factors), and were the places where trips began or ended. The road system within the study area was represented as a network made up of ‘links’ that represented road segments (of typically only arterials and freeways), and ‘nodes’ that represented intersections or interchanges. Trip making was estimated at the zonal level – hence the name ‘aggregate model’. Aggregated trip making was assumed to begin and end at the centre of activity in a TAZ – at the ‘zone centroid’. Shorter trips that begun and ended within the same TAZ were usually not directly included in travel forecasts. (Beimborn 1995)

The modelling procedure involved a sequence of stages that answered a series of questions about traveller decisions. Because of the limited capacity of early computers, the early transportation studies developed a set of sequential-independent models (i.e. different models were used in a certain order, but each model in the sequence was run separately from the others). The independent models were used to answer the questions associated with each stage of the procedure, and the results of one stage became the inputs to the next. Despite considerable development in modelling techniques relating to each of its sequential models, this modelling procedure has retained its general structure over time. Garrett and Wachs (1996) suggest a possible reason for this resilience is its simple logic – each stage addresses an intuitively logical question: how many trips will be made (trip generation), where will they go (trip distribution), what mode will be used (modal split), and what route will be taken (network assignment). The four stages are discussed in turn:

¹¹ A major turning point in the institutionalisation of the travel demand forecasting process in the United States was the passage of the 1962 *Federal Aid Highway Act* which required urban areas to employ a continuing, comprehensive and co-operative transportation planning process (known as the ‘3C process’) in order to receive federal funding. The US federal government made available as much as 90% of the funds needed to construct new freeways, provided that the road network was built in accordance with comprehensive regional transport plans. The 3C planning process included four technical phases: data collection, data analysis, travel forecasts, and the evaluation of alternative transportation networks. Travel forecasting procedures were therefore central to this process. In addition to these 3C process requirements, the technical forecasting procedures discussed above became further institutionalised through the publication of numerous manuals on travel forecasting produced by the Bureau of Public Roads. The models and procedures applied in the United States then gradually diffused throughout the rest of the world, mainly to the United Kingdom and Europe. (Batty 1994, Dimitriou 1992, Garrett and Wachs 1996, Pas 1990, 1995, Weiner 1997)

Figure 2.3 Sequential stages of the aggregate four-stage model



Source: IHT 1987:79

Trip generation models were used to predict the number of person trip ends generated by a TAZ over a particular time period. Trips ends were classed as being either a ‘production’ or an ‘attraction’, and the total number of trip productions was balanced with the total number of trip attractions. Simple equations involving generation rates were used to estimate the number of trips. Trip production rates were based on household characteristics like the number of people in the household and the number of

cars available (e.g. a household with x people and y cars may be assumed to produce z trips). Trip attraction rates were based on the level of employment or floor area in a TAZ (e.g. x number of employees may be assumed to attract y trips). The most common methods of trip generation included: (1) zonal analysis (which generates trips on a TAZ basis),¹² and (2) category, or cross-classification, analysis (which generates trips on a more detailed household category basis).¹³ (Bates and Dasgupta 1990, Beimborn 1995, IHT 1996)

Trip distribution models were used to predict the number of person trips from each zone going to each of the other zones in the study area – in essence, to convert trip production and attraction tables, to trip origin and destination matrices. The most common methods of trip distribution included: (1) gravity models (which distribute trips on the basis of TAZ size and distance),¹⁴ (2) intervening opportunities models (which distribute trips on the basis of the closest opportunities to satisfy trip purposes),¹⁵ and (3) growth factor, or Fratar, models (which distribute future trips on the basis of existing TAZ trip interactions).¹⁶ (Schoon 1996)

Modal split (or mode choice) models were used to predict which travel modes will be used. Trips between an origin and destination TAZ were split into trips taken by public transport, and trips taken by private motor cars (either as a passenger or driver). Person trips (the output of trip distribution models) were converted to vehicle trips, using car occupancy equations. Modal split and car occupancy analysis were either undertaken as two separate steps, or combined into a single step. In simple analyses a public transport:car split was made first, followed by a split of car trips into driver and passenger trips. The most common methods of forecasting modal split included: (1) ridership assumptions (which predict modal split as a simple function of socio-economic variables like income

¹² Zonal analysis involves the use of regression analysis to identify correlations between trip generation rates and either one, or multiple, variables. Given the high correlations which were typically observed to exist between trip generation and variables like household income, car ownership and employment, regression equations were developed to predict trip generation as a linear function of one or more of these variables. (Meyer and Miller 1984, Wright 1996)

¹³ Category analysis applies calculated trip rates to the estimated number of future households within particular household categories within TAZs. The future number of trips produced in a particular TAZ is then calculated as the sum of these individual household category trips. (Ortúzar and Willumsen 1994, Wright 1996)

¹⁴ The gravity model takes the trips produced at one TAZ and distributes them to other TAZs based on the size of the latter (as measured by their trip attractions), and a function of the distance between them (or in later applications the 'generalised cost' of travelling). A TAZ with a large number of trip attractions will therefore tend to receive a greater number of distributed trips than a TAZ with a small number of trip attractions. The number of trips to a TAZ will also therefore tend to decrease as the distance (or generalised cost) to the TAZ increases (i.e. the number of trips and distance are inversely proportional – the basic analogy of gravitational attraction). The model is usually iterated a number of times in order to balance the trip numbers to match the trip productions and attractions found in trip generation. (Beimborn 1995)

¹⁵ Whereas in the gravity model distance and zone size *per se* are seen to influence the chance of a trip being distributed to a particular TAZ, in the intervening opportunities model the critical factor is the number of other opportunities closer to an origin than any particular destination being considered by a traveller. Thus, instead of using distance and size as the basis for trip distribution modelling, a count of the number of 'intervening opportunities' is used. A trip maker leaving a particular origin is seen to consider each possible opportunity sequentially, starting with the closest. The probability of he or she stopping at the closest possibility is said to be proportional to the number of opportunities there. (Sheppard 1995)

¹⁶ A growth factor for a particular TAZ is the ratio of expected future traffic, to the existing traffic emanating from the TAZ. Future trip distribution patterns between TAZs are thus determined by the present travel patterns and growth factors. (Bates and Dasgupta 1990, Wright 1996)

and car ownership),¹⁷ and (2) diversion curves (which predict modal split on the basis of mode attractiveness).¹⁸ (Beimborn 1995, Schoon 1996)

Network assignment models were used to predict the paths that vehicles will take on the links that connect origin and destination TAZs, and the associated assignment of approximate traffic volumes to each of these links. The network was made up of 'nodes' (usually representing intersections), and the 'links' connecting nodes (usually presented as one-way roads between intersections, so that a two-way road was represented by two separate links). In addition, nodes were required to represent TAZ centroids (i.e. the points where trips were seen to start and finish), which were connected to the link network by notional links known as 'centroid connectors'. The centroids and nodes were numbered so that each network link or centroid connector was defined by a pair of numbers. Network loading involved assigning trip matrices onto the network, typically for morning peak hour travel. In instances where O-D pairs were presented on a 24 hour (or annual average day) basis, a ratio of peak hour travel to daily travel was needed to convert daily trips to peak hour trips (e.g. it may be assumed that 10% of daily trips occur in the peak hour). The most common methods of forecasting network assignment included: (1) all-or-nothing, or minimum path, assignment models (which predict network assignment on the basis of uncongested minimum time paths),¹⁹ (2) equilibrium assignment models (which predict network assignment on the basis of the minimum time and cost paths effected by traffic congestion),²⁰ and (3) stochastic equilibrium, or multipath, assignment models (which predict network assignment on the basis of capacity restraint as well as variations in driver perceptions of alternative route times and cost).²¹ (Bates and Dasgupta 1990, Beimborn 1995, IHT 1996)

2.2.2.2 Assumptions

The approach to travel analysis that emerged during this period made the following basic assumptions (see Bates and Dasgupta 1990, Dimitriou 1992, IHT 1996, Lam and Tam 1997, Mackie and

¹⁷ This method assumes that public transport ridership is a direct function of socio-economic variables. Virtually all public transport users are therefore assumed to be 'captive' (i.e. they have no other choice of mode). The percentage of trips from a given TAZ made by public transport are typically expressed as a function of income, car ownership and population density. (Meyer and Miller 1984, Ortúzar and Willumsen 1994)

¹⁸ Diversion curves express the percentage of public transport:car trips as a function of one or more service ratios and socio-economic categories. The diversion curve is constructed by drawing a graph which plots the percentage of people using public transport, against some measure of the difference in the attractiveness of the two modes - usually travel time. These curves are often drawn for more than one measure and recalculated for different combinations of service and monetary cost for the two modes. (Meyer and Miller 1984, Sheppard 1995)

¹⁹ All-or-nothing assignment models estimate the shortest time path between each O-D pair based on uncongested speeds, and assign all the vehicles making these trips to the shortest time path - hence the name 'all-or-nothing'. (Meyer and Miller 1984, Schoon 1996)

²⁰ Equilibrium assignment models explicitly recognise that travel times depend on congestion levels. 'Capacity restraint' methods are used to take account of the relationship between congestion, travel time and route choice. Trips are incrementally loaded onto the network, thus allowing congestion to gradually build up and travel time estimates to adjust in response to this. Trips on congested links are shifted to uncongested links until 'equilibrium' occurs. (Beimborn 1995, Meyer and Miller 1984, Wright 1996)

²¹ Stochastic equilibrium assignment models recognise that several routes between any O-D pair might be perceived to have equal travel times or be equally attractive to a traveller. Route choice probabilities are calculated using a concept similar to the logit model for mode choice discussed later, and then used to estimate from a probabilistic perspective the number of trips that will take different routes. The assignment procedure is essentially the same as in equilibrium models, only it allows trips between the same O-D pair to be distributed across a number of alternative routes. (Wright 1996)

Preston 1998, Pas 1995, Stopher and Meyburg 1975, Talvitie 1997, amongst others – see Beimborn 1995 for a detailed unpacking of the assumptions associated with each stage):

- that it was possible to predict a future land use pattern (and use this fixed land use pattern as a basis for trip generation and distribution forecasts), independently of changes in the transport system – which meant that the four-stage model was unable to examine or take account of the influence future transport system changes have on land use location decisions;
- that it was possible to understand and predict changes in travel demand by studying data, on household characteristics, employment levels, trip-making behaviour, etc., that is aggregated at a TAZ level (i.e. that average household trip characteristics provide an adequate representation of trip-making behaviour within a particular TAZ);
- that relationships observed in ‘cross-sectional’ data on travel behaviour (i.e. data collected at one point in time) were in some form of equilibrium state and would remain constant over time (i.e. for the next 15-20 years), and therefore that models calibrated on cross-sectional data could be used to predict the future;
- that travel decisions (particularly in relation to mode and route choice) were made principally on the basis of a desire to minimise travel time and cost – which meant that a range of other physical, attitudinal, safety, socio-economic and inter-personal factors affecting travel decisions were generally not taken into account (e.g. some studies have shown that, for some drivers, signposting is a more important determinant of route choice than minimum time); and
- that inter-TAZ, average weekday peak hour trips provided an adequate representation of travel demand for the purposes of transport system improvements – which meant that in such instances the four-stage model was unable to examine shorter intra-TAZ trips or take account of transport system changes that spread trips over a longer period.

2.2.3 1970s-1980s: Responses to critiques of aggregate methods

The third period of travel analysis emerged in response to the observed limitations of the traffic forecasts of the 1960s and to the critiques of aggregate methods and large-scale models that were made during the 1970s to 1980s in the developed world, primarily in the United Kingdom and the United States. Criticisms of the assumptions made in the previous period, particularly those relating to land use-transport interactions, the use of aggregated data and the coarseness of assignment networks, effectively set the research agenda for the 1970s to 1980s period. Apart from the emergence of some integrated modelling systems concerned with land use-transport interaction, during this period the weaknesses of the four-stage model were typically addressed by developing new sub-models within the four-stage model framework – rather than by considering fundamentally different approaches to travel analysis.

In the 1970s a series of critiques of 'rational comprehensive' planning, and more specifically of the effectiveness and appropriateness of large-scale transport models, emerged (see Atkins 1986, Batty 1994, Harris 1994, Klosterman 1994, Lee 1994, Pas 1990, amongst others, for a review and retrospection on these critiques). One of the most seminal of these critiques was a paper written by Douglass Lee entitled *Requiem for large-scale models* (referred to in the literature as 'Lee's requiem'). Lee (1973) argued that large-scale urban models (and the aggregate four-stage model was clearly one of these) were too expensive, too complicated and yet too crude, and computer technology was too limited, to be useful in 'long range planning'.²² In retrospect, Batty (1994) argues however that these problems, particularly those relating to computers, were overcome in time, and were in fact superficial in comparison to the problems raised in later critiques. Later critiques argued that the models developed in the 1960s were too simplistic, in that they produced rational outcomes on the basis of simple equilibria that bore little resemblance to cities of the real world (see for instance, Atkins 1977, Polak 1987).

These critiques of transport models need to be understood within the context of a broader debate concerning the applicability of the natural sciences in explaining human behaviour (i.e. 'social physics'). In contrast to the natural sciences where theory tended to be consistent and incremental, in the social sciences little consensus existed as to which explanatory theory of social processes was the most appropriate one upon which to base the formation of predictive models. A body of literature developed in the 1970s, sometimes referred to as the 'crisis literature', expressing concern about the direction the social sciences were taking. The 'crisis literature' saw fundamental differences between the natural and social sciences. It argued that these differences placed significant limitations on the ability of generalised mathematical relationships and models of social phenomena – based on analogies to mathematical relationships in the natural sciences – to accurately explain and anticipate human behaviour.²³ (Pas 1990, Polak 1987)

In addition to the above criticisms of large-scale transport modelling systems, residents associations began voicing dissatisfaction with the intrusion of freeways into cities. As a result a new, what John Allen (1985) calls 'post-classical', approach to transport planning emerged, which to some extent replaced the classical transportation study of the 1960s. The new type of study was characterised by less reliance on computer models, more public participation, and an increased interest in shorter term management plans. In 1975 the US Federal Highway Administration and the Urban Mass Transportation Administration issued regulations which required transport plans to contain both a

²² Lee's (1973) 'requiem' identified the main problems, or 'seven sins', of large-scale models as being: 'hypercomprehensiveness', 'grossness', 'hungriness', 'wrongheadedness', 'complicatedness', 'mechanicalness', and 'expensiveness'.

²³ The essence of the criticism of models that used natural science analogies to explain human behaviour – of which the gravity model described earlier is a clear example – is perhaps captured in this quote from a paper written by Lee Cronbach entitled *Social inquiry in and for earthlings*: "Much of the similarity in person's actions comes from shared experiences, and customary behaviour is modified by a process of contagious reinterpretation of roles and goals. Traditional natural science encounters no irregularities of this character. Although particles are attracted to other particles, they do not fall in love". (Cronbach 1986:85)

long-range, as well as a short 'transport systems management' (TSM) component (i.e. low cost measures implemented in a relatively short time frame that make better use of existing capacities). This shift resulted in the need for new methods of travel analysis able to produce both long and short term forecasts. (Pas 1995)

Three key analytical methods emerged during this period – 'land use-transport interaction methods', 'disaggregate methods', and 'micro-simulation methods'.

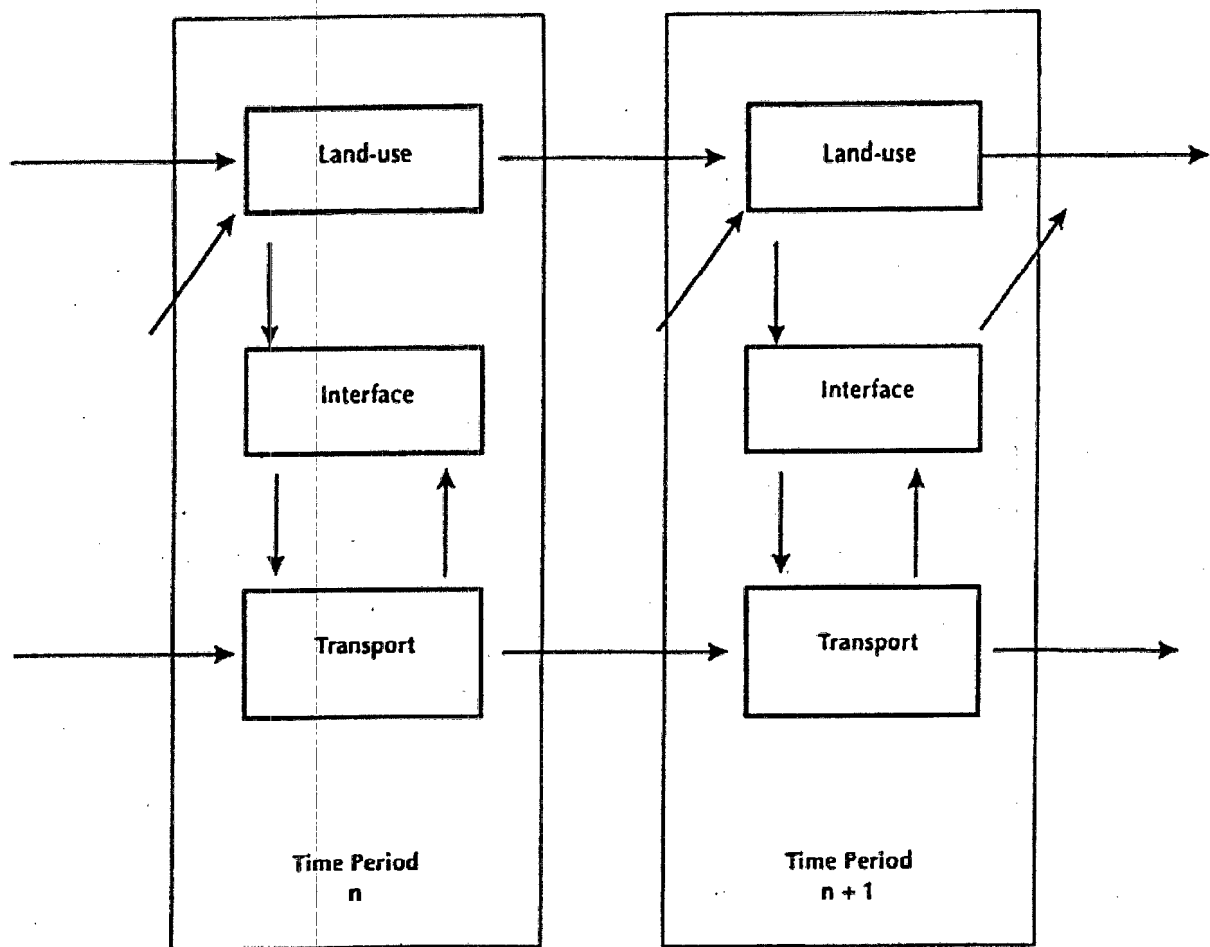
2.2.3.1 *Land use-transport interaction methods*

Land use-transport interaction methods emerged in the 1970s in response to criticisms of the inability of the earlier aggregate methods to take account of the impact of subsequent transport system changes, and their associated effects on spatial patterns of accessibility, on the distribution of population and employment in different parts of a study area. A wide variety of modelling techniques have been developed since the 1970s to take account of this land use-transport relationship, and there is no generic model structure, as in the case of aggregate four-stage models. The defining feature of these models is perhaps that they employ 'recursive simulation' (see figure 2.4). As recursive simulation models they divide the forecasting period (e.g. the next 20 years) into discrete sub-periods of 1-5 years. In order to take account of the dynamic interaction between transport system changes and land use distribution, the models are then run for each of these sub-period intervals, with the land use changes in 1-5 years time being a modelled response to transport changes in the run year. Despite modelling the development of a city over time, they nevertheless typically remain cross-sectional in nature. As in the case of four-stage models, their study areas were represented as a set of discrete zones, and travel data were collected in much the same way. Two well-documented examples of operationalised land use-transport interaction models are ITLUP²⁴ and MEPLAN.²⁵ (IHT 1996, Webster *et al* 1990, Wegener 1994)

²⁴ ITLUP was developed by Stephen Putman in Philadelphia initially at the University of Pennsylvania and later at S. H. Putman Associates. The model has been calibrated for many metropolitan areas in the United States. The land use activity system components of ITLUP were derived from the seminal land use distribution model originally proposed for Philadelphia by Ira Lowry (1968). It uses a sequence of calculations starting with the location of 'basic employment' (e.g. factories), and proceeding to the attraction of the population and the resulting creation of 'non-basic employment' (e.g. shops). ITLUP's inputs are expected growth in employment and population, the locations of existing employment and population, and the characteristics of the transportation system. It uses a gravity model to allocate new employment and population to zones. This forecast pattern of land use essentially feeds into a four-stage transport model to determine traffic flows. This information iterates back to the land use model, which updates land use patterns based on the effects on accessibility of the forecast traffic flows. The allocation of employment and population in the next simulation period, according to the travel cost factors generated in the network assignment results in the existing period, enables the land use-transport relationship to be modelled. Each simulation period represents 5 years. The model iterates until little change occurs in each iteration (i.e. until 'convergence' occurs). (Giuliano 1995, Moore and Thorsnes 1994)

²⁵ MEPLAN was developed by Marcial Echenique and Partners in Cambridge (United Kingdom), and has been applied in numerous cities in the developed and developing world. As in the case of ITLUP, the starting point in MEPLAN is the location of 'basic employment'. This gives rise to residential location choices, which in turn gives rise to 'non-basic employment' (e.g. shops locating close to resident demand). The various forms of employment require raw material as well as employees, while employees and other members of the resident population in turn have demands for goods and services. This builds up a complex structure of travel and land use. The interactions between activities are determined by an input-output analysis. (Bates and Dasgupta 1990, IHT 1996)

Figure 2.4 *The recursive simulation procedure in land use-transport interaction models*



Source: Inaudi *et al* 1995:172 (Appendix N)

2.2.3.2 Disaggregate methods

Disaggregate methods also emerged in the 1970s, in response to criticisms of the coarseness of the aggregated zonal data used in earlier aggregate methods. Disaggregate models, also known as discrete or individual choice models, were therefore constructed using data at the level of the individual traveller, rather than at the level of aggregated zonal averages. Whereas aggregate methods analysed travel demand directly at the aggregate zonal level through coefficients applied to the number of people or households in a zone, disaggregate methods first predicted individual trip maker decisions on the basis of choice probabilities and then added these individual decisions together in order to obtain aggregate demand predictions. Eric Pas (1990) argues that the primary concerns of disaggregate methods, while motivated in part by the recognised theoretical shortcomings of aggregate models, were for improved sampling and statistical efficiency, and efficient data collection. He suggests that the advances made in this period related to the econometrics of discrete choice models, rather than to an improved understanding of traveller behaviour (which was the focus of the later 1980s-1990s period). Most of the disaggregate models developed were applied in the mode choice stage of the four-

stage forecasting procedure, in the form of binary, multinomial or nested logit models which predicted modal split on the basis of the relative [dis]utility of different modes.²⁶

The theoretical basis for disaggregate methods was utility maximisation and random utility theory drawn from the field of micro-economics. Utility maximisation theory states that a decision maker will rank available alternatives on the basis of their relative desirability (i.e. the alternative's 'utility'), and will always attempt to derive maximum utility or benefit in choosing an alternative. In random utility theory this assumption is relaxed somewhat in that it acknowledges that decision makers do not always, if ever, have perfect information on the relative utility of alternatives, and that they do not always respond rationally (in a utility maximisation sense). Random utility theory still assumes that a decision maker will choose the alternative which 'appears' to maximise benefits, but subject to individual variation in perceptions and preferences. As a result, travel data collection focused on the degree to which attributes like comfort and safety were important to travellers in their choice of mode, in addition to travel time and cost. Travel analysts employed 'scaling techniques', developed in the field of psychology, to collect quantitative data on travellers' perceptions of, and attitudes towards, different transport modes. (Meyer and Miller 1984, Pas 1990, Wegener 1994)

2.2.3.3 *Micro-simulation methods*

Micro-simulation methods emerged in the early 1980s in response to criticisms of the coarseness of networks and travel impedance used in early network assignment methods within the four stage forecasting procedure – more specifically, that these earlier assignment methods took account of neither intersection delays in travel times, nor potential routings using local roads. Earlier assignment models had relied on link speed-flow relationships to estimate journey times for use in determining route choice, and traffic was loaded onto the entire route from origin to destination regardless of intersection capacity. Micro-simulation models therefore used assignment networks incorporating all the links and intersections within a local area road network (as opposed to simply arterials), and incorporated the estimation of delays at intersections, to evaluate the impacts of TSM and other traffic control measures. They simulated either the behaviour of individual vehicles as they move through a road network in 'platoons' (i.e. microscopic simulation) or the movement of vehicles as a fluid (i.e. macroscopic simulation). They required a more detailed TAZ demarcation and assignment network

²⁶ Logit analysis predicts modal split on the basis of each mode's relative desirability for any given trip. The logit model involves a comparison of the 'disutility' of travel between two TAZs for the different modes available. Disutility is a term used to represent a combination of the travel time, cost and convenience of a mode between an origin and a destination. It is found by placing multipliers (or weight coefficients) on these factors, and adding them together. A mode is seen to be more desirable (i.e. have greater 'utility') if it is faster, cheaper, or has other more favourable attributes than competing modes. The size of the multiplier will be different depending upon the purpose of the trip, because it has been found, for instance, that travellers tend to be more willing to wait or walk longer distances for work trips than for shopping trips. Once disutilities are known for the various mode choices between an origin and a destination, the trips are split among various modes based on the relative differences between disutilities. A large advantage in disutility will mean a high percentage predicted for that mode. (Beimborn 1995, CRA Inc. 1976)

than area-wide models, but had no significant implications for travel data collection methods. An example of a micro-simulation model is SATURN.²⁷ (Willoughby and Emmerson 1999)

2.2.3.4 Assumptions

The approaches to travel analysis that emerged during this period explicitly addressed the problematic underlying assumptions of earlier aggregate four-stage models. Individual approaches however tended to address only one or two of these problematic assumptions, not all. The new land use-transport interaction models for instance, while explicitly addressing the assumption that land use patterns could be forecast independently of transport changes, continued to assign trips to coarse interzonal networks. Other problematic assumptions from the earlier 1950s-1960s period were not explicitly addressed during this period – these include (see Bates and Dasgupta 1990, Cairns *et al* 1998, Goodwin 1997, IHT 1996, amongst others):

- that ‘cross-sectional’ data on travel behaviour was stable, and that disaggregated individual or household travel behaviour is thus habitual or highly repetitive (i.e. if an individual chooses a particular mode and a particular destination for one trip, that individual will continue to choose the same mode and the same destination for subsequent trips with the same purpose);
- that (in the case of gravity theory-based trip distribution models used in disaggregate four-stage and land use-transport interaction models) interzonal trips can be distributed on the basis of the quantity of, and the travel times between, trip ends – which meant that socio-economic-cultural factors in trip distribution continued to be ignored; and
- that (in the case of equilibrium-based network assignment models) driver choices relate only to alternative routes²⁸ – which meant that the numerous possible driver responses to congested routes (that do not involve simply selecting another quicker route) continued to be ignored.

Further assumptions shared by the new approaches that emerged during this period include (see Hanson and Schwab 1995, Kurani and Lee-Gosselin 1996, Pas 1996, Pipkin 1995, RDC Inc. 1995, Supernak 1983, amongst others):

- that focusing on the trip, in either aggregated or disaggregated form, was the most appropriate way of understanding travel behaviour and demand;
- that travel behaviour and choices across disaggregated individuals were fairly homogenous; and
- that disaggregated individuals are relatively free, unconstrained agents in making travel choices.

²⁷ SATURN (Simulation and Assignment of Traffic to Urban Road Networks) was developed by Dirck van Vliet *et al* of the University of Leeds, and applied in various parts of the developed and developing world. It analyses and evaluates traffic management schemes (e.g. the introduction of one-way streets, changes to intersection controls, bus lanes, etc.) over local road networks (typically of the order of 100-150 intersections). (Hall *et al* 1980, Ortúzar and Willumsen 1994, van Vliet 1982)

²⁸ Phil Goodwin (1997) argues that while this assumption within John Wardrop’s principle of equilibrium was initially only a simplifying assumption, it became entrenched in network assignment modelling practice and has only recently been questioned.

2.2.4 1980s-1990s: Responses to critiques of static, trip-based analyses and their behavioural theory

The fourth period of travel analysis emerged in response to critiques of static and trip-based approaches to analysis, and their underlying behavioural theory, that were made during the late 1970s and 1980s in the developed world, primarily in Sweden, the United Kingdom, and the United States. Critics argued that the assumptions underpinning the approaches from the previous periods, particularly those relating to the homogeneity, freedom and repetitiveness of trip decisions, were problematic. It was argued that the earlier approaches could neither take into account the diversity of travel needs across individuals, nor reveal whether particular groups of individuals (categorised on the basis of gender, age, disability, income, etc.) had adequate and equitable access to transport services²⁹. It was argued that travel choices (e.g. mode and destination choice) are rarely truly free or independent choices, but rather choices made within, sometimes considerable, constraints and differences in power and divisions of labour within households and society more generally. It was further argued that trip choices are not necessarily repetitive.

Two key analytical methods emerged during this period in response to these criticisms – ‘dynamic methods’, and ‘activity-based methods’.

2.2.4.1 *Dynamic methods*

Dynamic methods emerged in the early 1980s in response to criticisms of the static nature of earlier methods – most travel analysis had up until the 1980s been based upon models estimated on cross-sectional data. Critics argued that different generations and sectors of society have different travel needs, and consequently that as the overall composition of society changes as it ages, so the aggregate nature of travel demand will change as well. They also argued that responses to changes in the transport system are slow and periodic – often associated with ‘life-cycle’ change and its associated ‘shocks’. The life-cycle concept recognised that there are a number of specific stages in household formation which have very different travel implications (e.g. couples with children have different travel patterns to couples without). It recognised that the transition from one stage of the ‘life cycle’ to another is often the cause of a specific reassessment of transport options, and that travel decisions are not in a process of constant reappraisal, as some disaggregate choice models had assumed. (Bates and Dasgupta 1990, Zimmerman 1982)

²⁹ A body of literature emerged in the 1970s which argued that certain groups within society were consistently overlooked in transportation planning. Two seminal books within this literature were authored by John Falcocchio and Edmund Cantilli (1974) entitled *Transportation and the disadvantaged*, and by Delbert Taebel and James Cornehlis (1977) entitled *The political economy of urban transportation*. The ‘transport disadvantaged’ or ‘outsiders’ identified in these texts included ‘the poor’, ‘the young’, ‘the elderly’, ‘the handicapped’ and ‘minority groups’. Subsequent literature has tended to focus on three main themes: gender, age and disability.

This emphasis on temporal change and hysteresis, led to the emergence of dynamic models that predicted the impact of life cycle and other changes on the travel patterns of a 'synthetic' population,³⁰ and to new methods of 'longitudinal' travel data collection. These took the form of either 'repeated cross-sectional surveys' whereby similar observations on samples from an equivalent population were made at different points in time (i.e. the population samples surveyed at different points in time were made up of different respondents), or 'panel surveys' whereby similar observations on the same population sample were made at different points in time (e.g. every two years).

2.2.4.2 Activity-based methods

Activity-based methods emerged in the late 1970s and early 1980s in response to the limited behavioural theory underlying earlier analytical methods. In activity-based methods the phenomenon being analysed was redefined – activities, and the demand for travel derived from participation in these, replaced trips as the new unit of observation. Emphasis was placed on understanding the complexity and interrelatedness of travel patterns within households, and within the constraints that this interrelatedness placed on an individual's travel choices. It was argued that it was not possible to understand how travel behaviour might respond to changes in the transport system, without a much deeper understanding of the everyday lives and activities within which travel decisions are embedded. As in the case of other travel analysis methods, activity-based methods drew behavioural theories and analytical techniques from other fields, particularly micro-economics and psychology, but what made these methods distinct however was that their theoretical roots lie primarily in geography. (Ettema and Timmermans 1997, Jones *et al* 1990, Kurani and Lee-Gosselin 1996)

The work on activity-based methods in the 1980s focused on new approaches to data collection in the form of household activity-travel diaries. As the analytical framework applied in the primary research presented in this dissertation, these data collection methods and their theoretical underpinnings are discussed in greater detail later in chapter 3. In the 1990s, work focussed on developing various activity-based travel forecasting models. The single defining feature of these models is perhaps that they attempt to predict travel behaviour by simulating changes in the daily 'activity schedules' of representative synthetic individuals, or households, in response to changes in the temporal, spatial and transportation environment. An example of an activity-based travel demand model is SAMS.³¹

³⁰ An example of a synthetic dynamic model is MASTER (Micro-Analytic Simulation of Travel and Employment and Residences Model) developed by Roger Mackett of University College London, and applied in Leeds (United Kingdom). Within MASTER each synthetic individual and household is progressed through a sequence of events, including demographic, socio-economic, travel and locational changes. The model is designed to represent the individual's short term responses (e.g. mode choice), as well as long term responses to changes in the cost of transport (e.g. choice of home or job). (Bates and Dasgupta 1990)

³¹ SAMS (Sequenced Activity Mobility Simulator) was developed by Resource Decision Consultants Inc. in San Francisco, and applied in Washington DC. It is, in essence, an integrated simulation model of land-use, socio-demographics, vehicle transactions, activity-travel behaviour, network performance and air quality. It is different from earlier models in the following main respects. Firstly, it shifts from trip-based analysis to activity-based analysis, which enables the model to address issues related to the choice of non-travel alternatives. Secondly, it shifts from cross-sectional analysis to longitudinal analysis, which enables the model to examine the effects of adaptation to life-cycle change. Thirdly, it shifts from deterministic aggregate extrapolation (i.e. the use of statistical correlations of variables aggregated at a TAZ level to forecast

2.2.4.3 Assumptions

The dynamic and activity-based forecasting models discussed above are still effectively in the process of development, and in most instances have yet to be made operational. Little has therefore been said in the literature about the problematic assumptions that may become apparent in their application. Nevertheless, the basic assumptions made by these methods would appear to include (see Bates and Dasgupta 1990, Damm and Lerman 1981, Hanson and Huff 1986, Hartgen 1988, Supernak 1983, amongst others):

- that understanding travel behaviour in a more complex and systemic, dynamic or activity-based way will assist in improving transport planning and infrastructure investment (i.e. that there is a clear relationship between dynamic and activity data and decisions involving capital improvements) – some authors have argued that the usefulness of these data, and activity data in particular, does little more than confirm that travel behaviour is complex; and
- that data of the required complexity can indeed be collected accurately – in the case of panel surveys, that it is possible to maintain sufficient respondent participation, and in the case of activity surveys, that one-day diaries provide an accurate indication of household activity-travel patterns over a longer weekly or monthly time periods,³² or alternatively that multi-day diaries with greater respondent burden are completed accurately.³³

2.2.5 1990s: Responses to pollution and shifts from supply-side to demand-side transport policies

The fifth period of travel analysis emerged in response to declining air quality, the threat of global climatic change as a result increased ‘greenhouse gas’ emission,³⁴ and fundamental changes in transport policy that occurred in the 1990s within the developed world. Numerous ‘watershed’ events occurred at the end of the 1980s and early 1990s, in the United Kingdom and United States in particular, which caused transport policies to be fundamentally reconsidered.

future travel) to stochastic micro-simulation. (i.e. the simulation of specific trips made by individuals), which enables the model to be more sensitive to transport system characteristics like localised parking costs and availability. Fourthly, it shifts from optimisation to satisficing in decision-making assumptions. (RDC Inc. 1995, Spear 1996)

³² Empirical studies in Sweden, the United Kingdom and Australia showed that an individual’s daily travel patterns tend to vary considerably over time (a phenomenon referred to as ‘intra-personal variability’). The causes and patterns of intra-personal variability subsequently became an active arena of activity-based study and debate in the transport planning literature (see for instance Hanson and Huff 1988, Jones and Clarke 1988, Kitamura and van der Hoorn 1987, Kunert 1994, Pas and Koppelman 1986, Pas and Sundar 1995, among others).

³³ Some studies have shown that respondents (particularly children) sometimes fail to record certain types of activities and trips later in the survey period (particularly walking trips and discretionary trips that formed part of a trip chain). (Golob and Meurs 1986)

³⁴ The main greenhouse gases produced by human activity include chlorofluorocarbons (CFCs), carbon dioxide (CO₂), and nitrous oxide (NO_x). Studies have shown that petroleum-fuelled transportation is a major global source, with road transport estimated to be responsible for some 88% of carbon monoxide (CO), 48% of NO_x, 37% of hydrocarbon (HC), and 20% of CO₂ emissions (Blessington 1994, Cervero 1996, Greene and Santini 1993, Replogle 1993).

In the United States some of these events included the passing of the *Clean Air Act Amendments* (CAAA) in 1990, and the *Intermodal Surface Transportation Efficiency Act* (ISTEA) in 1991. CAAA addressed the attainment and maintenance of National Ambient Air Quality Standards (NAAQS). It classified 'non-attainment areas' according to the severity of their air pollution problem.³⁵ The CAAA prescribed transportation actions which needed to be taken in each non-attainment area in order to achieve compliance. These actions, which included conducting an emissions inventory and introducing transportation control measures (TCMs), were cumulative, according to the degree of non-attainment. The TCMs referred to in the CAAA included *inter alia* enhanced public transportation services, provision of higher occupancy vehicle lanes, and congestion pricing. ISTEA gave States and urban areas in the US unprecedented flexibility with respect to the transfer of funds between road building and public transport projects. ISTEA required that the transportation planning process give greater consideration to the social, economic and environmental effects of transport systems. It provided the funds with which non-attainment areas (in terms of the CAAA) could implement urban transportation strategies aimed at achieving their CAAA targets. It also mandated greater consideration of transportation system management and travel demand management strategies to make existing transport systems more efficient. (Papacostas and Prevedouros 1993, Pas 1995, Shrouds 1995, Weiner 1997)

In the United Kingdom some of these 'watershed' events included: a conference on *Transport: the new realism* in London in 1991, and the publishing of a report by the Department of Transport's Standing Advisory Committee on Trunk Road Assessment (SACTRA) in 1994 on the traffic impacts of increased road capacity. The *Transport: the new realism* conference discussed the implications of the Department of Transport's revised national traffic forecasts and white paper of 1989, entitled *Roads to prosperity*. The forecasts suggested that by the year 2025, traffic levels would be between 83% and 142% higher than they were in 1988. A report prepared for discussion at the conference (by the same name) – the product of a research programme on traffic growth and policy solutions – argued that there was growing consensus that it was neither possible to increase the capacity of road networks to accommodate such traffic increases, nor, for environmental reasons, a particularly good idea to do so even if this were possible (Goodwin *et al* 1991). The conference led to a fairly widespread realisation within the transport planning discipline (i.e. the 'new realism') that there was no realistic possibility of increasing road supply to a level that would match the forecast growth in demand, and that subsequently whatever road construction policy was followed, in the absence of a transport policy centred on demand management and the improvement of public transport systems, the amount of traffic per unit of road would increase rather than reduce (i.e. congestion would get more severe or more widespread). In other words, there was a realisation that if supply could not be matched to demand, demand would have to be matched to supply. The SACTRA report, entitled *Trunk roads and the generation of traffic*, concluded that empirical and simulated evidence illustrated that increases in

³⁵ In 1988, 101 urban areas in the United States failed to meet NAAQS for ozone, and 44 areas failed to meet NAAQS for carbon monoxide. (Weiner 1997)

road capacity in congested conditions were likely to generate, or 'induce', more traffic – lending support to the 'new realists' claim that traffic forecasts could not be accommodated through new road construction. Thus, far from being an exogenous variable, SACTRA illustrated that, under certain conditions and with certain caveats, the construction of new and wider roads to accommodate traffic forecasts did little to relieve traffic congestion, at least in the longer term, as it simply released latent traffic demand. (Goodwin 1996)

These 'watershed' events led to what Sally Cairns (1998) called the 'formal demise of predict and provide', and to what Phil Goodwin (1997) called a recognition that 'different policies will result in different forecasts'. It became increasingly clear that the volume of traffic on a road network, and its concomitant congestion and pollution effects, is the result of, or at least influenced by, policy, and therefore subject to some degree of normative policy choice. At a discursive level at least, supply-side 'predict and provide' policies thus began to be replaced by demand management policies. This shift had fundamental consequences for the nature and purpose of travel analysis, and the very questions addressed in analysis were challenged. There was an increasing recognition that the travel demand forecasting models used up until the 1980s were not intended to evaluate the effects of demand management policies.³⁶ It was recognised therefore that new methods of travel analysis needed to be developed. (Goodwin 1997, IHT 1996, Pas 1995)

Two key analytical methods emerged during this period – 'stated preference methods' and 'policy appraisal models'.³⁷

2.2.5.1 Stated preference methods

Stated preference (SP) methods emerged in the 1980s, initially as a way of assessing the impact of public transport improvements on private to public mode switching, but later as a way of assessing the impact of wider transport system changes (e.g. examining fare elasticities or responses to road tolls and service improvements). The normal approach to data collection was to present a number of hypothetical alternatives and to invite each survey respondent to either choose between them, place them in order of preference, or assign a rating to them. The unique characteristic of SP surveys (also known as 'hypothetical surveys') is that rather than collecting observed (or 'revealed preference') data, they are based on respondents' reactions to hypothetical alternatives. The outputs of SP surveys

³⁶ This recognition is perhaps best captured in this quote from Phil Goodwin's inaugural lecture as the Professor of Transport Policy at the University College London, entitled *Solving congestion: when we must not build roads, increase spending, lose votes, damage the economy or harm the environment, and will never find equilibrium*: "our ability to treat the new policies analytically; to understand their effects; to assess their costs and benefits; is seriously hindered by our inheritance of an analytical tool-kit that is bright, impressive, of unchallengeable intellectual achievement, and wrong." (Goodwin 1997:8)

³⁷ It should be noted that the dynamic and activity-based methods discussed earlier were also developed, in part, to examine the ability of policies to manage travel demand, and therefore fall within this period as well. The separation of the two periods is therefore somewhat artificial, based mainly upon analytical method.

have also been used in some of the mode choice models discussed earlier. (Bradley 1997, Hensher 1993)

2.2.5.2 Strategic policy appraisal methods

Strategic policy appraisal methods emerged in the early 1990s in the United Kingdom, in response to the above mentioned shift from supply-side to demand-side policies. Earlier methods were generally unable to test the efficacy of a wide variety of policy options (e.g. congestion pricing, peak period surcharges on public transport services, parking charges) quickly and cheaply. Strategic policy appraisal methods predict the potential impact of different travel demand management policy scenarios on travel behaviour, at a strategic (i.e. non-detailed) level. Short turnaround times are achieved by limiting the spatial detail of the model – they have a smaller number of bigger zones (typically only 10-30 TAZs, chosen to reflect only broad variations in land use and traffic density), and coarser, sometimes schematic, assignment networks, than conventional models. They are essentially multi-modal ‘equilibrium’ models in which the demands for transport are balanced iteratively (or ‘converged’) with the available supply. In other words, the models seek a point where the demand for travel is consistent with the performance of the transport system in servicing that level of demand. The models take as a given an externally provided base description of travel movement considered to be in equilibrium, and predict the changes that would occur, relative to this base, given changes in the generalised cost of travel. Outputs typically include travel and generalised cost matrices of standard performance measures (e.g. number of trips, public transport ridership, vehicle kilometres travelled, etc.). An example of a strategic policy appraisal model is START.^{38,39} (Dasgupta *et al* 1994, Halden 1996, Roberts and Simmonds 1997)

2.2.5.3 Assumptions

The approaches to travel analysis that emerged during this period made the following basic assumptions (see IHT 1996, Inaudi *et al* 1995, among others):

³⁸ START (Strategic and Regional Transport Model) was developed by The MVA Consultancy in the United Kingdom, and applied in Bristol, Edinburgh, London and Merseyside (United Kingdom), and Sao Paulo (Brazil). Policies and strategies for appraisal can be fed into the model in two ways. Firstly, by intervening directly in the generalised cost matrix (e.g. by pricing policies), or secondly, by modifying the transport supply process (e.g. by road space management), to represent changes in capacity. In both cases the result is a change in travel demand which can be compared to, and evaluated against, the results of other policies and strategies. (IHT 1996, Coombe and Copley 1993, Roberts and Simmonds 1997)

³⁹ A further form of policy appraisal model are the air quality emissions models that have emerged in the United States in response to clean air requirements. Air quality emissions have been modelled either within an additional fifth sequential-independent model added onto conventional four-stage framework (e.g. MOBILE), or within integrated activity-based travel demand forecasting models that include interactive air quality emissions (e.g. TRANSIMS, SAMS). By assuming a certain mix of vehicles in the regional fleet, air quality emission models estimate the particular set of air pollutant emissions that would result from traffic flows. Emissions (measured in grams) are calculated by multiplying vehicle travel activity (usually measured in vehicle kilometres travelled) by an ‘emission factor’ (usually measured in grams/vehicle kilometre travelled). Emission factors vary depending on vehicle characteristics (e.g. class, age), fuel and the vehicle operating environment (e.g. altitude, meteorological conditions). Atmospheric dispersion models then mix emissions from traffic with emissions from stationary sources, to estimate the concentrations of pollutants at different locations and at different times of day. (FHWA 1994, Garrett and Wachs 1996, Inaudi *et al* 1995, Pas 1995, SAI 1994)

- that (in the case of stated preference methods) respondents would actually do what they said they would do in survey responses, and that they are able to fully appreciate the consequences of their responses for household activity scheduling, expenditure, time use, etc. within an interview environment;
- that (in the case of policy appraisal methods) estimated behavioural responses to transport system changes, modelled on the basis of coarse TAZ and network descriptions, are sufficiently detailed for the purposes of making strategic policy decisions – which meant that the appraisal of any policy which affects travel in a way which is not homogenous over the TAZ (e.g. the impact of a new fixed public transport line with a catchment area narrower than the TAZ) is unlikely to be accurate; and
- that (in the case of policy appraisal methods) representing the travel demand consequences of introducing a particular policy and strategy in the form of a static supply-demand equilibrium condition, will provide an indication of behavioural responses to changes over time that is sufficient for the purposes of making longer term strategic policy decisions – which means that the pace of behavioural change cannot be particularly well understood, and the impact of life-cycle changes and ‘cohort effects’ on travel behaviour is unlikely to be taken into account.

2.3 TRAVEL ANALYSIS AND DATA COLLECTION METHODS APPLIED IN SOUTH AFRICA

Which then of the data collection and analytical methods described above have been applied in South Africa? A review of the South African literature of the latter half of the 20th century on travel analysis, supplemented by practitioner interviews, reveals four discernible overlapping periods in which travel analysis was dominated by either a particular theme, or a group of related themes (see figure 2.5). These periods, their analytical themes, and the methodological streams they employed, are discussed briefly in turn.

Figure 2.5 *Periodisation of dominant themes in South African travel analysis*

	1960s	1970s	1980s	1990s
Collection (and updating) of data necessary for the calibration of earlier travel demand forecasting models		[Bar spanning 1960s and 1970s]		
Analysis of the of travel patterns of the black/disadvantaged population				[Bar spanning 1980s and 1990s]
Collection (and updating) of data necessary for the calibration of EMME/2 modelling software				[Bar spanning 1990s]
Collection of data to inform a policy shift to customer-based passenger transportation				[Bar spanning 1990s]

The first period of travel analysis occurred during the late 1960s, 1970s and early 1980s and was concerned primarily with the collection of the data necessary for the calibration of the earlier travel demand forecasting models run in South Africa. Most of these models took aggregate four-stage form, with MINI-TRAMP and DELTRAN the most commonly applied software (see table 2.1). Some land use-transport interaction and disaggregate mode choice methods were also applied, but to a limited extent. In reviews of transport modelling software and travel data sets available in South Africa, Ferreira (1977), Jordaan (1989), Crous and Price (1993) and Wilmot *et al* (1990) illustrate that between 1965 and 1985 most of the major urban centres applied these models in one form or another, and administered the surveys and traffic counts necessary for their calibration and updating (generally at 8-9 year intervals). The surveys that were administered typically took the form of racially stratified home interviews. Their scope was usually, but not always, limited to weekday morning peak periods, within which data were collected on variables like trip purpose (but sometimes limited to just home-based work trips), origin, destination, mode use, travel time, distance and frequency (Wilmot *et al* 1990).

Table 2.1 *Travel demand forecasting software applied in South Africa during 1960s to 1980s period*

SOFTWARE	MODEL DESCRIPTION	SOUTH AFRICAN APPLICATIONS
MEPLAN	land use- transport interaction model	Cape Town (CMT)
DELTRAN	four-stage travel demand forecasting model	Durban, Witbank, Sandton, Port Elizabeth, Klerksdorp, East Rand (ORMET)
MINI-TRAMP	four-stage travel demand forecasting model	Bloemfontein (BLOEMET), Johannesburg (JOMET), Port Elizabeth (PEMET), Pietermaritzberg (PMBMET), Pretoria, Sandton, Vryheid, Ladysmith/Newcastle, Sasolburg, Vosloorus, Randburg, Modderfontein
MOTORS	four-stage travel demand forecasting model	Verwoedburg, Sandton
QRSII	four-stage travel demand sketch planning model	East Rand (ORMET)
TANDEM	four-stage travel demand forecasting model	Pietersburg
UTPS	four-stage travel demand forecasting model	PWV, Pretoria (PREMET)
BLOGIT	disaggregate logit choice model	Rustenburg, Bloemfontein (BLOEMET), East Rand (ORMET), Pretoria
ULOGIT	disaggregate logit choice model	PWV

Sources: Jordaan 1989, Crous and Price 1993

The second discernible period⁴⁰ of travel analysis occurred during the mid 1980s and early 1990s and was concerned primarily with analysing the impacts of apartheid urbanisation and segregation policies on the travel patterns of 'black' workers, and with gathering data on the travel patterns of the 'black' (or 'disadvantaged') population necessary for either informing urban transport policy formation or for

⁴⁰ A body of travel analysis prior to this period, but insufficiently large to be called a period, was concerned with travel patterns and traffic behaviour within residential neighbourhoods and their implications for the development road layout planning and geometric design guidelines. Two such studies were undertaken by the National Institute for Transport and Road Research (NITRR) of the Council for Scientific and Industrial Research in the early 1980s. The first study conducted either 12 hour or peak period vehicle and pedestrian cordon counts in six middle-income 'white' residential areas in Pretoria (Cameron and Del Mistro 1981). Data were collected on vehicle and pedestrian flows, timing, mode use and trip direction. The second study conducted an activity-based home interview survey to analyse activities, attitudes and trip-making in seven residential neighbourhoods in Pretoria, Johannesburg, Durban and Cape Town (Cameron *et al* 1984). The study was limited to higher and middle-income 'white' residential areas (with the exception of 'coloured' households in Mitchells Plain, Cape Town). The 24 hour weekday activity diary was used to record the daily activity and travel pattern of household members. Data were collected on trip purpose, timing, mode use and route choice into and out of the residential area.

including previously excluded township areas in travel demand forecasting studies. Studies concerned with the travel impacts of apartheid policies were undertaken by Fourie and Morris (1985) and Morris (1982, 1986), and by various urban geographers (see review of South African transport geography by Pirie and Khosa, 1992). Fourie and Morris (1985) and Morris (1986) applied activity-based methods to study the effect of long journey times on the daily activities of black commuters in Pretoria. Data were collected on work trip lengths, time budgets and mode use. Studies concerned with gathering data to inform policy and travel demand forecasting studies were undertaken by various consultants and transport authorities. Personal or home interview surveys of the trip generation, travel characteristics and infrastructure needs of 'black' travellers were undertaken by Davies and Bester (1994), de-Lange and Vorster (1989) and Pienaar (1994). Survey and cordon counts of 'black' and 'coloured' commuters were undertaken by Aron *et al* (1990), CTCC (1981) and VKE (1986, cited in Wilmot *et al* 1990). Surveys of the impact of the emerging minibus-taxi industry on the mode choice of 'black' travellers were undertaken by Freeman (1987), and Oosthuizen (1986) and VKE (1989) (both cited in Wilmot *et al* 1990). Perhaps the most extensive study however was the national passenger panel survey run between 1987 and 1994, which collected longitudinal data on the transport expenditure, mode availability, mode use and transfer and travel time of 'black' (or 'disadvantaged') commuters (van der Reis *et al* 1993, van der Reis and Lombard 1995).

A third period of travel analysis occurred during the early 1990s and was concerned primarily with the collection of the travel data necessary for the calibration of newly acquired EMME/2 four-stage travel demand modelling software. Whereas numerous software packages were in application in the late 1980s (see table 2.1), Davies *et al* (1995) demonstrate that by the early 1990s almost all South African transport authorities had converted to the Canadian software EMME/2 (see table 2.2). This shift can be attributed to the, at the time, superior flexibility, multi-modal assignment and graphics capabilities of EMME/2 over earlier four-stage modelling software (Crous and Price 1993, Davies and Rontiris 1992). Data collection to calibrate and update these models occurred between 1989 and 1999 (Davies *et al* 1995). In many, if not most instances, the models have been calibrated for the weekday morning peak period when congestion is generally worst, and consequently travel data (i.e. origin, destination, timing, mode use) were either collected for only work trips or trips occurring within the weekday morning peak.

Table 2.2 *Travel demand forecasting software applied in South Africa during 1990s period*

SOFTWARE	MODEL DESCRIPTION	SOUTH AFRICAN APPLICATIONS
DELTRAN	four-stage travel demand forecasting model	Durban
EMME/2	modular four-stage travel demand forecasting model	Pretoria, Johannesburg, East Rand, Vaal, Bloemfontein, Cape Town, Port Elizabeth, East London, PWV, Durban
TRANPLAN	modular four-stage travel demand forecasting model	Welkom

Sources: Davies *et al* (1995), Crous (1992)

The fourth, and most recent, period of travel analysis occurred during the latter half of the 1990s and was concerned primarily with the collection of data to inform a post-apartheid government policy shift from 'commuter-based' to 'customer-based' passenger transportation (i.e. a shift in concern from transporting peripherally located labour into and out of employment centres, to improving the access of peripheral township populations to the full range of educational, social and economic opportunities offered by urban agglomerations).⁴¹ The identification and analysis of 'customer segments' in post-apartheid transport policy was based on October Household Survey (OHS) data (which was initially hoped to replace the annual national passenger panel survey as a source of data to inform policy formulation), and a home interview survey to compensate for the work trip focus of the OHS. In the survey, data were collected mainly on mode use, availability and satisfaction, travel time and expenditure, and attitudes towards mode switching. More recently, the *National Land Transport Transition Act (No. 22)* of 2000 has required the collection of public transport ridership data in the major urban centres for the purposes of formulating public transport rationalisation and licensing strategies, in the form of 'current public transport records'. (NDoT 1998, TRC Africa 2000)

2.4 REPRESENTATIONS OF TRAVEL NEEDS AND BEHAVIOUR IN CAPE TOWN AND OTHER SOUTH AFRICAN CITIES

How then have travel needs and behaviour in Cape Town and other South African cities been represented as a result of the analytical activity described above? A combination of apartheid policies, that dictated an analytical focus on the daily transportation of labour in and out of cities, and the dominance of predictive four-stage travel demand models and their data requirements in South African travel analysis, has resulted in most representations of travel needs and behaviour being restricted to either home-based work trip-making or travel occurring within peak periods. In both instances the focus has been on interzonal (i.e. longer distance) travel by motorised modes. As will be demonstrated later in this section, there are of course exceptions that provide insights into non-work, off-peak and non-motorised travel needs and behaviour, but these are limited and many had as their underlying purpose the development of trip generation rates for use in the first stage of the four-stage travel demand forecasting procedure, rather than the development of a complex understanding of travel behaviour, choices and constraints.

Only published (revealed preference) studies involving household or personal interview surveys are included in the review of secondary data sources reported in this section. Studies involving just traffic or passenger counts are not included on the grounds that they reveal insufficient data on travel

⁴¹ For a discussion on the political economy of urban transportation in South Africa during the apartheid era, see McCaul (1992), Pirie (1992) and Robinson (1985).

behaviour. Only written reports on the surveys are reviewed – access to electronic data sets was not obtained.⁴²

In the case of studies administered in Cape Town, only those conducted between 1973 and 1998 are included in the review. These are listed in table 2.3. In his MSc thesis – the first of these studies – Eric Pas (1974) identifies an origin-destination survey of 1956 as the only travel survey in Cape Town conducted prior to 1973. The survey was administered by the City Engineer's Department of the Cape Town City Council. Together with subsequent traffic counts, it provided the bulk of the data used for the planning and design of that part of Cape Town's urban freeway system constructed in the 1960s and early 1970s. In the case of national studies, or studies of particular interest to the research topic administered in cities other than Cape Town, only those conducted between 1989 and 1999 are included in the review. These are listed in table 2.4.

Table 2.3 *Household/personal interview travel surveys in metropolitan Cape Town (1973-1998)*

SURVEY YEAR(S)	STUDY	TARGET POPULATION AND SAMPLE SIZE	TEMPORAL SCOPE	TRIP PURPOSE SCOPE
1973	An analysis of residential trip generation in Cape Town	'white' population living in southern suburbs and Atlantic seaboard (1 690 home interviews)	previous 24 hour weekday (Thursday)	work, shopping, return home, education, pleasure, other
1976	Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey	'white' and 'coloured' populations living in 'Cape Town and vicinity' (3 035 home interviews)	previous 24 hour weekday	home, work, business, personal business, shopping, educational, social/recreation, serve passenger, changing mode of transport
1977	Scholar transport survey	Sub A to Standard 10 scholars attending 'southern suburbs' schools (2 624 personal interviews)	usual school day	school, leisure
1980-1981	Cape Flats commuter study	middle and lower income 'coloured' and 'black' commuters living on the Cape Flats (5% sample of 1980 Census)	weekday morning peak	work
1981	Activities, attitudes and trip-making in residential areas	'middle income group' living in Plumstead, Edgemoed and Mitchells Plain (268 home interviews)	next 24 hour weekday	work/further education, school, shops, visiting, recreation, entertainment
1984	Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey	'white', 'coloured' and 'black' populations living within the Cape Town metropolitan transport area (750 home interviews)	usual 7 day week	from home to work, from home to education, from home to shops and/or services, from home to social and/or recreational activities, on employer's business, from home to serve a passenger

continued overleaf ...

⁴² It was decided that past electronic data sets (in Cape Town) were too outdated to warrant primary analysis, with the exception of Moving South Africa survey of 1997 (see table 2.3) which was unobtainable (Ibrahim Seedat pers comm 2000).

1985	Short distance commuting and the use of combi-taxis in Cape Town	short-distance (<15 km) 'black' and 'coloured' commuters living on the Cape Flats	usual weekday	work
1991-1992	Survey of the transport problems experienced by residents in the Cape Town metropolitan area	population of the Cape Metropolitan Area, stratified into 'white', 'coloured' and 'black' areas (500 home interviews)	usual 7 day week	to work, looking for work, taking children to school, to attend school/college, to shop for the household, recreation, church related
1991-1992	Cape Town Metropolitan Transport Study (EMME/2) household interview survey	commuters living in transport zones across the Cape Town metropolitan transport area (15 000 home interviews)	usual weekday	work
1992	National passenger panel 1992	'black', 'white', 'coloured' and 'Asian' commuters aged 18 years or older (970 personal interviews)	previous month	work
1994	National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities	'disadvantaged' (i.e. 'black', 'coloured' and 'Asian') commuters aged 18 years or older (292 personal interviews)	usual and previous trip	work
1995, 1997	Moving South Africa market segmentation	passengers (or 'customers') living in Khayelitsha, Gugulethu, Nyanga, Wynberg, Kenilworth, Claremont, Plumstead and Parow North (125 home interviews)	previous week	to and from work, in the course of work, looking for work, shopping, taking children to school, social/visiting friends/family, education, sport and recreation, other
1998	Study to determine the transport needs of mobility disadvantaged persons	mobility disadvantaged passengers (156 personal interviews)	no timeframe specified	not specified

Table 2.4 (Selected) household/personal interview travel surveys in South Africa (1989-1999)

SURVEY YEAR(S)	STUDY	TARGET POPULATION AND SAMPLE SIZE	TEMPORAL SCOPE	TRIP PURPOSE SCOPE
1989	Walking distances by income group, by mode and by trip purpose	'white' and 'black' (as a proxy for income group) pedestrians in the central business districts of Johannesburg and Pretoria (2 315 personal interviews)	current weekday (and Saturday) afternoon peak	work to home, shopping, other
1992	Trip-making characteristics of squatters	residents of informal housing in Mamelodi (Pretoria) and Daveyton (Johannesburg) (592 household interviews)	previous weekday	home, work, change, job seek, education, shop, other
1992	Walking patterns in black residential areas	'black' pedestrians in 4 age group categories living in Mangaung (Bloemfontein), Botshabelo (4 642 personal interviews)	Fridays 06h00-18h00	shopping, medical care, institutional, home, business, work
1987-1988, 1991-1994	National passenger panel 1987-1994	national 'black'/all/'disadvantaged' commuters living in urban centres (between 752 and 3 618 personal interviews)	usual and previous trip	work

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1993-1999	October Household Survey 1993-1999	national employed workers (between 16 000 and 30 000 home interviews)	usual trips in October	work (including limited questions on education, health and access to services)
1995	South African trip generation rates	national passengers (review of secondary sources)	morning/evening peak periods, daily	home-based trip ends
1995, 1997	Moving South Africa market segmentation	national metropolitan/urban passengers (or 'customers') (500 home interviews)	previous week	to and from work, in the course of work, looking for work, shopping, taking children to school, social/visiting friends/family, education, sport and recreation, other
1998-1999	Greater Pretoria household travel survey	morning peak passengers living in the Pretoria metropolitan area (7 883 home interviews)	previous weekday morning peak period (06h00-09h00)	to go home, to go to work, as part of work, to go to school/college, to take someone to school/college, to take someone to work, to take someone to other place, to go shopping, other (with some questions on off-peak travel as well)
1999	Durban Metropolitan key performance indicator/quality of life survey	households living in traffic zones within the Durban metropolitan area (3 967 home interviews)	usual trips	work, study
1995-1997, 1999	Strategic customer-based passenger transport information project	national metropolitan/urban passengers (or 'customers') (review of secondary sources)	usual trips	work

On the basis of a review of these studies, current knowledge of travel needs and behaviour in Cape Town and other South African cities is summarised below. This knowledge is examined in terms of the following variables that, with the exception of attitudes and satisfaction ratings, broadly represent the collective scope of these studies:

- traveller segmentation;
- trip generation;
- trip purpose and chaining;
- trip timing;
- vehicle ownership and availability;
- mode use, transfer, availability and switching;
- travel distance;
- travel and waiting time;
- transport expenditure; and
- latent demand.

2.4.1 Traveller segmentation

The most recent identification and quantification of traveller segments was undertaken by the National Department of Transport (NDoT) and their consultants as part of the earlier mentioned repositioning of urban passenger transport policy within the post-apartheid era (NDoT 1997, TRC Africa 2000). The initial, and subsequent alternative, categorisation of national urban passenger 'customer segments' identified in these studies, and their respective characteristics, are listed in tables 2.5 and 2.6, and illustrated in figure 2.6. The most striking features of these categorisations are perhaps that presently 5-13% of South Africa's urban population do not have access to any form of motorised transport, 60-67% do not have access to private transport, but that if left unmanaged that category of travellers only prepared to travel by private transport could increase by up to 88% in the year 2020.

Table 2.5 *National urban passenger 'customer segments' (1995 n = 30 000 h, 1997 n = 500 h)*

CUSTOMER SEGMENT	DESCRIPTION	DEFINING CHARACTERISTICS	% OF URBAN POP.	PROJ. % GROWTH IN 2020	
non-motorised	'stranded'	cannot use public transport due to cost and access (12% commuters, 42% scholars, 46% other)	<ul style="list-style-type: none"> very low household income resides in ex-homelands, informal settlements/townships walks/cycles > 20 minutes one way 	13%	28%
	'strider'	does not require motorised transport - walking or cycling is adequate for trip distance (9% commuters, 58% scholars, 33% other)	<ul style="list-style-type: none"> all income bands all residential locations except ex-homelands and informal settlements walks/cycles < 20 minutes one way 	25%	28%
	'survival'	captive to a mode within public transport and cost-sensitive (35% commuters, 7% scholars, 58% other)	<ul style="list-style-type: none"> low household income resides in ex-homelands, informal settlements, townships/inner city 	19%	24%
motorised public transport	'sensitive'	captive to public transport but quality sensitive (i.e. choice is made not only based on affordability) (37% commuters, 10% scholars, 53% other)	<ul style="list-style-type: none"> moderate household income resides in ex-homelands, townships, inner city/suburbs mainly female (60%) 	10%	25%
	'selective'	can afford to own a car but willing to give it up, or owns one but willing to use public transport (55% commuters, 10% scholars, 35% other)	<ul style="list-style-type: none"> moderate to high household income resides in townships, inner city or suburbs 	19%	39%
motorised private transport	'stubborn'	unwilling to use any mode other than private car (63% commuters, 13% scholars, 24% other)	<ul style="list-style-type: none"> high household income resides in suburbs and townships averse attitude to public transport predominantly male (63%) 	14%	88%

Source: Moving South Africa market segmentation

In Cape Town no equivalent traveller segmentation has been published. The only recent study of the needs of specific traveller categories, is that commissioned by the Cape Metropolitan Council on the needs of mobility disadvantaged persons (CMC 1999a). This study did not yield quantified data, beyond estimating that there could be at least 714 037 special needs passengers (including disabled,

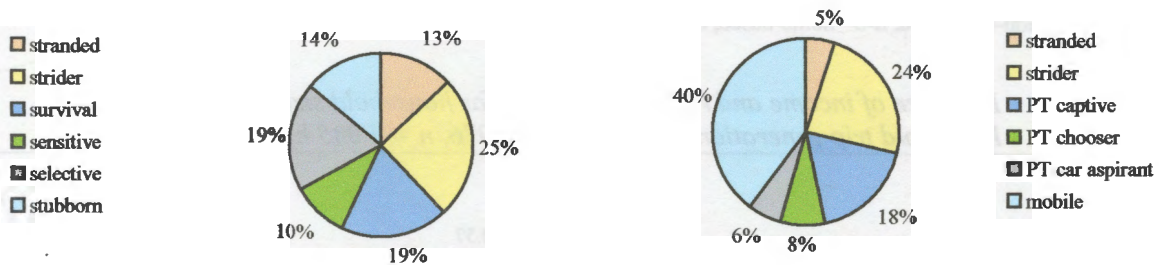
young, old and pregnant passengers) within the Cape Metropolitan Area (CMA) (24.4% of the total CMA population), of which about 99 704 have serious sight, hearing, physical and mental impairment (3.9% of the total CMA population). The conclusion of the study was that existing transport systems did not provide an accessible service to special needs passengers.

Table 2.6 *Alternative national urban passenger 'customer segments' (1995, n = 30 000 h)*

CUSTOMER SEGMENT	DESCRIPTION	DEFINING CHARACTERISTICS	% URBAN POP.	% METRO POP.
'stranded'	cannot use public transport due to cost and access	<ul style="list-style-type: none"> very low household income walks/cycles > 30 minutes one way 	5%	2%
'strider'	does not require motorised transport - walking or cycling is adequate for trip distance	<ul style="list-style-type: none"> all income bands walks/cycles < 30 minutes one way 	24%	10%
'public transport captive'	captive to a mode within public transport and cost-sensitive	<ul style="list-style-type: none"> <R2 500 monthly household income 	18%	24%
'public transport chooser'	captive to public transport but quality sensitive	<ul style="list-style-type: none"> R2 500-R4 000 monthly household income 	8%	13%
'public transport car aspirant'	uses public transport but aspires to using a private car	<ul style="list-style-type: none"> >R4 000 monthly household income 	6%	12%
'mobile'	uses a private car	<ul style="list-style-type: none"> high monthly household income averse attitude to public transport 	40%	39%

Source: Strategic customer-based passenger transport information project

Figure 2.6 *Moving South Africa (left) and subsequent alternative (right) national urban passenger 'customer segments' (1995, 1997)*



Sources: Moving South Africa market segmentation, Strategic customer-based passenger transport information project

2.4.2 Trip generation

Numerous potential factors influence how many trips a household makes, including socio-demographic variables, levels of independent and private mobility, and ease of access to activity sites. Given the importance of trip generation in the four-stage travel demand forecasting procedure, considerable research has been undertaken to identify correlation between such variables and rates of household (and personal) trip-making. Data on (all purpose) trip generation in Cape Town are however outdated (see table 2.7). Comparisons across these and national data for the purposes of establishing patterns, are also problematic. This is due mainly to inconsistencies in the travel modes and trip purpose categories that are included or excluded in different survey questionnaires, and to

inconsistencies in any time or distance exclusions imposed upon walking trip data collection. In addition, as will be discussed later (in chapter 3), the survey methodology itself can have an effect on respondent's trip recall. Nevertheless the local and national data reveals fairly clearly that daily household trip rates tend to increase as household size increases (typically associated with racial stratifications) (see table 2.7), as well as decrease as household incomes decline (see table 2.8). This is perhaps best illustrated in the analysis of trip generation that was undertaken as part of the preparation of Cape Town's 1980-1985 Transport Plan (VKE 1978). Figure 2.7 illustrates the effect of annual household income on trip rates among 'white' and 'coloured' households with typically variant average household sizes. This study also indicated that household trip-making increases with increased car ownership, and with the number of employed household members.

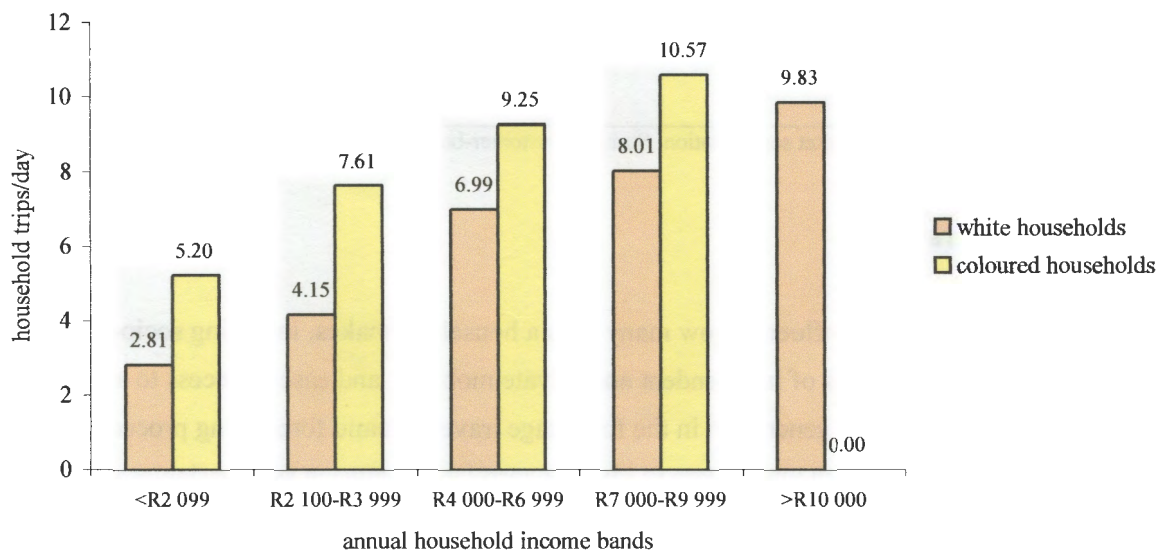
Table 2.7 *Trip generation findings in Cape Town surveys*

	1973 ¹ (exc. n-m modes)	1976 ² (exc. n-m modes except for work and educ trips)	1981 ³	1984 ⁴ (inc. only trips from home)
'white' pop.	6.29 h-b h trips/day 2.88 p trips/day (n = 1 690 h)	7.11 h trips/day (n = 1 020 h)	6.80 h trips/day 2.06 p trips/day (n = 180 h)	17.25 h-b h trips/week (n = 300 h)
'coloured' pop.		7.38 h trips/day (n = 2 015 h)	13.58 h trips/day 2.30 p trips/day (n = 106 h)	27.41 h-b h trips/week (n = 300 h)
'black' pop.				29.15 h-b h trips/week (n = 150 h)

Sources: 1= An analysis of residential trip generation in Cape Town, 2= Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey, 3= Activities, attitudes and trip-making in residential areas, 4= Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey

Note: n-m= non-motorised, h-b= home-based, h= household, p= person

Figure 2.7 *Influence of income and racial (as a proxy for household size) stratification on household trip generation in Cape Town (1976, n = 3 035 h)*



Source: Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey (excluding non-motorised modes except for work and education trips)

Table 2.8 *Trip generation findings in national surveys*

	1992 ¹	1995 ²
medium income residential area		8.20 person trips/dwelling unit/day 3.90 vehicle trips/dwelling unit/day (various secondary data)
low income residential area		6.10 person trips/dwelling unit/day 2.60 vehicle trips/dwelling unit/day (various secondary data)
'black' population	6.79 household trips/day 2.85 person trips/day (n = 592 h)	

Sources: 1= Trip-making characteristics of squatters, 2= South African trip generation rates

2.4.3 Trip purpose and chaining

Data on trip purpose distribution in Cape Town are outdated and they often include only home-based trips⁴³ by motorised travel modes (see table 2.9). Comparisons across studies for the purposes of establishing patterns are made problematic by inconsistencies in the travel modes and trip types included or excluded in data collection. Nevertheless the local data reveals that home-based work trips tend to be the most common trip purpose (around 30%), followed by education (around 25%) and social/recreational trips (around 20%). The most recent analysis of trip purpose distribution (see figure 2.8) indicates that home-to-work trips account for a surprisingly similar proportion of trip purposes amongst 'white', 'coloured' and 'black' households, but that (assuming race to be an adequate proxy for income) poorer households tend to make relatively fewer shopping and more school trips (Lombard 1985). Of interest is that more recent travel surveys elsewhere in South Africa have found that during the morning peak period education trips (43.4% in Pretoria and 55% in Durban) outnumber work trips (35.6% in Pretoria and 45% in Durban) (TRC Africa 1999, VKE 1999). These studies clearly illustrate the limitations of analysing future link traffic flows during congested periods on the basis of only work trips, as was, for instance, the case in the most recent metropolitan-wide travel demand modelling in Cape Town (CMC 1998).

Table 2.9 *Trip purpose distribution findings in Cape Town surveys*

	1973 ¹ (exc. n-m modes)	1976 ² (exc. n-m modes except for work and educ trips)	1981 ³	1984 ⁴
'white' pop.	18% h-b work 7% h-b education 7% h-b shopping 9% h-b pleasure 10% h-b other 49% return home (n = 1 690 h)	30.8% h-b work 20.4% h-b education 7.6% h-b shopping 15.9% h-b recreation 8.6% h-b other 16.7% non-home-based (n = 1 020 h)	36.4% work 15.9% school 15.2% shops 32.5% recreation (n = 180 h)	31% h-b to work 21% h-b to school 2% h-b to business 24% h-b to shops 22% h-b to social (n = 300 h)

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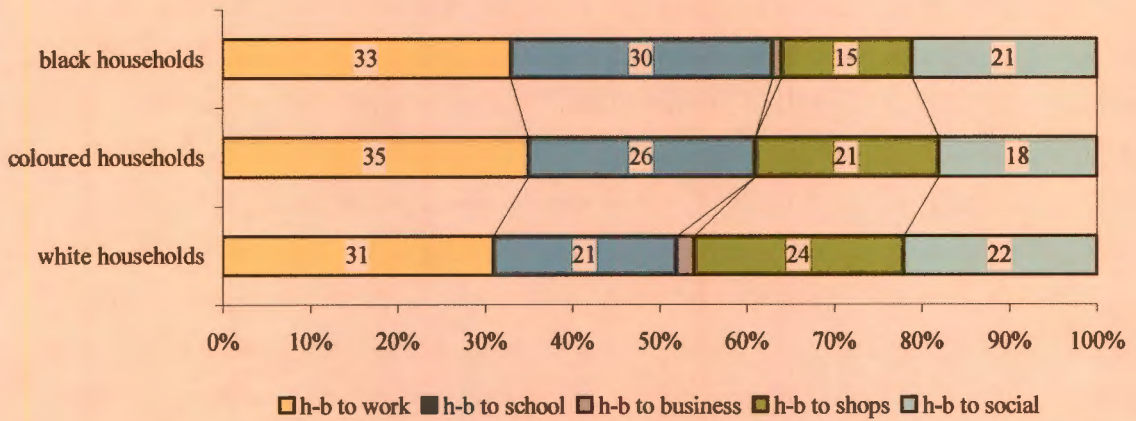
⁴³ A home-based trip is conventionally defined as a trip whose origin activity or destination activity is the home of the individual undertaking the trip. A non-home-based trip is thus defined as a trip with neither the origin activity nor destination activity at the home of the individual undertaking the trip.

'coloured' pop.	48.6% h-b work 43.2% h-b education 2.8% h-b other 5.4% non-home-based (n = 2 015 h)	30.3% work 36.2% school 9.7% shops 23.9% recreation (n = 106 h)	35% h-b to work 26% h-b to school 0% h-b to business 21% h-b to shops 18% h-b to social (n = 300 h)
'black' pop.			33% h-b to work 30% h-b to school 1% h-b to business 15% h-b to shops 21% h-b to social (n = 150 h)

Sources: 1= An analysis of residential trip generation in Cape Town, 2= Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey, 3= Activities, attitudes and trip-making in residential areas, 4= Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey

Note: n-m= non-motorised, h-b= home-based, h= household

Figure 2.8 *Influence of racial (as a proxy for income) stratification on household trip purpose distribution in Cape Town (1984, n = 750 h)*



Source: Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey

No information on trip chaining was found in the literature review beyond that reported in a survey undertaken in 1991/92 as part of a Public Transport Study for the Cape Metropolitan Transport Area (Market and Opinion Surveys 1992). This survey found that despite low levels of private mobility, particularly amongst peripherally located township respondents, surprisingly few shopping trips were combined with work trips (see table 2.10).

Table 2.10 *Shopping trip chaining findings in Cape Town surveys*

	ONLY WENT SHOPPING	1991/92 ¹ SHOPPED ON WAY TO/FROM WORK	DID SOMETHING ELSE BEFORE/AFTER
'white' population (n = 100 h)	74%	12%	14%
'coloured' population (n = 200 h)	83%	9%	9%
'black' population (n = 200 h)	78%	8%	14%

Sources: 1= Survey of the transport problems experienced by residents in the Cape Town metropolitan area

2.4.4 Trip timing

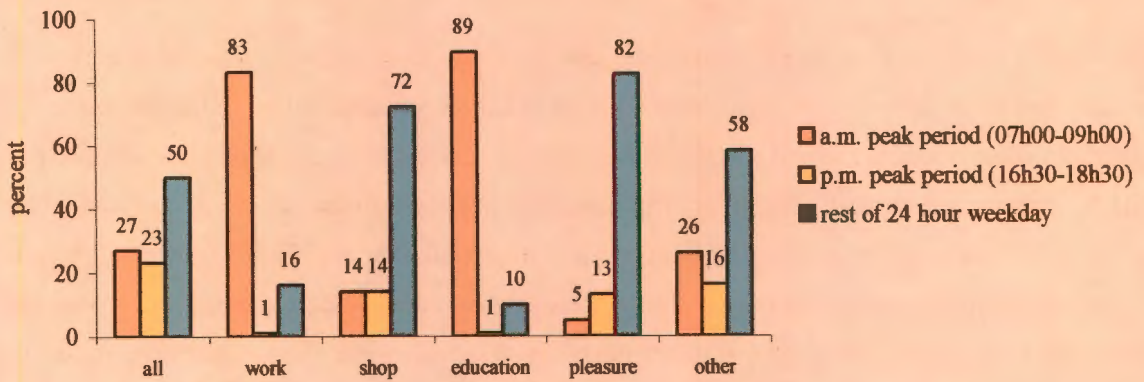
Data on trip timing in Cape Town are outdated and cross-comparisons are made problematic by inconsistencies in the travel modes and trip types included or excluded in data collection (see table 2.11). Nevertheless the local data, together with the national trip generation rates supplied by the NDoT, indicate that generally 25-30% of trips are made within the morning peak period, and 40-60% of trips are made in off-peak periods. Data on 'white' households from 1973 illustrate that, as would be expected, trips from home to work and school occur predominately during the morning peak period (83% and 89% respectively), and that trips from home to shopping and pleasure activities occur predominantly during off-peak periods (72% and 82% respectively) (see figure 2.9). More recent data from 1991/92 illustrate that whereas arrival times for work trips are fairly similar across different racial stratifications, 'black' and 'coloured' commuters start their work trips significantly earlier than 'white' commuters (see figures 2.10 and 2.11). This can presumably be attributed to slower travel modes (i.e. longer walking and waiting times) and longer travel distances associated with peripheral township locations. The findings from the latter survey regarding arrival times are slightly different from national data collected in the 1997 October Household Survey, which indicated that 33% of commuters arrive at work between 06h01 and 07h00 - the equivalent figure for Cape Town is 3% for 'whites', 22% for 'coloured' and 9% for 'blacks' (TRC Africa 2000).

Table 2.11 (All purpose) trip timing findings in Cape Town (and national) surveys

	1973 ¹ (home-based trips, exc. n-m modes)	1981 ² (inc. only car driver trips, unweighted averages)	1995 ³ (national)
'white' pop.	27% a.m. peak (07h00-09h00) 23% p.m. peak (16h30-18h30) 50% rest of 24 hour weekday (n = 1 690 h)	25% 2 hour a.m. peak 24% 2 hour p.m. peak 51% rest of 24 hour weekday (n = 180 h)	
'coloured' pop.		29% 2 hour a.m. peak 32% 2 hour p.m. peak 39% rest of 24 hour weekday (n = 106 h)	
medium income			28% a.m./p.m. peak hour 44% rest of day (various secondary data)
low income			19% a.m./p.m. peak hour 62% rest of day (various secondary data)

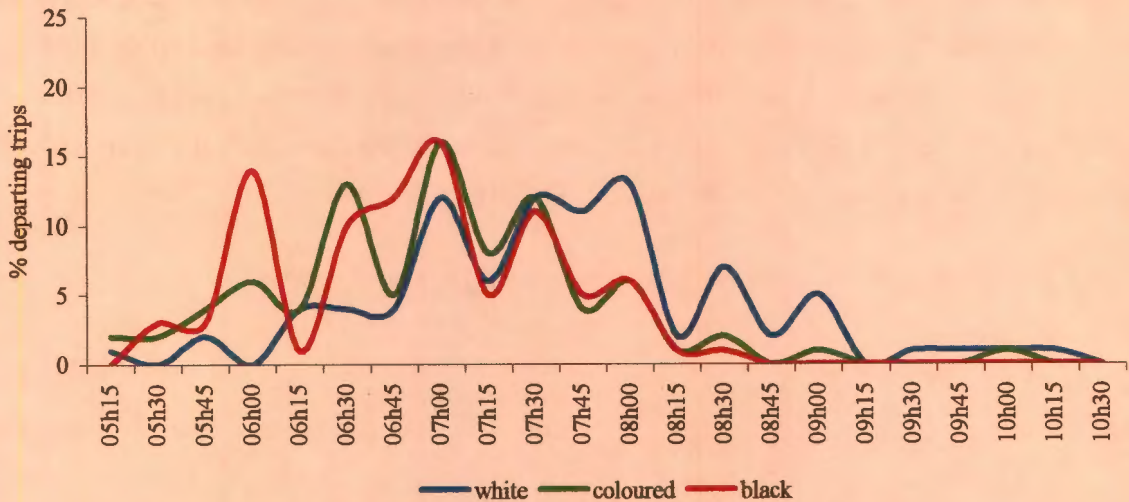
Sources: 1= An analysis of residential trip generation in Cape Town, 2= Activities, attitudes and trip-making in residential areas, 3= South African trip generation rates

Figure 2.9 *Home-based trip timing by purpose in Cape Town (1973, n = 1 690 h)*



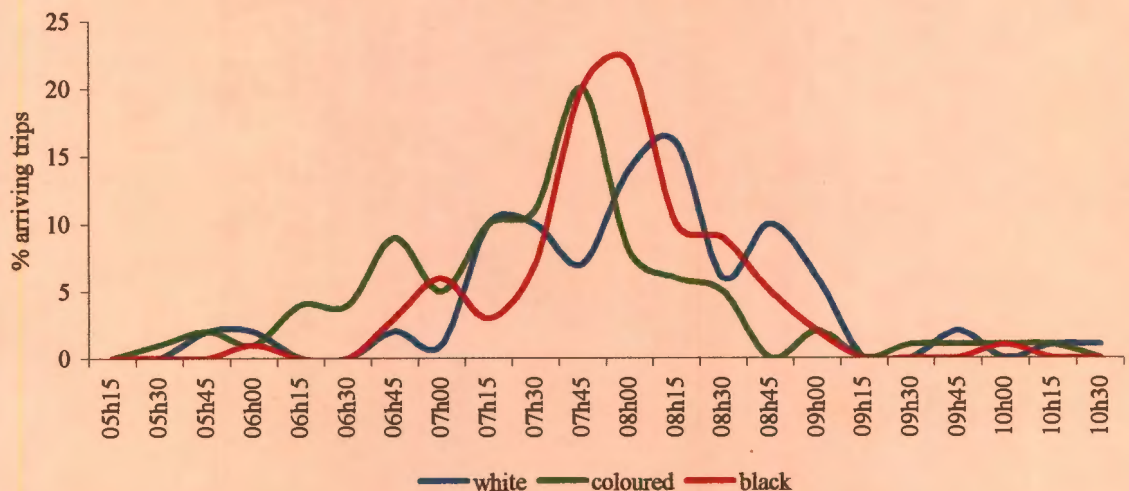
Source: An analysis of residential trip generation in Cape Town (including only motorised trips from home by 'white' population)

Figure 2.10 *Work trip departure time by race in Cape Town (1991/92, n = 500 h)*



Source: Survey of the transport problems experienced by residents in the Cape Town metropolitan area

Figure 2.11 *Work trip arrival time by race in Cape Town (1991/92, n = 500 h)*



Source: Survey of the transport problems experienced by residents in the Cape Town metropolitan area

2.4.5 Vehicle ownership and availability

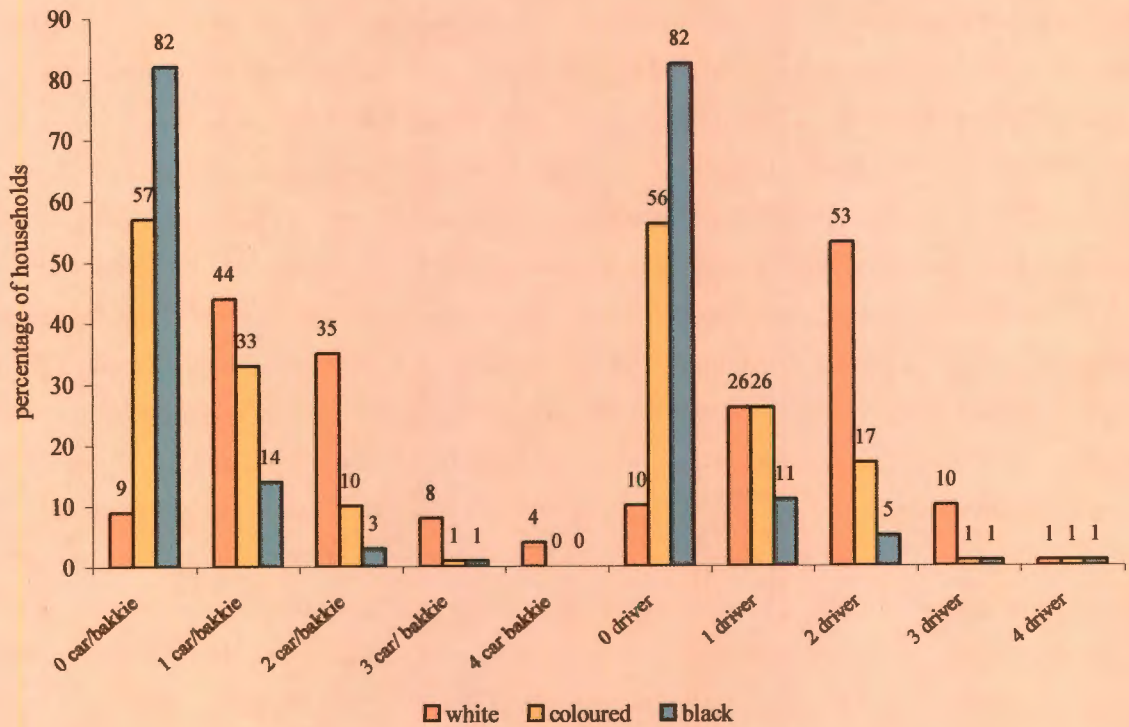
As would be expected data on vehicle ownership and availability in Cape Town indicate clearly that car ownership, and the number of household members who drive household cars, increases with household income (see table 2.12 and figure 2.12). Consequently relatively low levels of car ownership are prevalent amongst 'black' and 'coloured' households with lower average household incomes. Car ownership amongst 'black' households is particularly low – 95% did not own a car in 1994. The published data indicate however that car ownership has increased steadily since the 1970s. In 1976 for instance 17% of 'white' households did not own a car whereas in 1991/92 this figure had decreased to 9%, and the equivalent figures for 'coloured' households were 65% in 1976 and 57% in 1994. Over the 1985-1996 period the number of registered vehicles (of all classes) grew by 2.7% per annum (CMC 1998). The most recent data from 1999 indicate that in total 54% of Cape Town's households have access to a private vehicle (at ± 170 cars/1 000 people). Data from other South African cities would suggest that Cape Town has relatively higher levels of car ownership – surveys in Pretoria and Durban have found that 66% and 65% of households have no access to a private car respectively (compared to 46% in Cape Town) (TRC Africa 1999, VKE 1999). In 1996 national car ownership was estimated at ± 126 cars/1 000 people (NDoT 1997). Data from 1991/92 indicate that bicycle ownership amongst 'black' and 'coloured' households is low - around 93-99% of households did not own a bicycle (see figure 2.13).

Table 2.12 Household vehicle ownership/availability findings in Cape Town surveys

	1976 ¹	1984 ²	1991/92 ³	1994 ⁴	1999 ⁵
'white' pop.	17% 0 owned 47% 1 owned 36% >1 owned (n = 1 020 h)	1.34 cars/h (n = 300 h)	9% 0 owned 44% 1 owned 47% >1 owned (n = 100 h)		
'coloured' pop.	65% 0 owned 30% 1 owned 5% >1 owned (n = 2 015 h)	0.47 cars/h (n = 300 h)	57% 0 owned 33% 1 owned 11% >1 owned (n = 200 h)	57% 0 owned 43% ≥1 owned (n = 192 p)	
'black' pop.		0.15 cars/h (n = 150 h)	82% 0 owned 14% 1 owned 4% >1 owned (n = 200 h)	95% 0 owned 5% ≥1 owned (n = 100 p)	
total pop.					46% 0 available 54% ≥1 available (AMPS data)

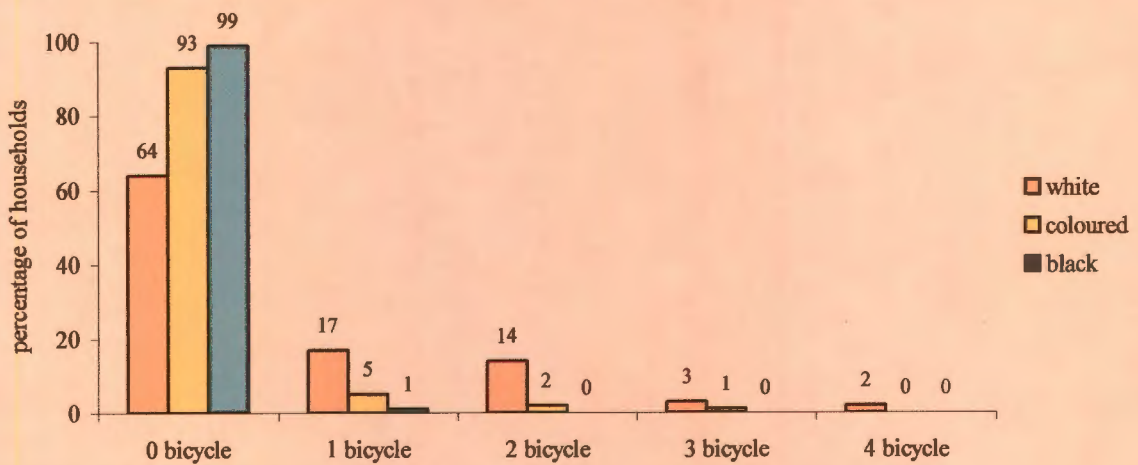
Sources: 1= Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey, 2= Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey, 3= Survey of the transport problems experienced by residents in the Cape Town metropolitan area, 4= National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities, 5= Strategic customer-based passenger transport information project

Figure 2.12 *Influence of racial (as a proxy for income) stratification on household vehicle ownership and drivers of household car(s) in Cape Town (1991/92, n = 500 h)*



Source: Survey of the transport problems experienced by residents in the Cape Town metropolitan area

Figure 2.13 *Influence of racial (as a proxy for income) stratification on household bicycle ownership in Cape Town (1991/92, n = 500 h)*



Source: Survey of the transport problems experienced by residents in the Cape Town metropolitan area

2.4.6 Mode use, transfer, availability and switching

Data on home-based work trip main mode⁴⁴ use in Cape Town are recent and numerous (see table 2.13). The most recent data from the 1997 October Household Survey indicate a 38:47:11

⁴⁴ In the case of multi-mode trips, the 'main' mode is typically defined as that which covers the greatest travelled distance.

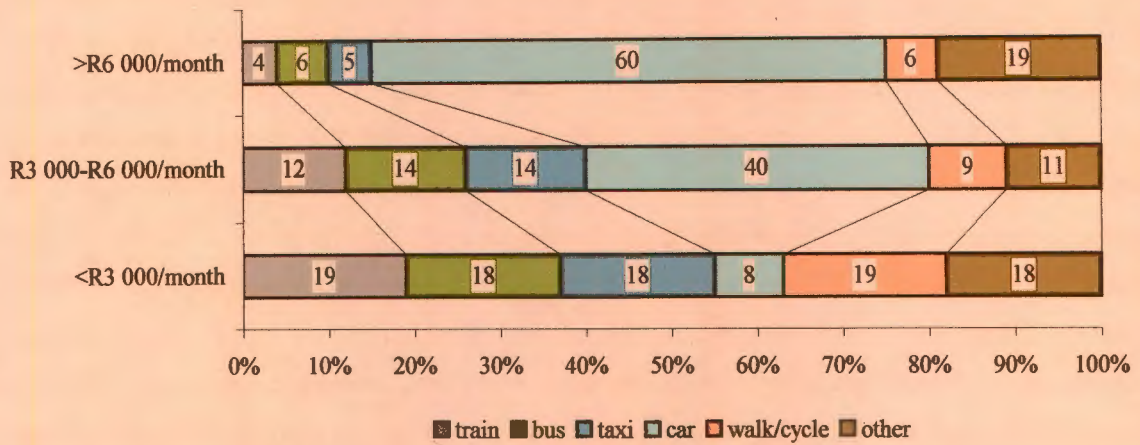
percentage split across private:public:non-motorised modes (TRC Africa 2000). This split is broadly consistent with the findings of the largest ever sample (of 15 000 households) surveyed in Cape Town in 1991/92 – 44:49:5. National data from the 1997 October Household Survey indicate that when household incomes rise above R3 000-R4 000/month, commuting by car increases fairly dramatically (see figure 2.14). Figure 15 illustrates that work trip main mode use in Cape Town is predominantly motorised, and that private:public transport ratios vary considerably across racial stratifications. The most recent data indicate that private transport accounts for about 76% of ‘white’ commuters work trip main mode use, but only 2-17% of that of ‘black’ commuters. Cape Town’s work trip modal split is somewhat unique compared to other South African cities in that a relatively extensive passenger rail network accounts for trains carrying the greatest number of public transport commuters (TRC Africa 2000). Longitudinal data on morning peak mode use into the city centre indicate that car and rail’s share of modal split has remained fairly constant over time, with the growth in minibus-taxi share since the mid-1980s largely at the expense of the bus (see figure 2.16).

Table 2.13 (Selected) home-based work trip main mode use findings in Cape Town surveys

	1976 ¹	1980/81 ² (inc. m modes in a.m. peak)	1991/92 ³	1991/92 ⁴	1994 ⁵	1997 ⁶
‘white’ pop.	20.8% tn/bs/tx 70.7% car 8.5% walk/cy (n = 1 020 h)		8.0% train 5.0% bus 3.0% taxi 76.0% car 8.0% walk (n = 100 h)			
‘coloured’ pop.	49.4% tn/bs/tx 34.7% car 15.9% walk/cy (n = 2 015 h)	40.0% train 21.0% bus 2.5% taxi 32.0% car 4.5% truck (5% 80census)	30.0% train 8.0% bus 11.0% taxi 40.0% car 11.0% walk (n = 200 h)		38.0% train 5.0% bus 17.0% taxi 34.0% car 5.0% walk 1.0% other (n = 192 p)	
‘black’ pop.			26.0% train 46.0% bus 6.0% taxi 17.0% car 5.0% walk (n = 200 h)		72.0% train 5.0% bus 18.0% taxi 2.0% car 3.0% walk 0.0% other (n = 100 p)	
total pop.				27% train 16% bus 6% taxi 44% car 5% walk 2% other (n = 15 000 h)		23.7% train 7.6% bus 15.5% taxi 37.6% car 10.7% walk/cy 5% other (OHS data)

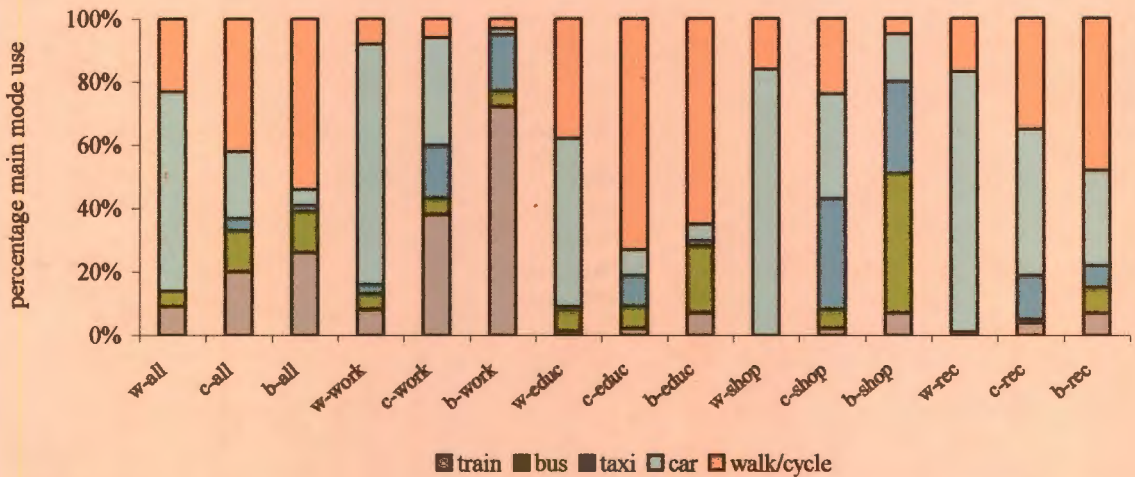
Sources: 1= Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey, 2= Cape Flats commuter study, 3= Survey of the transport problems experienced by residents in the Cape Town metropolitan area, 4= Cape Town Metropolitan Transport Study (EMME/2) household interview survey, 5= National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities, 6= Strategic customer-based passenger transport information project

Figure 2.14 *Influence of household income on work trip mode use in South Africa (1997 OHS, n = 30 000 h)*



Source: Strategic customer-based passenger transport information project

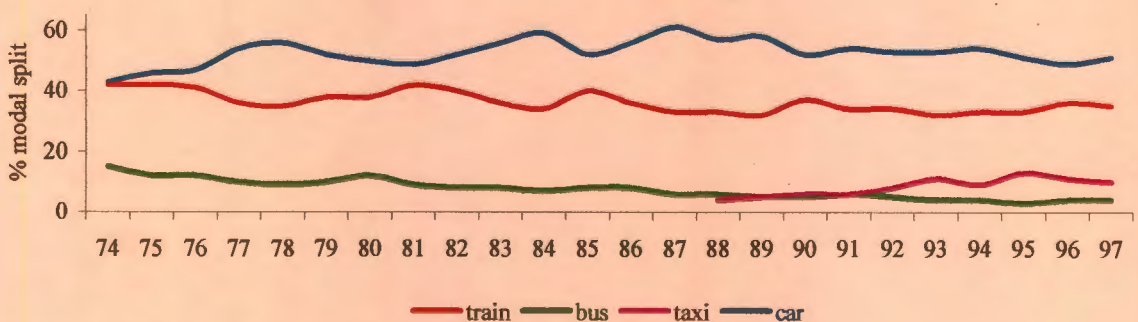
Figure 2.15 *Influence of racial (as a proxy for income) stratification on main mode use by trip purpose in Cape Town (compiled from: 1984 n = 750 h, 1991/92 n = 500 h, 1994 n = 292 p)*



Sources: Survey of the transport problems experienced by residents in the Cape Town metropolitan area, Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey, National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities

Note: w= 'white', c= 'coloured', b= 'black'

Figure 2.16 *Cape Town city centre inbound weekday morning peak period (07h00-09h00) mode use (excluding non-motorised modes) (1974-1997)*



Source: Annual/biennial Cape Town CBD commuter and screenline survey



Mode use data on trip purposes other than commutes are however outdated and limited (see tables 2.14 to 2.17). Data from 1984 would suggest that walking is the most common main mode for 'coloured' and 'black' households when all trip purposes are combined, but that amongst 'white' households the car is the most common main mode. These mode splits are unlikely to be an accurate reflection of all trip purpose main mode use today however, particularly considering the apparent decline of walking/cycling trips to and from education activities between 1976 and 1992 (see table 2.15). In 1976 38% of 'white' scholars were driven to school by car, whereas in 1992 this figure had risen to 52% (decline is also noticeable amongst 'coloured' and 'black' scholars although car use has always been relatively small). The 1992 data indicate that 50%, 11% and 7% of 'white', 'coloured' and 'black' scholars are taken to school by their parents respectively (de Vries 1992). Figure 2.15 illustrates a general pattern of increasing use of public transport and non-motorised modes amongst 'coloured' and 'black' households for different trip purposes. Of interest is the relatively small use of walking for shopping trips amongst 'black' households ($\pm 5\%$) – a finding possibly inconsistent with the earlier discussed finding of low levels of shopping trip chaining (see table 2.10).

Table 2.14 *All trip purpose main mode use findings in Cape Town surveys*

	1973 ¹ (home-based trips, exc. n-m modes)	1976 ² (exc. n-m modes except for work and educ trips)	1981 ³ (unweighted averages)	1984 ⁴ (trips from home)
'white' pop.	9.0% train 10.0% bus 0.0% taxi 53.0% car driver 27% car passenger 1.0% motorcycle (n = 1 690 h)	11.4% train/bus/taxi 75.7% car 12.9% walk/cycle (n = 1 020 h)	2.5% bus 44.9% car driver 25.3% car passenger 1.2% motorcycle 4.2% bicycle 22.4% walk 1.3% other (n = 180 h)	9.0% train 5.0% bus 0.0% taxi 38.8% car driver 19.9% car passenger 22.8% walk (n = 300 h)
'coloured' pop.		29.8% train/bus/taxi 25.0% car 45.2% walk/cycle (n = 2 015 h)	5.6% bus 10.8% car driver 8.9% car passenger 0.0% motorcycle 0.9% bicycle 72.8% walk 1.0% other (n = 106 h)	19.9% train 13.2% bus 3.8% taxi 7.5% car driver 13.2% car passenger 42.4% walk/cycle (n = 300 h)
'black' pop.				25.7% train 13.1% bus 2.0% taxi 2.3% car driver 2.9% car passenger 54.0% walk (n = 150 h)

Sources: 1= An analysis of residential trip generation in Cape Town, 2= Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey, 3= Activities, attitudes and trip-making in residential areas, 4= Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey

Table 2.15 *Home-based school/education trip main mode use findings in Cape Town surveys*

	1973 ¹ (exc. n-m modes)	1976 ²	1978 ³	1984 ⁴ (trips from home)	1991/92 ⁵
'white' pop.	15.0% train 15.0% bus 0.0% taxi 13.0% car driver 56.0% car pass 2.0% motorcycle (n = 1 690 h)	13.0% trn/bus/taxi 37.8% car 49.2% walk/cycle (n = 1 020 h)	14.5% train 7.0% bus 0.0% taxi 1.0% car driver 32.5% car pass 1.0% motorcycle 42% walk/cycle (n = h)	4.6% train 5.9% bus 0.0% taxi 4.2% car driver 30.0% car pass 53.5% walk/cycle (n = 300 h)	1.0% train 7.0% bus 1.0% taxi 52.0% car 38.0% walk/cycle (n = 100 h)
'coloured' pop.		9.2% trn/bus/taxi 4.5% car 86.3% walk/cycle (n = 2 015 h)		2.6% train 7.2% bus 0.7% taxi 0.0% car driver 9.3% car pass 80.2% walk/cycle (n = 300 h)	2.0% train 7.0% bus 10.0% taxi 8.0% car 73.0% walk (n = 200 h)
'black' pop.				5.3% train 4.9% bus 0.0% taxi 0.0% car driver 0.4% car pass 89.1% walk (n = 150 h)	7.0% train 21.0% bus 2.0% taxi 5.0% car 64.0% walk (n = 200 h)

Sources: 1= An analysis of residential trip generation in Cape Town, 2= Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey, 3= Scholar transport survey, 4= Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey, 5= Survey of the transport problems experienced by residents in the Cape Town metropolitan area

Table 2.16 *Home-based shopping trip main mode use findings in Cape Town surveys*

	1973 ¹ (exc. n-m modes)	1976 ²	1991/92 ³
'white' pop.	5.0% train 13.0% bus 0.0% taxi 58.0% car driver 21.0% car passenger 1.0% motorcycle (n = 1 690 h)	6.8% train/bus/taxi 93.2% car 0.0% walk/cycle (n = 1 020 h)	0.0% train 0.0% bus 0.0% taxi 84.0% car 16.0% walk (n = 100 h)
'coloured' pop.			2.0% train 6.0% bus 35.0% taxi 33.0% car 24.0% walk (n = 200 h)
'black' pop.			7.0% train 44.0% bus 29.0% taxi 15.0% car 5.0% walk (n = 200 h)

Sources: 1= An analysis of residential trip generation in Cape Town, 2= Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey, 3= Survey of the transport problems experienced by residents in the Cape Town metropolitan area

Table 2.17 Home-based social/recreational trip main mode use findings in Cape Town surveys

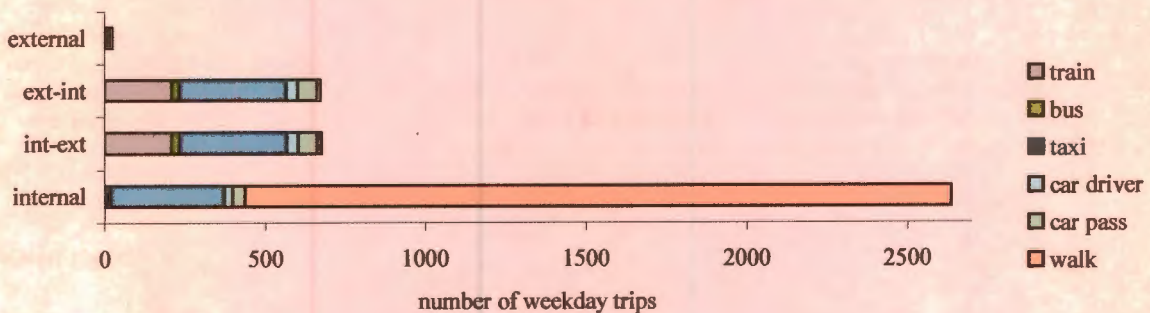
	1973 ¹ (exc. n-m modes)	1976 ²	1991/92 ³
'white' pop.	2.0% train 5.0% bus 0.0% taxi 52.0% car driver 41.0% car passenger 0.0% motorcycle (n = 1 690 h)	3.4% train/bus/taxi 96.6% car 0.0% walk/cycle (n = 1 020 h)	1.0% train 0.0% bus 0.0% taxi 82.0% car 17.0% walk (n = 100 h)
'coloured' pop.			4.0% train 1.0% bus 14.0% taxi 46.0% car 35.0% walk (n = 200 h)
'black' pop.			7.0% train 8.0% bus 7.0% taxi 30.0% car 48.0% walk (n = 200 h)

Sources: 1= An analysis of residential trip generation in Cape Town, 2= Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey, 3= Survey of the transport problems experienced by residents in the Cape Town metropolitan area



Obtaining a realistic indication of the importance of walking as a travel mode is made difficult by the frequent collection of data on only the main mode used (i.e. ignoring walking at either end of motorised trips), the combination of walking and cycling modes, or the exclusion of main mode walking trips altogether. An exception is the 1981 survey of households living in Plumstead, Edgemoad and Mitchells Plain, which indicated that amongst 'coloured' households walking was the most commonly used main mode (Cameron *et al* 1984). 'Coloured' households were found to make around 7 times more walking trips than 'white' households, with ± 84% of these being undertaken by children. From outside Cape Town, a relatively detailed study of travel patterns amongst 'black' households living in Mamelodi and Daveyton in Gauteng in 1992 indicated that 84% of internal trips, and 55% of all trips, are undertaken by walking (see figure 2.17). The importance of walking is likely to be under-numerated in this study however as data collection excluded walking trips of less than 5 minutes (± 335 m).

Figure 2.17 Influence of internal/external trip origin and destination on main mode use (excluding walking trips <5 min) in Mamelodi and Daveyton (1992, n = 592 h)



Source: Trip-making characteristics of squatters

Data on mode transfer, mode availability and willingness to switch mode in Cape Town are generally limited to work trips. The most recent published data indicate that 'coloured' and 'black' commuters (21% and 39% respectively) make more transfers than 'white' commuters (2%), and that relatively few commuters (1-3%) need to use more than two modes in order to get to work (see table 2.18). The most recent published data on mode availability indicate that public transport services are generally less frequently available to 'white' commuters than to 'coloured' and 'black' commuters (see table 2.19). The National Passenger Panel data from 1992 and 1994 indicate that commuters establish habitual travel patterns which seldom change over the course of a month. These data also indicate that the vast majority of commuters with access to private cars use them to travel to work (van der Reis *et al* 1993, van der Reis and Lombard 1995).

Table 2.18 *Work and shopping trip mode transfer findings in Cape Town surveys*

	1991/92 ¹		1994 ²
	SHOPPING TRIPS	WORK TRIPS	WORK TRIPS
'white' pop.	76.0% 0 transfer 9.0% 1 transfer 0.0% 2 transfers (n = 100 h)	86.0% 0 transfer 2.0% 1 transfer 0.0% 2 transfers (n = 100 h)	
'coloured' pop.	51.0% 0 transfer 37.0% 1 transfer 11.0% 2 transfers (n = 200 h)	73.0% 0 transfer 17.0% 1 transfer 3.0% 2 transfers (n = 200 h)	79.0% 0 transfer 19.0% 1 transfer 1.0% 2 transfers 1.0% 3 transfers (n = 192 h)
'black' pop.	18.0% 0 transfer 82.0% 1 transfer 1.0% 2 transfers (n = 200 h)	80.0% 0 transfer 18.0% 1 transfer 1.0% 2 transfers (n = 200 h)	61.0% 0 transfer 36.0% 1 transfer 3.0% 2 transfers 0.0% 3 transfers (n = 100 h)

Sources: 1= Survey of the transport problems experienced by residents in the Cape Town metropolitan area, 2= National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities

Table 2.19 *Work trip mode availability findings in Cape Town surveys*

	1984 ¹ (trips from home)	1991/92 ²	1992 ³	1994 ⁴
'white' pop.	18.0% train alt mode 12.2% bus alt mode 0.4% taxi alt mode 32.0% car dr alt mode 27.3% car pass alt mode 7.6% walk alt mode (n = 300 h)	0.0% train alt mode 88.0% bus alt mode 13.0% taxi alt mode 0.0% car dr alt mode 0.0% car pass alt mode 0.0% walk alt mode 0.0% no alternative (n = 100 h)	67.7% access to train 70.0% access to bus 45.9% access to taxi (n = 220 h)	
'coloured' pop.	18.9% train alt mode 24.7% bus alt mode 6.5% taxi alt mode 5.3% car dr alt mode 40.7% car pass alt mode 3.6% walk alt mode (n = 300 h)	5.0% train alt mode 32.0% bus alt mode 30.0% taxi alt mode 3.0% car dr alt mode 17.0% car pass alt mode 6.0% walk alt mode 4.0% no alternative (n = 200 h)		78.0% access to train 61.0% access to bus 69.0% access to taxi 64.0% access to car 8.0% access to company trans (n = 192 h)

continued overleaf ...

'black' pop. (n = 150 h)	26.7% train alt mode 37.2% bus alt mode 27.2% taxi alt mode 2.2% car dr alt mode 3.3% car pass alt mode 3.3% walk alt mode	20.0% train alt mode 33.0% bus alt mode 34.0% taxi alt mode 2.0% car dr alt mode 3.0% car pass alt mode 2.0% walk alt mode 4.0% no alternative (n = 200 h)	83.0% access to train 93.0% access to bus 100.0% access to taxi (n = 100 h)	84.0% access to train 65.0% access to bus 87.0% access to taxi 7.0% access to car 1.0% access to company trans (n = 100 h)
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Sources: 1= Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey, 2= Survey of the transport problems experienced by residents in the Cape Town metropolitan area, 3= National passenger panel 1992, 4= National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities

2.4.7 Travel distance



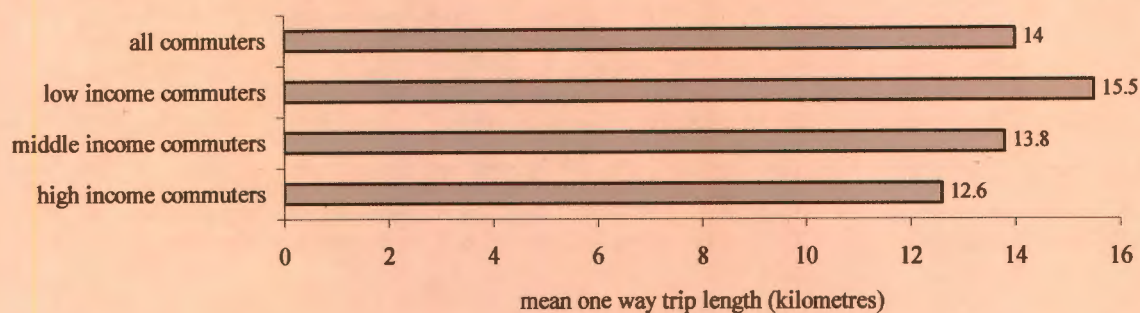
Data on travel distances in Cape Town are outdated (see table 2.20). The most recent data from 1991/92 indicate that low-income commuters travel longer mean distances than high-income commuters (15.5 km vs. 12.6 km) (see figure 2.18). This finding is consistent with earlier mentioned findings on work trip arrival and departure times by race (assuming this to be an adequate proxy for income – see figures 2.10 and 2.11) and is the direct result of the construction of 'coloured' and 'black' townships on the periphery of Cape Town during the apartheid era, and the continuation of this practice in more recent times. Data from national surveys would suggest that average commutes in Cape Town are relatively shorter than in other South African cities. 1995 October Household Survey data indicate that the national mean work trip length by public transport is around 20 km (16 km by minibus-taxi, 28 km by bus and 20 km by train) – which is considerably higher than elsewhere in the world (11 km in Europe, 15 km in the United States and 9 km in developing Asian countries) (NDoT 1997). Average work trip lengths would appear to be longer than those of other trip purposes.

Table 2.20 (One-way) trip length findings in Cape Town surveys

	1991/92 ¹ WORK TRIPS	1991/92 ²			
		SCHOOL TRIPS		RECREATIONAL TRIPS	
'white' pop. (n = 100 h)		56% 0-5 km 25% 6-10 km 2% 11-15 km	12% 16-30 km 4% >30 km 7.1 km ave	40% 0-5 km 21% 6-10 km 17% 11-15 km	11% 16-30 km 11% >30 km
'coloured' pop. (n = 200 h)		87% 0-5 km 2% 6-10 km 1% 11-15 km	1% 16-30 km 1% >30 km 2.7 km ave	70% 0-5 km 18% 6-10 km 4% 11-15 km	5% 16-30 km 1% >30 km
'black' pop. (n = 200 h)		59% 0-5 km 22% 6-10 km 10% 11-15 km	0% 16-30 km 0% >30 km 4.7 km ave	59% 0-5 km 30% 6-10 km 11% 11-15 km	0% 16-30 km 0% >30 km
high income	12.6 km mean				
middle income	13.8 km mean				
low income	15.5 km mean				
total pop. (n = 15 000 h)	14.0 km mean				

Sources: 1= Cape Town Metropolitan Transport Study (EMME/2) household interview survey, 2= Survey of the transport problems experienced by residents in the Cape Town metropolitan area

Figure 2.18 *Influence of income stratification on (one-way) work trip length in Cape Town (1991/92, n = 15 000 h)*



Source: Cape Town Metropolitan Transport Study (EMME/2) household interview survey

No published data on walking distances in Cape Town were found in the surveys reviewed. National data from 1992 collected in Johannesburg, Pretoria and Bloemfontein however indicate that 'black' pedestrians on average walk considerably further than 'white' pedestrians. These data also indicate that walking distances are longer at the home end of multi-modal trips (see table 2.21). It was found that 'black' pedestrians walk up to 4.5 km (or 67 minutes) (9 km both ways) in order to access work, shopping, school and health care destinations (see figure 2.19). The mean walking distance for all trip purposes was found to be 1 650 m (or 25 minutes) (see table 2.22). Assuming race to be an adequate proxy for income, this is consistent with the internationally held axiom that wealthier travellers value travel time more, and are thus prepared only to walk relatively shorter distances (Khisty 1993). In so-called 'transit-oriented developments' in the United States for instance, as mentioned in chapter 1, maximum walking times to public transport stops are typically judged to be 5-10 minutes (335-670 m, assuming a walking speed of 4 km/h).

Table 2.21 *Mean and 95 percentile walking distance at the attraction and production ends of multi-mode trips: findings in national surveys*

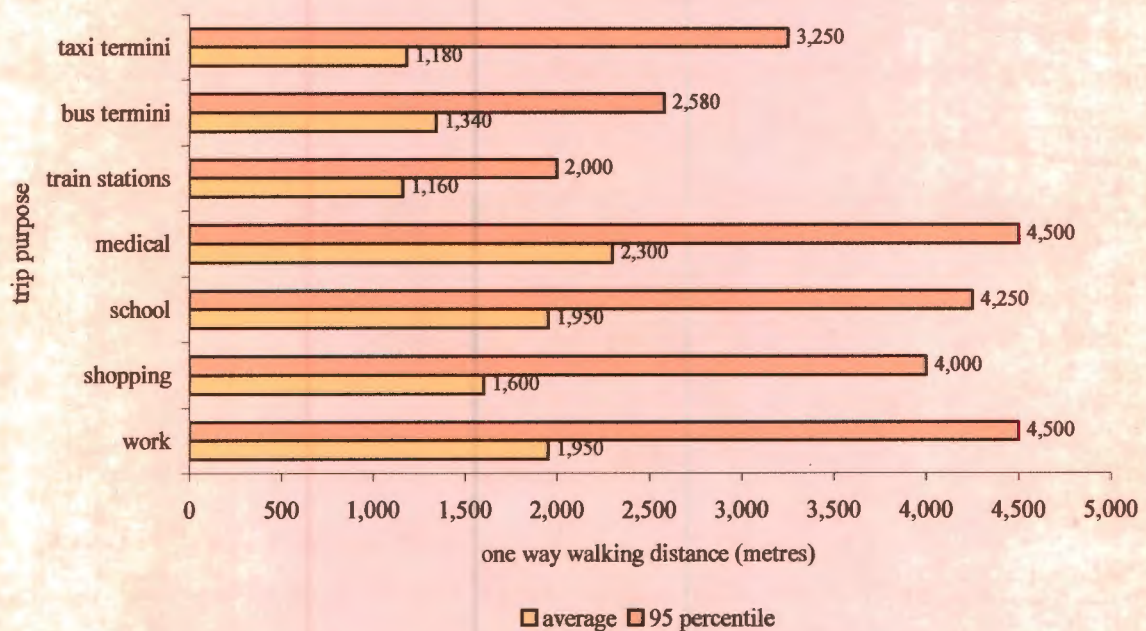
	1992 ¹ (work trips, Johannesburg and Pretoria CBDs)				1992 ² (all trips, Mangaung and Botshabelo)	
	TRAIN STATIONS	BUS TERMINI	TAXI TERMINI	PARKING GARAGES	BUS TERMINI	TAXI TERMINI
'white' pop.		521 m ave 1 150 m 95%ile (n = 1 393 p)		290 m mean 650 m 95%ile (n = 1 393 p)		
'black' pop.	1 162 m ave 2 000 m 95%ile (n = 1 393 p)	1 138 m ave 2 400 m 95%ile (n = 922 p)	1 012 m ave 2 200 m 95%ile (n = 922 p)		1 550 m ave 2 750 m 95%ile (n = 4 642 p)	1 350 m ave 4 300 m 95%ile (n = 4 642 p)

Sources: 1 = Walking distances by income group, by mode and by trip purpose, 2 = Walking patterns in black residential areas

Table 2.22 *Mean and 95 percentile (single mode) walking trip length findings in national surveys*

	1992 ¹ (Mangaung and Botshabelo)				
	WORK TRIPS	SHOP TRIPS	SCHOOL TRIPS	MEDICAL TRIPS	ALL TRIPS
elderly (>56yrs)	1 200-2 400 m ave	1 400-1 700 m ave		4 250 m mean	1 625 m mean
adult (19-55 yr)	1 900-2 450 m ave	1 600-1 700 m ave	1 750-2 200 m ave	2 000 m mean	1 685 m mean
teenger (13-18)	1 750-1 950 m ave	1 450-1 750 m ave	1 800-2 100 m ave	2 900 m mean	1 790 m mean
child (<12 yrs)				1 750 m mean	
'black' pop. (n = 4 642 p)	1 950 m mean 4 500 m 95 %ile	1 600 m mean 4 000 m 95 %ile	1 950 m mean 4 250 m 95 %ile	2 300 m mean 4 500 m 95 %ile	1 650 m mean

Sources: 1= Walking patterns in black residential areas

Figure 2.19 *'Black' pedestrian walking distance findings (by trip purpose in metres) in Johannesburg, Pretoria and Bloemfontein (1992 n = 2 315 p, 1992 n = 4 642 p)*

Sources: Walking distances by income group, by mode and by trip purpose; Walking patterns in black residential areas

2.4.8 Travel and waiting time

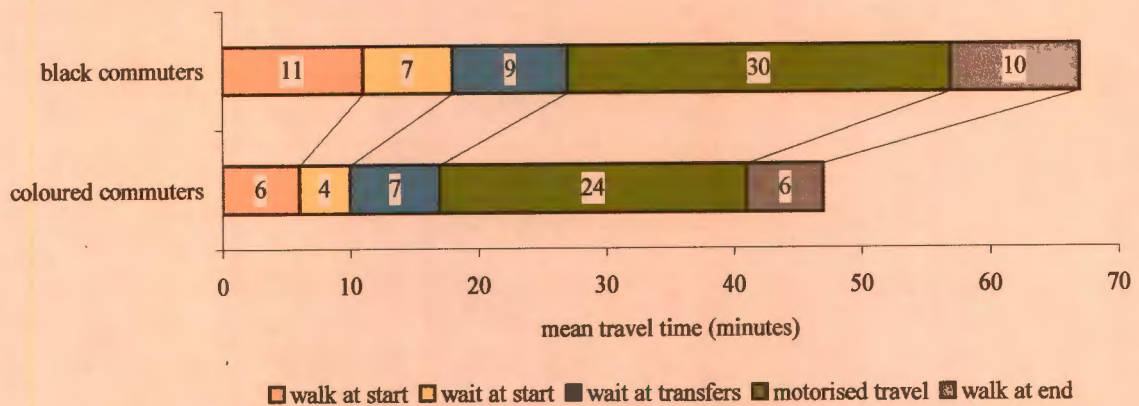
Data on work trip travel and waiting time in Cape Town indicate that 'black' commuters spend more time travelling than 'white' and 'coloured' commuters (45-67 minutes, 31-32 minutes and 47-49 minutes respectively) (see table 2.23). Data collected in the National Passenger Panel survey of 1994 indicate that waiting accounts for $\pm 23\%$, and walking for $\pm 29\%$, of total travel time by public transport modes amongst 'black' and 'coloured' commuters (see figure 2.20). Data collected in the 1995 and 1997 October Household Surveys indicate that, on average, public transport travel times are longer than private transport and non-motorised travel times (see figure 2.21). Comparisons with national (1997 OHS) data would suggest that average commuting times are shorter in Cape Town (at 43 minutes) than in other South African cities - at 53 minutes in Pretoria, 52 minutes in Johannesburg, and 48 minutes in Durban (TRC Africa 2000).

Table 2.23 Mean (one-way) travel time findings in Cape Town surveys

	1984 ¹ (trips from home)		1991/92 ²	1994 ³	1995 ⁴	1997 ⁵
	WORK	SCHOOL	SCHOOL	WORK	WORK	WORK
'white' pop.	31 minutes (n = 300 h)	15 minutes (n = 300 h)	12 minutes (n = 100 h)		32 minutes (OHS data)	
'coloured' pop.	49 minutes (n = 300 h)	16 minutes (n = 300 h)	9 minutes (n = 200 h)	47 minutes (n = 192 h)		
'black' pop.	63 minutes (n = 150 h)	22 minutes (n = 150 h)	18 minutes (n = 200 h)	67 minutes (n = 100 h)	45 minutes (OHS data)	
total pop.					40 minutes (OHS data)	43 minutes (OHS data)

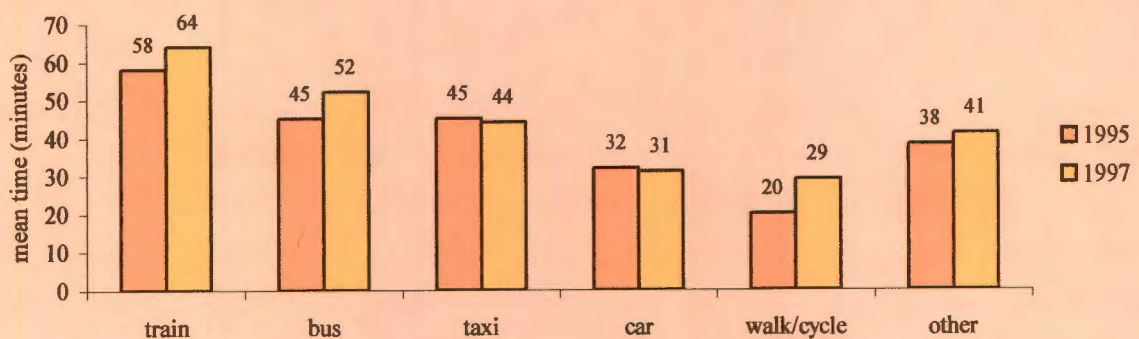
Sources: 1= Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey, 2= Survey of the transport problems experienced by residents in the Cape Town metropolitan area, 3= National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities, 4= Moving South Africa market segmentation, 5= Strategic customer-based passenger transport information project

Figure 2.20 Components of (one-way) work trip travel time for 'coloured' and 'black' commuters in Cape Town (1994, n = 292 h)



Source: National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities

Figure 2.21 Influence of main mode on (one-way) work trip travel time in Cape Town (1995, 1997 OHS data)



Source: Strategic customer-based passenger transport information project October Household Survey

Data on travel times associated with other trip purposes in Cape Town are outdated and limited (see tables 2.23 and 2.24). Nevertheless from the available published data it would appear that work trips take, on average, longer than school and shopping trips. Travel time distributions from 1991/92 data indicate that ± 50% of work trips take more than 30 minutes, whereas most school trips take less than

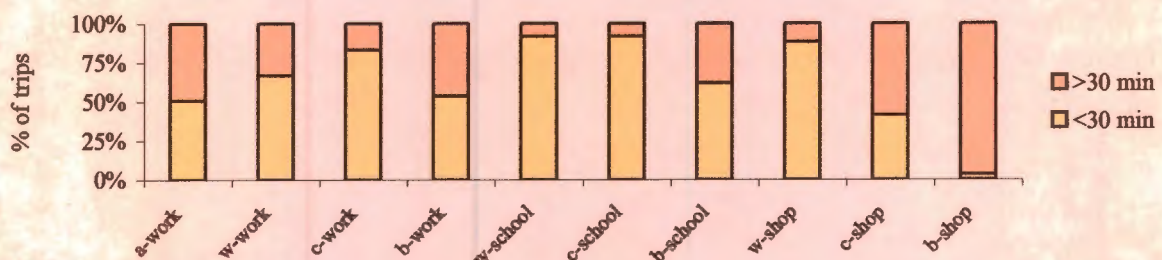
30 minutes (see table 2.24 and figure 2.22). Data on shopping trips from 1991/92 indicate highly variant travel time distributions across racial stratifications. Given the surprisingly low share of walking in shopping trip modal split mentioned earlier (see figure 2.15), the finding that only 3% of shopping trips by 'black' consumers took less than 30 minutes is difficult to explain.

Table 2.24 (One-way) travel time distribution findings in Cape Town surveys

	1991/92 ¹			1995 ² WORK	1997 ² WORK
	SHOPPING	SCHOOL	WORK		
'white' pop. (n = 100 h)	88.0% <30 min 10.0% 30-60 min 1.0% 61-90 min 0.0% 91-120 min 1.0% 121-150 min	33.0% 0-5 min 23.0% 6-10 min 10.0% 11-15 min 13.0% 16-20 min 6.0% 21-25 min 6.0% 26-30 min 8.0% >30 min	8.0% 0-5 min 11.0% 6-10 min 22.0% 11-15 min 13.0% 16-20 min 7.0% 21-25 min 3.0% 26-30 min 32.0% >30 min		
'coloured' pop. (n = 200 h)	42.0% <30 min 41.0% 30-60 min 12.0% 61-90 min 3.0% 91-120 min 2.0% 121-150 min 1.0% 151-180 min	37.0% 0-5 min 27.0% 6-10 min 12.0% 11-15 min 7.0% 16-20 min 5.0% 21-25 min 4.0% 26-30 min 8.0% >30 min	12.0% 0-5 min 16.0% 6-10 min 24.0% 11-15 min 12.0% 16-20 min 8.0% 21-25 min 11.0% 26-30 min 17.0% >30 min		
'black' pop. (n = 200 h)	3.0% <30 min 17.0% 30-60 min 22.0% 61-90 min 27.0% 91-120 min 14.0% 121-150 m 5.0% 151-180 min 1.0% >180 min	9.0% 0-5 min 17.0% 6-10 min 16.0% 11-15 min 10.0% 16-20 min 3.0% 21-25 min 5.0% 26-30 min 37.0% >30 min	2.0% 0-10 min 5.0% 11-20 min 7.0% 21-30 min 7.0% 31-40 min 13.0% 41-50 min 19.0% 51-60 min 46.0% >60 min		
total pop. (OHS data)				52.0% 1-30 min 38.0% 31-60 min 10.0% >60 min	51.0% 1-30 min 33.0% 31-60 min 16.0% >60 min

Sources: 1= Survey of the transport problems experienced by residents in the Cape Town metropolitan area, 2= Strategic customer-based passenger transport information project

Figure 2.22 Influence of racial stratification on (one-way) travel time distribution by trip purpose in Cape Town (1991/92 n = 500 h, 1997 OHS data)



Sources: Survey of the transport problems experienced by residents in the Cape Town metropolitan area, Strategic customer-based passenger transport information project

Note: a= total population, w= 'white', c= 'coloured', b= 'black'

2.4.9 Transport expenditure

Data from the 1990s on transport expenditure in Cape Town are limited to work trips (see table 2.25). The most recent study, the 1994 National Passenger Panel survey, found that 48% of 'black'

commuters spent more than 10% of their personal income on travelling to work, and that the equivalent figure for 'coloured' commuters was 28%. These data also indicate that bus commuters tend to spend more of their monthly income on travelling to work than commuters using other public transport modes (see figure 2.23).⁴⁵ Data from the earlier National Passenger Panel survey in 1992 indicate that 'white' commuters spend about three times more on work trips than 'black' commuters (R185 vs. R56/month). Recent national analysis of transport expenditure, as part of the urban passenger 'customer segmentation' associated with the new national policy and strategy framework (see table 2.6), indicates that the 'public transport captive' segment spend relatively more than other segments on transport – 35% of passengers within this segment were estimated to spend more than 10% of their disposable income on travel in 1995 (see figure 2.24) (TRC Africa 2000).

Table 2.25 *Transport expenditure findings in Cape Town surveys*

	1984 ¹		1991/92 ²	1992 ³	1994 ⁴
	SCHOOL	WORK	(pers exp on pub trans) WORK	(personal expenditure) WORK	(personal expenditure) WORK
'white' pop.	R0.20/trip average (n = 300h)	R1.63/trip average (n = 300h)		R185 trans cost/mth ave (n = 220 p)	
'coloured' pop.	R0.90/trip average (n = 300h)	R1.19/trip average (n = 300h)	4% R0-R20/month 40% R21-R40/month 24% R41-R60/month 20% R61-R80/month 3% R81-R100/month 8% >R100/month (n = 200 h)		R89 trans cost/mth ave R1 493 income/mth ave 6.0% of pers inc ave 28% spent >10% of inc (n = 100 p)
'black' pop.	R0.06/trip average (n = 150h)	R0.85/trip average (n = 150h)	1% R0-R20/month 15% R21-R40/month 61% R41-R60/month 14% R61-R80/month 6% R81-R100/month 4% >R100/month (n = 200 h)	R56 trans cost/mth ave 41.4% spent >10% inc (n = 100 p)	R81 trans cost/mth ave R837 income/mth ave 9.7% of pers inc ave 48% spent >10% of inc (n = 100 p)

Sources: 1= Cape Town Metropolitan Transport Area Land-Use / Transport Study (MEPLAN) household survey, 2= Survey of the transport problems experienced by residents in the Cape Town metropolitan area, 3= National passenger panel 1992, 4= National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities

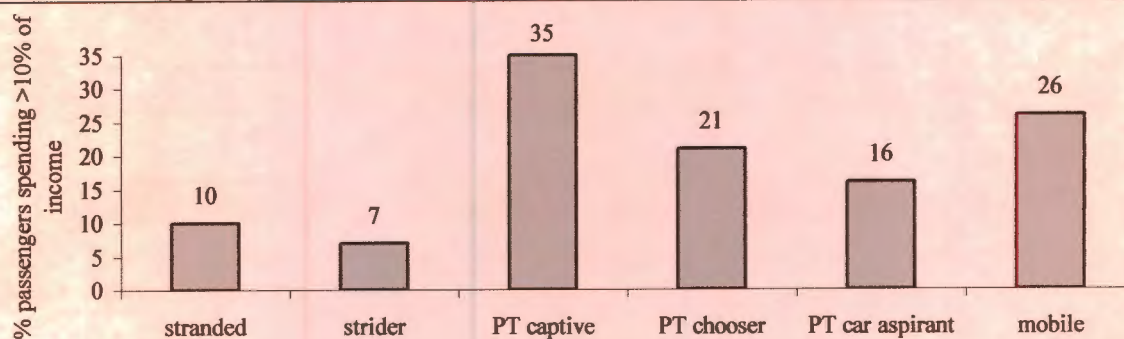
Figure 2.23 *Influence of travel mode on average monthly commuting cost in Cape Town (1994, n = 292 p)*



Source: National passenger panel 1994: A data base monitoring transport needs in disadvantaged communities

⁴⁵ This is a surprising finding as in the 1998/99 financial year bus commuters received greater subsidy than train commuters, at 36.8 cents vs. 12.8 cents/passenger km (or R3 278 vs. R864/commuter/annum). Bus trips shorter than 10 km are however unsubsidised. (CMC 1999b)

Figure 2.24 *Relationship between national urban passenger 'customer segments' and percentage of passengers paying more than 10% of disposable income on transport (1995 OHS, n = 30 000 h)*



Source: Strategic customer-based passenger transport information project

2.4.10 Latent demand

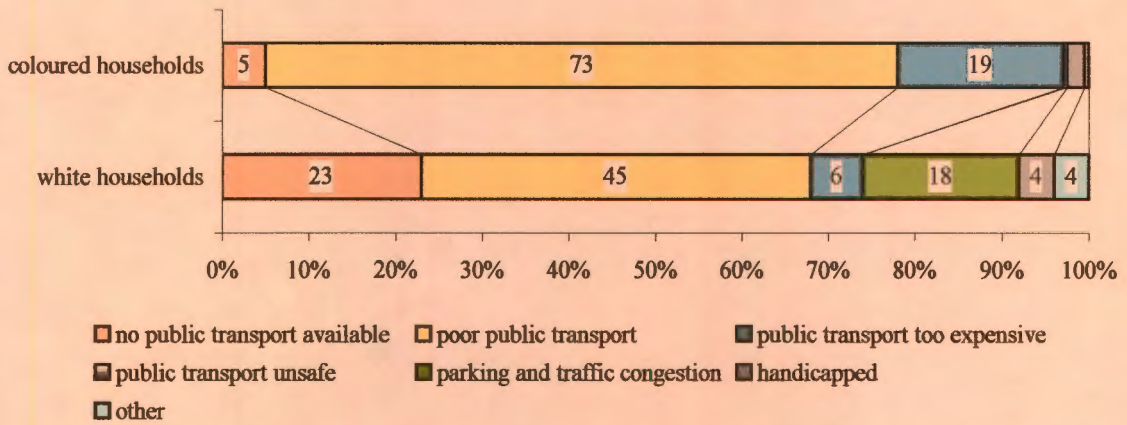
The only explicit attempt to analyse latent travel demand in the surveys reviewed, was undertaken as part of the preparation of Cape Town's 1980-1985 Transport Plan.⁴⁶ In this study it was acknowledged that measuring latent demand, or those trips that would have been made had the necessary transport services been available or affordable, is problematic, and the analysis essentially took the form of simply identifying and ranking the 'difficulties' experienced by respondents in making particular trips.⁴⁷ In the survey 37% of 'coloured' and 20% of 'white' households indicated that at least one member had difficulty in making certain trips. 'Difficult trips' accounted for 6% and 3% of 'coloured' and 'white' household trips respectively. Figure 2.25 presents the reasons given for difficulty in trip-making, and figure 2.26 presents the purpose of difficult trips. Given that discretionary trips are more likely to be subject to suppression (as opposed to compulsory trips like work or school trips), from these data it would appear that shopping and social/recreational trips are perhaps those most likely to be suppressed, and that the reasons for whatever trip suppression may occur are most likely to be associated with inaccessible or poor public transport services.

These data are of course considerably outdated. Most notably perhaps, whereas 'unsafe public transport' was provided as the reason for trip difficulty by only 0% and 0.3% of 'white' and 'coloured' households respectively in 1976, more recent data from 1991/92 on the problems facing public transport commuters (of all races) found that accident and crime safety were ranked as first and second most important respectively (see figure 2.27). The 1991/92 data indicate that safety, reliability and cost are likely to be the most important difficulties facing public transport commuters generally today (de Vries 1992).

⁴⁶ A more recent study in 1998 on the needs of mobility disadvantaged passengers in Cape Town, while not explicitly focused on latent demand, concluded that existing transport systems do not provide an accessible service to special needs passengers and that as a result much trip suppression is likely to occur amongst this category of travellers (CMC 1999a).

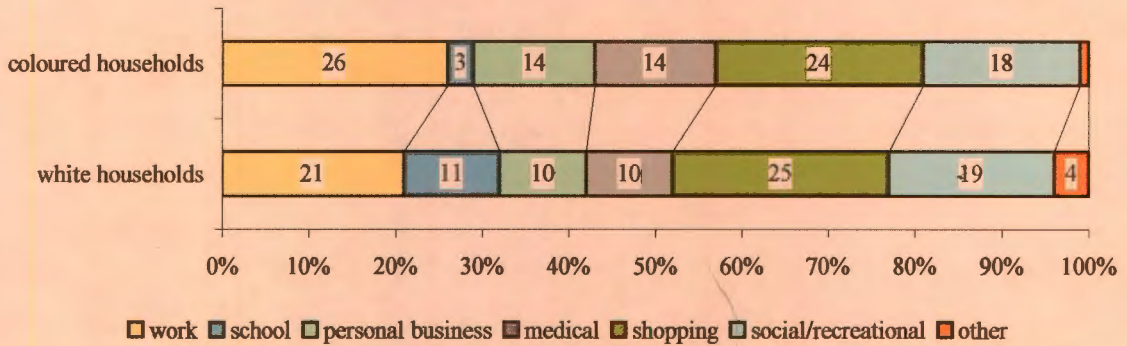
⁴⁷ Some of the problems associated with measuring latent travel demand are discussed later in chapter 3.

Figure 2.25 *Influence of racial stratification on reasons given for difficulty in trip-making (1976, n = 3 035 h)*



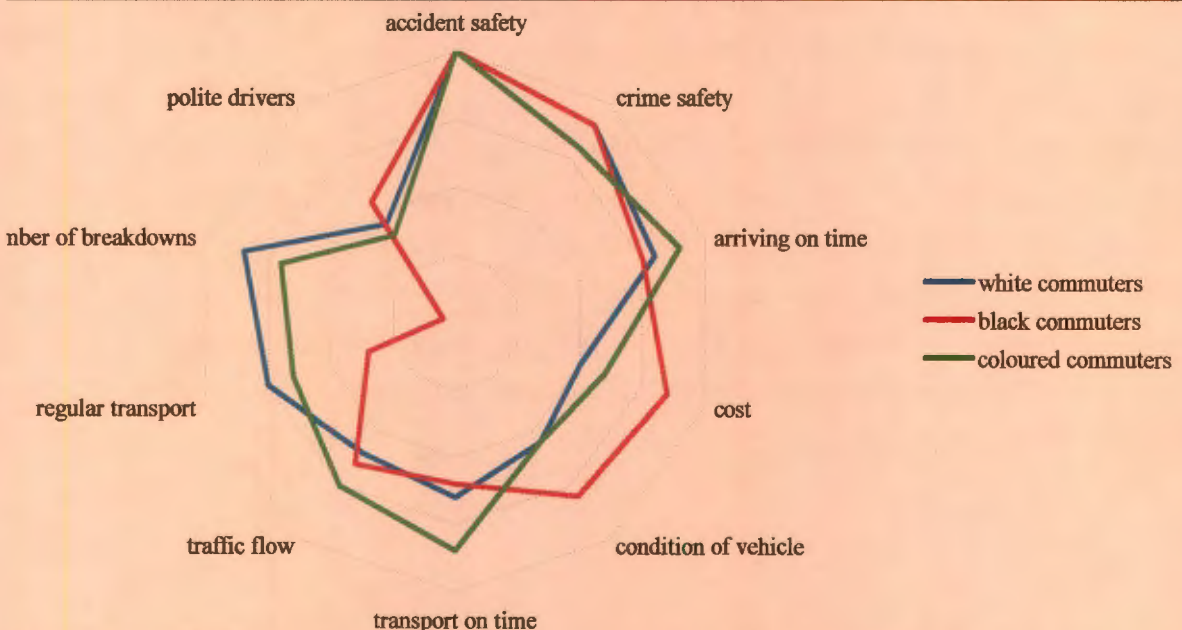
Source: Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey

Figure 2.26 *Influence of racial stratification on purpose of difficult trips (1976, n = 3 035 h)*



Source: Cape Metropolitan Transportation Study (1980-1985 Transport Plan) home interview survey

Figure 2.27 *Influence of racial stratification on the ranked importance of (the top ten) public transport commuting problems (1991/92, n = 500 h)*



Source: Survey of the transport problems experienced by residents in the Cape Town metropolitan area

2.5 GAPS IN UNDERSTANDING

What then are the major gaps in knowledge of current travel needs and behaviour? An immediate conclusion that can be drawn from the foregoing review of published data is that much existing knowledge is outdated. Most of the surveys reviewed were conducted eight or more years ago. Subsequent surveys (with the exception of the Moving South Africa survey in 1997) – in the form of the final National Passenger Panel in 1994 and the annual October Household Surveys – have focused almost exclusively on home-based work trips. Subsequent surveys in other cities – in Pretoria and Durban in 1999 – while covering more than just work trips, have focused on only the morning peak. Data on all but work trips (and morning peak trips in some other South African cities) are therefore outdated.

The issue of outdated data aside, in order to identify where gaps in knowledge exist, it is necessary first to conceptualise, at a crude theoretical level at least, what complete knowledge of travel needs and behaviour would encompass. The difference between the respective scopes of complete and current knowledge would thus represent gaps in knowledge or understanding. There are numerous possible ways in which the scope of such complete knowledge could be conceptualised and measured. It is conceptualised here in terms of four basic interrelated dimensions: the personal, functional, logistical and temporal. Travel is undertaken by people, and the particular circumstances of each individual influences his or her travel opportunities and choices (i.e. the personal dimension). The need for people to travel is derived from their need to engage in a variety of activities distributed across space (i.e. the functional dimension). In order to move between activity sites people need to make (sometimes highly complex) arrangements regarding how they will travel (i.e. the logistical dimension). Where and how people travel, changes over time in response to changes in their personal circumstances and in their broader environment (i.e. the temporal dimension).

Within the personal dimension, the scope of complete knowledge would cover the personal, household, socio-economic and spatial circumstances of travellers. Such circumstances include the age, gender, disability, independent mobility, household responsibilities, affordability and residential location of travellers. The available data in Cape Town cover the influence of race, income, vehicle access and location on travel patterns, and some data are available on mobility disadvantaged passengers and scholars in particular. Most studies however have tended to analyse trips, rather than the people who make them. National studies provide some insights into the influence of affordability, mobility and age on travel patterns. But in general it could be argued that there is little knowledge of the needs and behaviour of different kinds of individuals categorised on the basis of variables like age, gender and poverty, particularly of those individuals referred to in the international literature as the 'disadvantaged' or 'outsiders' around whom most equity issues in urban passenger transportation revolve (Denmark 1998, Falcocchio and Cantilli 1974, Rosenbloom and Altshuler 1979, Taebel and Cornehlis 1977). Equally importantly it could be argued that there is little knowledge of how individual

travel decisions are made within the context of household relationships and divisions of responsibility, and the construction of household survival strategies.

Within the functional dimension, the scope of complete knowledge would cover all the purposes for which travel is necessary. Such purposes typically include trips to work, education, shopping, business, social, personal business, recreation and home activities. The available data cover trips to education, shopping and social/recreational activities, but as mentioned earlier the emphasis has been on trips to work activities. It could be argued that there is little knowledge of current travel to non-work activities generally, and almost none of travel to business and personal business activities more specifically. In addition, travel by persons involved in informal income generating activities have received little explicit attention in travel surveys.

Within the logistical dimension, the scope of complete knowledge would cover the various arrangements and decisions that need to be made in order for a passenger to travel from one activity site to another. Such arrangements and decisions include the timing, mode use, transfer, chaining, distance, time and cost of trips. The available data in Cape Town cover the logistics involved in travelling to and from work relatively extensively (with the exception of how work trips are chained to other trip purposes), and to a lesser extent those involved in travelling to and from education and shopping activities. Little is known on other trip purposes. National studies provide some insights into shorter distance, non-motorised travel for various purposes, not covered by Cape Town data. It could be argued in general however that there is little knowledge of trip chaining (particularly the chaining of shopping trips with other trip purposes where, as mentioned earlier, some anomalies are apparent in the available data), of mode transfer (particularly for non-work trips), and of shorter distance travel for all purposes by non-motorised modes.

Within the temporal dimension, the scope of complete knowledge would cover the patterns of travel associated with seasonal, weekly and daily time scales, as well as even longer term changes in travel behaviour in response to changes in the factors that influence travel arrangements and decisions. Most available data cover weekday travel, and distinguish between peak and off-peak periods. Within peak periods published data are available on trip timing on a quarter hourly basis. Some data cover travel across the week, but seldom analyse weekday and weekend travel independently. It could be argued that there is little knowledge of trip timing across the day, of weekend travel, of the influence of school holidays on travel patterns, of response lags to transport supply or generalised cost changes, and of the influence of household life-cycle stage on travel.

Major gaps in current knowledge can thus be summarised fairly crudely as follows:

- the needs and behaviour of the different kinds of people who travel - particularly those travellers experiencing the greatest constraints on their mobility and access;

- how individual travel decisions are made within the context of household relationships, responsibilities and survival strategies, and how life-cycle stage influences travel behaviour;
- arrangements and decisions regarding travel to non-work activities generally, and the relationship between these and work trips;
- travel by persons involved in informal income generating activities;
- travel by non-motorised modes generally, and their relationship with motorised modes;
- the timing of trips across the day (particularly the off-peak periods) and across the week, and the influence of school holidays on travel patterns; and
- how, and over what timeframe, travellers respond to changes in the factors that influence their travel arrangements and decisions.

2.6 SUMMARY AND CONCLUSION

Since the first appearance of the specialist transport planning and traffic engineering disciplines in the 1930s, a number of distinct methodological streams in the analysis of travel need and behaviour have emerged – from the interview surveys that emerged in the 1930s and 1940s, to the aggregate methods of the 1950s and 1960s, to the land use-transport interactive and disaggregate methods of the 1970s, to the micro-simulation, dynamic, activity-based and strategic policy appraisal methods of the 1980s and 1990s. The methodological change and innovation that led to the emergence of these streams, typically occurred as changes in legislative and policy environments altered the nature of the analytical questions asked, as computing power increased, and as underlying behavioural theory improved. Most theoretical and methodological innovation occurred in developed countries of North America and Europe.

Methods of data collection and travel analysis applied in South Africa – principally in the form of inter-zonal O-D surveys and four-step traffic forecasting models – have been drawn from that stream of aggregate methods developed in the United States in the 1950s and 1960s in the context of a policy environment in which highway construction was the principle response to increasing car use and traffic congestion. While these methods have been refined and improved over time, they remain, procedurally and substantively, largely the same as those first developed in the late 1950s, and remain centrally focused on the problem of congestion and the construction of highways in its alleviation. In terms of recent discursive shifts from supply-side and commuter-based urban passenger transport policies, to demand-side and customer-based policies, these imported travel analysis practices are argued to be incapable of adequately addressing the range of analytical questions (regarding for instance equity and the scale and pace of behavioural change) that the new South Africa policy *milieu* raises. In terms of more recent methodological developments elsewhere, they might also be argued to be outdated.

A focus on traffic congestion, together with the labour transportation requirements of urban apartheid, led to a focus on home-based work trips and morning peak periods in South African travel analysis – as a primary contributor to motorised trips during peak periods and the period when congestion is worst respectively. As a result, little is currently understood of non-home-based, non-work, off-peak and non-motorised trip-making generally, and how this behaviour varies across different individuals and households. Of particular relevance to the focus of this dissertation, local travel – much of which is to non-work activities and by non-motorised modes – is thus either overlooked or poorly understood in travel analysis. It is concluded that, as a result of the limited scope of past surveys, there are insufficient current data available with which to adequately understand the nature and relative extent of local travel behaviour.

Chapter 3

Towards understanding the full diversity and complexity of travel need and behaviour in Cape Town

3.1 INTRODUCTION

Having established in chapter 2 that significant gaps in understanding exist in South African representations of travel need and behaviour, and more specifically that there are insufficient current data available with which to adequately understand the nature and relative extent of local travel behaviour, this chapter addresses the question of what travel need is in its fuller diversity and complexity, and what the relative importance of local travel need is in particular. A travel survey was undertaken that looked beyond commutes or morning peaks – the scope of most earlier travel analysis in South Africa as demonstrated earlier – to address this question. For purely pragmatic reasons, metropolitan Cape Town was selected as a case study of a South African city. This chapter documents this survey.

The chapter starts out by discussing the objectives of the survey. It goes on to select and describe the theoretical framework and method applied, and presents what the application of this framework method revealed. In a field dominated by prediction and mathematical modelling, and in a context of increasing economic uncertainty and demand-side and equity-oriented transport policies, I argue, for reasons articulated below, that travel analysis studies focussed on improved understanding of existing need and behaviour through empirical observation are important in and of themselves. Consequently I regard the collection and analysis of data to improve our understanding of current travel need and behaviour as an end in its own right, and make no attempt to develop a predictive model. An important reason for conducting the primary research was to enable a more comprehensive view of local travel to be developed, and the relative importance of local travel to be viewed in perspective. In addressing the latter, a number of new insights into travel need and behaviour more generally were gained, and these are reported on as well. As discussed earlier, this represents an expansion of the core research focus.

The chapter is divided into ten sections, including this introduction and a concluding summation. Section 3.2 (the next section) sets out the objectives of the survey. Section 3.3 discusses the theoretical origins of the survey and analytical method, and how the survey instrument was developed and tested. Time geography and activity-based analysis were selected as the theoretical and analytical framework, and because this a framework that is to a large extent untested in South Africa, the preparation for and administration of the survey is documented in some detail. Section 3.4 describes the survey sample, how the survey data were managed, as well as its limitations. Section 3.5 discusses the travel characteristics of the sample population as whole, while sections 3.6 to 3.9 discuss the influence of household income, neighbourhood form and location, household life-cycle stage, and personal circumstances on travel behaviour.

3.2 SURVEY OBJECTIVES

Having established in chapter 2 that most representations of travel need and behaviour in Cape Town have been limited to baseline surveys and future predictions of motorised commuter or peak period travel, why is *understanding* of existing travel patterns (as opposed to *prediction*) important, and why is it important for this understanding to be broader than simply of work- and congestion-related travel?

3.2.1 Importance of understanding diverse and dynamic travel patterns

In chapter 2 the point was made that aggregate (and later disaggregate) four-stage demand models and their data requirements have dominated South African travel analysis in the latter half of the 20th century. The same can be argued to be true internationally, even though more recently many European, North American and Australasian countries have applied alternative methods – in the form of activity-based, stated preference and panel analysis – to a far greater extent. This dominance has resulted in much greater importance being attached to the prediction (through mathematical modelling), than to the understanding (through empirical observation), of travel.

It has been argued that an increasingly fluid and globally competitive (or ‘post-Fordist’) urban economic context casts aspersions on longer term predictions, and an emphasis on prediction has hampered the ability of much travel analysis to develop an understanding of current behaviour in a period of rapid change (Gillespie *et al* 1998).⁴⁸ Policy changes have also been argued to have rendered

⁴⁸ In a critique of the conceptual and methodological paradigm that dominates urban transport studies, Andrew Gillespie, Patsy Healey and Kevin Robins for instance argue: “At the root of the problem appears to be an approach to social scientific enquiry that, faced with the enormous complexity of travel behaviour ... has tended to eschew *understanding* in favour of *prediction*. There are a number of inter-related features of transport research, which seem to stem from this predictive or forecasting objective, which we contend are undermining its intellectual credibility and hampering its ability to cope with the challenges it is facing, which primarily concern developing a better understanding of travel behaviour in a period of rapid change. ... Despite the critique, from the 1970s onwards, of the legitimacy of quantitative modelling of human behaviour, which has caused a major rethink of methodology within the social sciences, transport research remains largely locked into a quantitative modelling paradigm. This paradigm seems in the transport field to derive either from the systems analysis approach of engineers or from neo-liberal micro-economics, with its highly questionable assumptions

mainstream travel analysis increasingly obsolete (Axhausen 1997, Goodwin 1998, Hutchinson 1981). As discussed earlier, both internationally and locally, a clear change in transport policy discourse can be observed in recent decades – from ‘predict-and-provide’, to a greater emphasis on travel demand management. In South Africa this has been accompanied by a discursive shift from ‘commuter-based’ to ‘customer-based’ service provision. In chapter 2 the point was also made that within ‘predict and provide’ policies the urban transport planning problem was defined as one of avoiding the congestion associated with forecast traffic growth. As a consequence (at least in the South African context), travel analysis usually focused on (typically inter-zonal and motorised) commuter peak travel when congestion is at its worst. The implicit underlying assumption was that a transport system which satisfies the need for travel during the commuter peak, will be able to satisfy all other travel needs worth satisfying. As policies have recognised that it is neither financially, socially nor environmentally desirable to simply match predicted traffic with increased road construction, so it has become increasingly clear that new ways of conceptualising and analysing travel behaviour are necessary, and that the scope of analysis needs to extend beyond simply work and peak trips. Some authors have gone further to argue that the restricted scope of past travel analysis has in fact introduced a routine bias in the way in which the urban transportation problem has been understood, and in the nature of the interventions that have been implemented as a result. More specifically that a perception has been created that shorter slower journeys are less important than longer faster journeys, and that shorter distance non-motorised travel, depended upon by many of the transport disadvantaged, has thus either been underestimated or neglected in the planning and design of infrastructure improvements (Dimitriou 1993, Hillman 1994, Mashiri 1997, Vasconcellos 1997, Weatherall 1997).

Greater uncertainty, together with demand-side and equity-oriented passenger transport policies, thus necessitate an analytical emphasis on the diversity of current tangible accessibility problems, and on the complexity of travel adaptations to changes in urban transport systems brought about by the introduction of travel demand management strategies. While still necessary for the purposes of infrastructure design, longer term traffic predictions are no longer of paramount importance because road construction is no longer, or at least should not be, the cornerstone of transport policy. To identify accessibility problems, or so-called ‘equity gaps’, the scope of empirical observation clearly needs to extend to cover all travel undertaken by all people (as argued by Vasconcellos 1997). To identify travel adaptation to change, travel behaviour needs to be observed over time, and regarded more as a dynamic process of adaptation (or ‘churn’), than as an equilibrium state (as argued by Goodwin 1998). *Understanding* of behavioural patterns and responses to change, derived from empirical observation, is thus important, and studies focussed on improved understanding through empirical observation are important in and of themselves.

3.2.2 General study objective and research questions

Given the gaps in, and importance of, understanding discussed above, what then are the objectives of the primary research recounted in this chapter? The general objective is to demonstrate the diversity of travel needs and behaviour through empirical observation, and in doing so to begin to fill some of the gaps in understanding identified earlier (in section 2.5). Based on cross-sectional observation, the study will attempt to indicate the degree to which current representations of travel behaviour misrepresent the full diversity (and complexity) of travel needs, and to indicate what the true extent of these may be. It will not attempt to investigate the dynamics of travel adaptation to policy change (or seasonal change) however, as this would require the collection of longitudinal data not possible within the timeframe of this research. It will however, in a pseudo way (through the analysis of income bands and life-cycle stages), attempt to investigate the dynamics of travel adaptation to household change.

Before proceeding any further with elaborating upon this general objective however, it is necessary to take a position on the question of whether empirically observed, or expressed, travel behaviour, necessarily equate with the *need* for travel. As discussed earlier (in section 2.4.10) unexpressed travel desire is generally termed latent demand. The quantitative extent of such latent demand is difficult to measure. This is partly because it has been found that different methods of collecting quantitative data on suppressed travel yield different results (Rosenbloom and Altshuler 1979), and partly, and perhaps more importantly, because it has been argued that the desire to travel is not absolute or fixed (Denmark 1998). It has been argued that the desire to travel is largely a function of opportunity and cost, and that it thus varies as opportunities and costs change. So it is difficult to establish whether the difference in the absolute amount of travel observed in the same or similar individuals as a result of, for instance, increased or decreased road capacity (as discussed by Goodwin 1996), or public transport- or car-oriented local network configurations (as will be discussed later in chapter 5), is the result simply of changed desire or trip suppression. The travel desires of a group of very similar, or even the same, individuals may therefore differ according to their micro-situations. The position adopted here is that latent demand undoubtedly exists, is of great importance, but its measurement is very difficult using quantitative survey methods and is therefore not included as an objective in the primary research.

The more detailed research questions to be addressed in the study are as follows:

- What is the nature and extent of all travel (across 24 hours and across the week) in terms of amongst other things, trip purpose, mode use, range, chaining and timing – and in particular, in relation to the gaps in understanding discussed earlier, what is the relative importance and nature of non-work, informal work, non-motorised and off-peak travel?

- What is the influence of household income, and access to private transportation, on travel behaviour – and thus in a pseudo way, what are the dynamics of behavioural change in response to households becoming wealthier and poorer?
- What is the influence of neighbourhood form (i.e. land use distribution and street pattern) and residential location on travel behaviour?
- What is the influence of household life-cycle stage on travel behaviour – and thus in a pseudo way, what are the dynamics of behavioural change in response to households ageing, separating and forming?
- What is the influence of personal circumstance on travel behaviour in terms of amongst other things, trip purpose, frequency, mode use and range – and in particular, in relation to current gaps in understanding, what are the impacts of (un/under)employment, household divisions of responsibility and survival strategies on travel behaviour?

3.3 SURVEY METHOD AND THEORETICAL FRAMEWORK

Of the methodological streams in travel analysis identified in chapter 2, activity-based methods are argued to be best suited to pursuing the above objectives. They are best suited to analysing travel behaviour within a personal and household context, and because of their diary format, have proved to be better at collecting data on all travel. International studies (in the United Kingdom, Australia and the United States) which have compared the quality of travel data collected using conventional trip diaries (see figure 3.1) and activity dairies (see section 3.3.2.1), have shown that trip recall – particularly short trips, non-home-based trips and trips made by non-motorised modes – tends to be higher (perhaps by around 13-22%) in activity diaries (Arentze *et al* 1997, Barnard 1986, Clarke *et al* 1981a, Stopher 1992). The better trip recall in activity-based survey methods is generally attributed to the fact that in activity diaries the respondent is required to account for his or her time continuously and is therefore forced to recall past events more rigorously, and that recounting activity participation (as opposed to trip-making) matches more closely the way people think and function. The above finding can perhaps be corroborated in comparisons of data sets in Cape Town where a form of activity diary survey in 1981 found that ‘coloured’ households generated 13.6 trips per day (Cameron *et al* 1984), whereas an earlier more conventional trip diary survey in 1976 found that households within the same racial stratification generated only 7.4 trips per day (Moolman 1976). The latter survey did however exclude non-motorised trips for all but work and education purposes, which would account for some (probably about 50 percentage points) of this 84% discrepancy. This suggests that amongst households with greater reliance on public transport and non-motorised modes, and with proportionately fewer formally employed members, activity diaries might recall closer to 30% more trips than conventional trip diaries.

Figure 3.1 Example of a trip diary table (after Tolley and Turton 1995:18)

Day: _____ Date: _____

Trips	Purpose of travel							Method of travel				Travel with		Departure time	Travel time (in minutes)	
	work	school college	shopping	visiting people	entertainment	recreation	meetings	taking people	walk	bust/train	van/car	moped/motorcycle	cycle			household member
1.																
2.																
3.																

continued for the number of trips made within the survey period ... ↓

Despite a couple of applications in the early and mid-1980s, activity-based methods are to a large extent unknown and untested in South Africa (Behrens 2000).⁴⁹ To the earlier listed study objectives can therefore be added that of testing activity-based methods of data collection and analysis in the South African context.

3.3.1 Theoretical origins of activity-based methods

Earlier methodological streams drew behavioural theories from a variety of fields. Aggregate methods for instance drew from physics and economics in the development of (gravity theory-based) models of trip distribution and (equilibrium theory-based) models of network assignment, while later disaggregate methods drew from micro-economics and psychology in the development of (utility maximisation and random utility theory-based) models of mode choice. Activity-based methods continued to draw theories from other fields, particularly micro-economics and psychology, but what makes them distinct from other methodological streams is that their theoretical roots lie *primarily* in geography, and more specifically 'time geography'. Time geography (or 'chronogeography') emerged out of research undertaken in the late 1960s and 1970s, by Torsten Hägerstrand and his colleagues Tommy Carlstein, Bo Lenntorp and Solveig Mårtensson, a group of Swedish geographers based at Lund University – who became known as the 'Lund School' (Carlstein *et al* 1978, Carlstein 1982, Hägerstrand 1970 1975, Parkes and Thrift 1980, Thrift 1977).

⁴⁹ Most of the interest in activity-based methods in the 1980s was displayed by researchers at the NITRR (CSIR). The first application was the earlier mentioned study undertaken in 1981 by Bill Cameron, Marina Lombard and Romano Del Mistro (1984), in their empirical study of activities, attitudes and trip-making in seven residential neighbourhoods in Pretoria, Johannesburg, Durban and Cape Town. In this study a form of activity-travel diary was used to collect the daily activity pattern of all the members of sample households, and a trip map was used to record the modes and routes used in making the trips associated with this activity pattern. Liz Fourie and Nesta Morris (1985) then, in 1984, applied another form of activity diary to analysing the effect of journey times on the daily activities of 50 shorter distance commuters travelling from Mamelodi, and of 50 longer distance commuters travelling from Bophuthatswana and Kwandebele. The sample was restricted to lower income workers employed in eastern Pretoria, and to the previous working day. An activity-based travel game board (the later discussed HATS) was then applied by Nesta Morris (1986) in a pilot study in Pretoria. As in her earlier work with Liz Fourie, the main objective of the pilot study was to investigate the impact of long-distance commuting on commuters' daily activity patterns. The study was limited to 14 individuals living in Mabopane and Soshanguve, and to the previous working day. Respondents were reported to have found the apparatus too complicated, and considerable explanation time was required. It was also reported that while pencil and paper were taken seriously, the apparatus was felt to be childish and condescending (Morris and van der Reis 1986). Despite these and other problems, Morris (1986) concluded that such a study was feasible, and recommended further applications.

Hägerstrand (1970) argued that in analysing only mass probabilistic behaviour, regional science – a growing field within the social sciences at the time that specialised in the analysis of human behaviour in space using mathematical models – was unable to engage with important questions of poverty and quality of life of the individual. Hence his seminal paper presented at the Ninth European Congress of the Regional Science Association in 1969 posed the question: ‘what about people in regional science?’. Here he argued for an analysis of the micro-situation of the individual, as well as of what he referred to as the ‘twilight zone between biography and aggregate statistics’, where the life and identity of the individual was not lost in large-scale analyses of aggregate behaviour. Such micro-analyses, he argued, provided insights into the operation and performance of urban systems not possible in aggregated analyses.

The Lund School argued that in order to analyse the micro-situation of the individual, *time* needed to be incorporated into space studies as a way of disaggregating aggregate population statistics. In the theoretical framework of time geography they developed, time and space were regarded as *resources*, and the primary determinants of the human experience were seen to be the *constraints* that restrict an individual’s utilisation of these resources⁵⁰. Constraints took three forms: ‘Capability constraints’ referred to the physical and technological limitations of an individual. ‘Coupling constraints’ referred to the need for an individual to undertake certain activities at certain time-space locations, or ‘stations’, with other people – which results in a ‘bundling’ of individuals’ activities at specific stations (e.g. schoolchildren attending school classes). ‘Authority constraints’ referred to institutionally imposed restrictions and regulations (e.g. office or shopping hours) – which result in a hierarchy of overlapping time-space ‘domains’ that represent the limits of an individual’s possible activity participation.

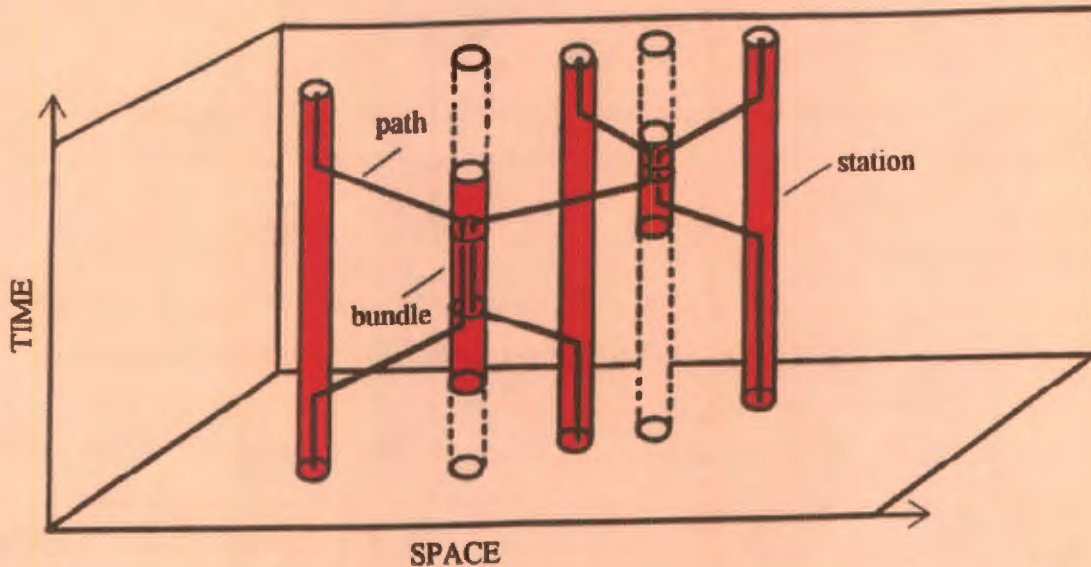
Two key analytical tools were developed by the Lund School to trace an individual’s, or a group of individuals’, utilisation of time and space resources, and the constraints that are imposed upon this: ‘time-space paths’ (see figure 3.2), and ‘time-space prisms’ (see figure 3.3).

A time-space *path*, or ‘trajectory’, referred essentially to an individual’s activity schedule through time and space. The paths of individuals were not seen to be isolated. As indicated above, they come into contact in the form of bundles, in accordance with the varying influence of the three types of constraints, and the positioning of ‘stations’ in time-space. The activities of a human population were

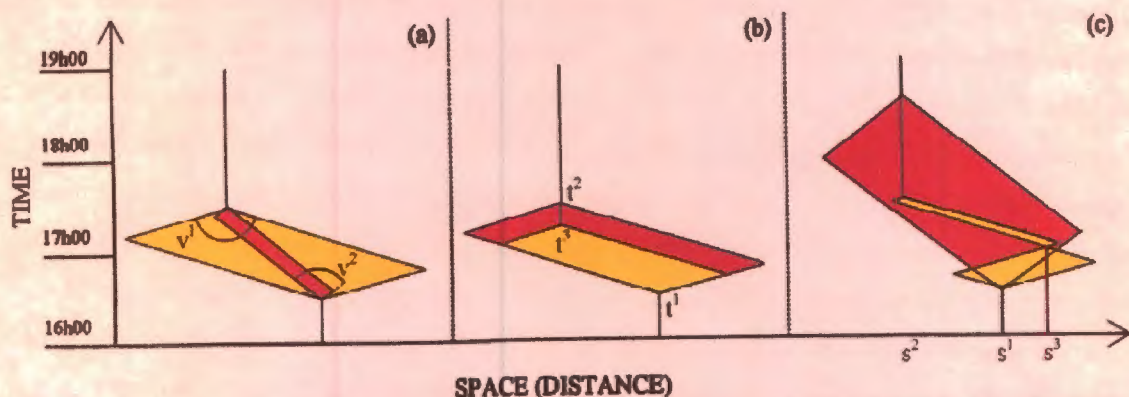
⁵⁰ Some authors have suggested that the contemporaneous, and broadly similar, work of Stuart Chapin, an American sociologist and urban planner based at the University of North Carolina at Chapel Hill, was equally influential in the emergence of the activity-based methodological stream in travel analysis (Bowman and Ben-Akiva 1996, Kurani and Lee-Gosselin 1996, Pas 1996). Nigel Thrift (1977) however argues that Chapin’s work is distinct from that of the Lund School in that activity participation and the human experience more generally were seen to be the outcome of choices that reflect the desires and values of the individuals who make them, rather than a series of constraints or ‘negative determinants’. Chapin (1974) argued that an individual’s demand to participate in various activities within an urban environment was motivated by a number of basic human desires, from ‘survival’, to ‘social encounters’, to ‘ego gratification’. The factors that were seen to impinge upon an individual’s choice of activity in order to meet one or more of these desires included: a ‘propensity’ for that activity to occur (e.g. the role of the individual within the household), a perceived ‘opportunity’ for the activity to happen (e.g. an accessible and appropriate place within which to conduct the activity), and an ‘appropriate situation’ within which the activity can occur (e.g. an appropriate time for the activity to occur).

therefore conceived of as forming a web of individual paths which flow through, and at times connect at, a set of time-space stations.

Figure 3.2 *Time-space paths, stations and bundles (after Parkes and Thrift 1980:250)*



A time-space *prism* referred essentially to the 'autonomy' of individuals to determine their time-space paths. The above-mentioned capability, coupling and authority constraints were seen to be central in defining the shapes and sizes of these prisms, and the paths that individuals took through them. The height of a prism was defined by the available time within which an individual could move from one spatially fixed activity to another, and make a discretionary trip or trips within this time as part of a trip chain or journey. The width of a prism was defined by the distance that could be covered by the individual to discretionary trip destinations within the time available. The amount of time available and the speed of the travel mode used therefore places constraints on an individual's time-space path. For instance, as the speed of the mode used increases, so the angle of the prism becomes more acute – non-motorised modes therefore result in narrower prisms, and a smaller range of possible 'discretionary' destination choices, than motorised modes. Time-space prisms enabled the collection of data on what people can and cannot do, rather than simply on what they chose to do (as in the case of revealed data collected in time-use surveys). This was argued to be more instructive for the purposes of formulating policies aimed at the creation of an 'isotropic plane of choice', or 'equitable urban environment' – the Swedish policy ideal at the time (Thrift 1977).

Figure 3.3 *Time-space prisms (after Thrift 1977:19-20)*

Note: Diagram (a) illustrates the effect maximum travel speed has on the width of a prism, where v^1 represents driving speed and v^2 cycling speed. Diagram (b) illustrates the effect time has on the height of a prism, where t^1 is the end of working hours (16h30), t^2 is the close of a child day-care centre (17h30), and t^3 is the adjusted close of the day-care centre (17h15). Diagram (c) illustrates the constraints placed on a parent leaving work (s^1) by car (v^1) and needing to draw cash from an automated telling machine (s^2) on the way to collecting his or her child from the day-care centre (s^2) before t^2 . From (c) it can be seen that the parent has the choice of few if any discretionary s^3 trip destinations, and would only have the choice of undertaking the trip chain by bicycle (v^2) if the day-care centre extended its closing time to 18h30.

3.3.2 Emergence of activity-based methods of data collection and analysis

The time geography theoretical framework, and more specifically its techniques of empirical observation, proved to be influential in various spheres of the social sciences. Time geographic techniques were used in the field of social theory, and more particularly the notion of constraint was adopted by analysts of travel behaviour in the field of transport planning. The emergence of activity-based travel analysis in the late 1970s and early 1980s marked what Eric Pas (1990) argues in his retrospection to be the only Kuhnian 'paradigm shift' in the evolution of the field. Pas argues that the shift from aggregate to disaggregate analytical methods that occurred in the 1970s was essentially a shift in statistical technique, rather than a shift in paradigm. The paradigm shift referred to involved, in essence, a redefinition of the phenomenon being analysed – *activities*, and the demand for travel derived from participation in these, replaced *trips* as the new unit of observation. The paradigm shift was however more than the kind of scientific revolution envisaged by Thomas Kuhn (1970) where one system of thinking is discredited by the scientific community and supplanted by another. It was the first time that positivism (with its associated stable, law-like ontology; objective or scientifically neutral epistemology; and hypothetico-deductive methodology) came into conflict, or at least coexisted, with other paradigms, in the field of travel analysis.⁵¹ Time geographic research, and the early applications of activity-based methods in travel research, might be argued to fall more neatly within the earlier mentioned 'critical social science' paradigm (with its associated dialectic, socially constructed ontology; value-driven epistemology; and deconstructionist and analytical methodology) (Neuman 1991, Terre Blanche and Durrheim 1999).

⁵¹ For a good illustration of this kind of paradigm conflict and coexistence, see the academic exchange between Janusz Supernak and John Polak in the mid-1980s. (Supernak 1983, Polak 1987, Supernak and Stevens 1987)

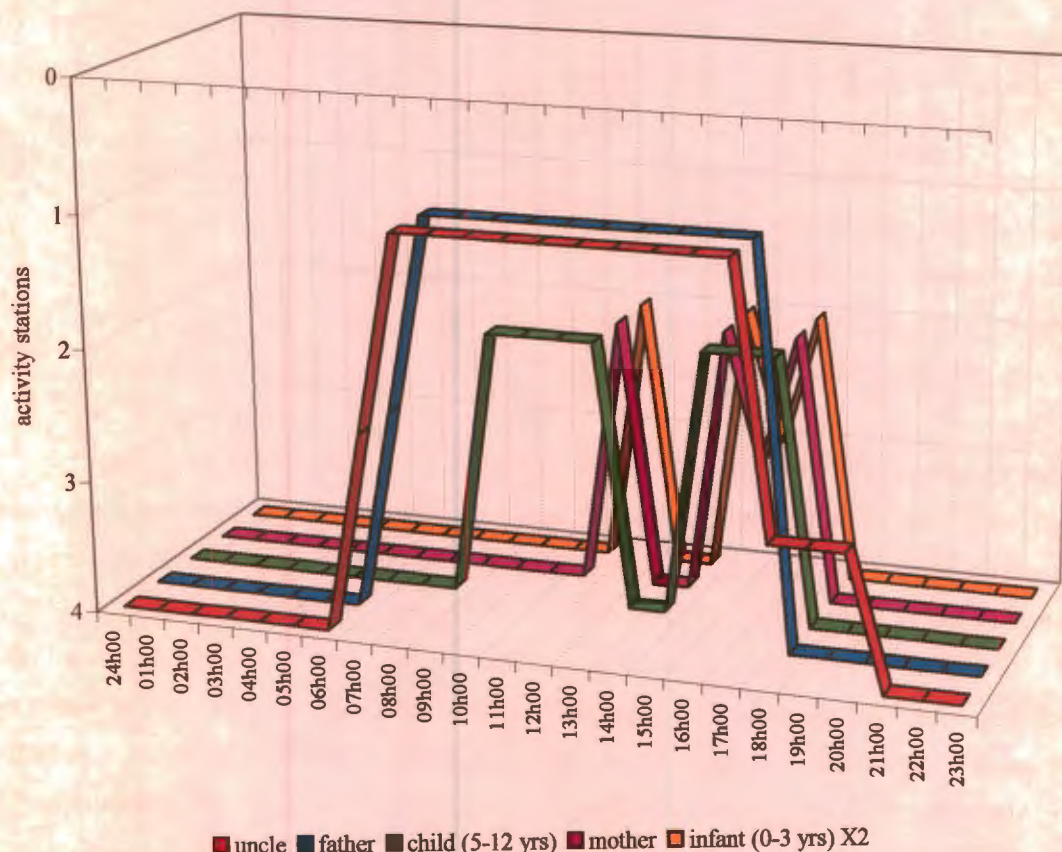
With a limited number of possible exceptions, the earlier aggregate, disaggregate and land use-transport interactive methodological streams had up until this point been based upon: the analysis of discrete trips; the analysis of choices in relation to discrete trips (using the theoretical framework of utility maximisation); and the achievement of, or at least the assumption that cross-sectional data collected on trip-making behaviour were in, some form of equilibrium state. Critics argued that these hitherto trip-, choice- and equilibrium-based analytical methods (operating largely within a positivist paradigm) neither explained travel behaviour and responses to transport system changes very well – particularly behavioural phenomena like trip chaining, timing, suppression and inducement, and intra-personal variability over time – nor were capable of identifying the varying impact of transport policies on different users. Earlier methods had been developed primarily for the long-term planning and design of road capacity improvements. The shift from supply-side to demand-side transport policies internationally, and more particularly the emergence of shorter term travel demand management strategies, highlighted the limitations of these methods in estimating the impacts of alternatives to increased road capacity (e.g. peak spreading, ‘park-and-ride’, telecommuting). As argued in the conclusion of chapter 2, despite incremental improvements, these methods remained fundamentally the same as those originally developed in the seminal transport studies of Detroit and Chicago in the 1950s and 1960s.

That time geography offered a theoretical framework that could overcome some of the limitations of earlier methods, was first recognised in the late 1970s. Pioneering studies into activity-based methods were undertaken by Ian Hoggie, and his colleagues Mike Clarke, Martin Dix and Peter Jones at the Transport Studies Unit (TSU), at Oxford University in the late 1970s and early 1980s (Clarke *et al* 1981b, Jones *et al* 1983). The emphasis in the activity-based methods developed by the TSU was on understanding the complexity and interrelatedness of travel patterns within households, and with the constraints that this interrelatedness placed on an individual’s travel choices. In contrast to earlier methodological streams, as stated earlier, the emphasis was therefore not solely on travel, but on people’s participation in activities and the connectedness among various activities, both for one person and for groups of people. It was argued that it was not possible to understand how travel behaviour might respond to changes in the transport system, without a much deeper understanding of the everyday lives and activities within which travel decisions are embedded. Activity-based studies applied the time-space paths and prisms of time geography to analyse household travel behaviour. Analyses of individuals’ time-use budgets were used to construct representative household time-space paths illustrating the range of constraints impacting upon travel behaviour (see figure 3.4). Jones *et al* (1990) identify the following as the defining features of the activity-based methods that emerged:

- explicit treatment of travel as derived demand;
- focus on sequences or patterns of behaviour rather than an analysis of discrete trips;
- emphasis on decision-making in a household context, taking explicit account of linkages and interactions among household members;
- emphasis on the detailed timing as well as the duration of activity and travel, rather than using the simple categorisation of ‘peak’ and ‘off-peak’ events;
- explicit consideration of spatial, temporal and inter-personal constraints on travel and location choices;

- recognition of the interdependencies among events which occur at different times, involve different people, and occur in different places; [and]
- use of household and person classification schemes (e.g. stage in family life-cycle), based on differences in activity needs, commitments and constraints. (Jones *et al* 1990:34)

Figure 3.4 *Hypothetical household 24 hour time-space path (modified from Clarke et al 1981b:3)*



Note: The 24-hour time-space paths illustrated in this diagram are for a 6 person lower income household, living in a township on the periphery of a larger city. The household is composed of an adult relative, a father, a child of 5-12 years, a mother, and two infants of 0-3 years. The household awakes at 05h30. The employed members of the household begin their long commute by train and taxi shortly before 06h00 in order to arrive at work (1) by 08h15. It is clear that the peripheral location of their home (4) and the 'authority constraints' imposed by their working hours, places a considerable burden on their time resources. Most of their 24-hour period is taken up with working, commuting and sleeping, with little time left for other activities. The mother keeps the two infants with her throughout the day, and delivers and collects the older child from school (2) and sporting activities in the morning and afternoon (a form of 'coupling constraint'). An arrangement with a neighbouring parent however means that she does not need to accompany the child to school at the beginning of the day. During the afternoon she stops at a local spaza shop (3) to purchase groceries. She has no access to private transport, so all her trips are undertaken on foot (a form of 'capability constraint'). It is clear that her child-care responsibilities and limited mobility place considerable constraints on her travel choices. The father and adult relative begin their commute home after work at 17h00. The relative stops at a shebeen (3) on the way home to meet friends and watch a football game. The household eats at 20h30, and all members are asleep by 22h30.

The work on activity-based methods in the 1980s focused mainly, but not exclusively, on *understanding* travel behaviour, and on new approaches to data collection and analysis – these are discussed next in section 3.3.2.1. Most work on *predicting* travel behaviour, and on the development of activity-based travel forecasting models occurred later, in the 1990s, by which stage numerous other academic institutions in countries like the United States, The Netherlands, Germany and Japan had developed research capacity in the activity-based field as well – these are discussed in section 3.3.2.2.

3.3.2.1 Activity-based survey instruments

The kind of data required by the emergent activity-based methods clearly necessitated more elaborate survey instruments than had previously been employed (principally in the form of trip diaries used in O-D surveys). These took the form of activity diaries. A review of the available literature reveals five generic activity diary forms:⁵²

- combined sedentary/travel activity diary tables;
- time-blocked combined sedentary/travel activity diary tables;
- linked sedentary and travel activity tables;
- in-depth interactive interviews and game simulation; and
- memory joggers and activity sheets.

Combined sedentary/travel activity diary tables were used in the earlier activity-based surveys administered in 1976 by the Oxford TSU in Abington (as a pilot survey) and Banbury (as the main survey), even though in Abington a 'free-form' diary was tested in which respondents were free to choose any way of recording their activities in a notebook provided (Clarke *et al* 1981b, Jones *et al* 1983). The diaries involved all household members keeping a temporal and spatial record of the activities they engage in, and of the trips they take in order to access these activities. The diaries were kept for seven days, and self-completed. Dairies for young children were kept by adults. Problems with the Abington and Banbury diaries included ambiguous location descriptions, difficulties in separating and describing activities, and fewer recorded activities and trips later in the seven day period. The relative advantage of combined sedentary/travel activity diary tables would appear to be that they are easy to understand. Their relative disadvantage is the limited amount of data they collect.

Figure 3.5 Example of a combined sedentary/travel activity diary table (after Jones *et al* 1983:60)

Household member name: _____ Day: _____ Date: _____

Time of start	Activity	Details of travel (describe each stage of journey)	Location		Time of finish
			home (tick)	elsewhere (describe)	

continued for 24 hour day ... ↓

Time-blocked combined sedentary/travel activity diary tables are a form of activity-based survey instrument that has been applied in South Africa. An early application was in six middle-income

⁵² In designing activity diary instruments, decisions needed to be made on a number of issues: their functional scope - whether activity descriptions are open or coded, and whether activity descriptions are required for all activities, out-of-home activities, or just place-related activities; their temporal scope - whether time intervals are open or fixed; their time horizon - whether activities are recorded for the previous day, or during the diary day; the diary period - the days of the week selected, and the number of days; and the administrative procedure - whether the diary is recorded in a personal interview, telephone interview, or by self-completion, and whether in interviews paper or electronic questionnaires are used. Theoretically at least some of these design options - the extent of activity disaggregation, the diary period and the administrative procedure - can apply to almost any diary form. Others are specific to particular forms.

'white' and 'coloured' residential areas in Johannesburg, Pretoria and Durban (Cameron *et al* 1984). A later application used a diary to analyse the behaviour of informal food traders in New Crossroads, KTC and Nyanga (in Cape Town) (Dierwechter 1999). In both of these diaries, activities and time intervals were prescribed. In the former the diary was kept for one day and self-completed, and in the latter it was kept for three days and completed by the interviewer in multiple visits. The relative advantage of time-blocked combined sedentary/travel activity diary tables would appear to be their simplicity and low respondent burden (no writing is required, just block marking), even though Cameron *et al* (1984) did report that a significant proportion of respondents found the diary too complicated. Their relative disadvantage is prescribed activities and time intervals which can result in coarser activity duration, travel time and trip timing data, or even omission.

Figure 3.6 *Example of a time-blocked combined sedentary/travel activity diary table (after Cameron et al 1984:6)*

		midnight								noon								
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
	
Asleep																		
Awake																		
At home																		
At work/further education																		
At school																		
Shopping																		
Visiting (any purpose)																		
At entertainment																		
Adult recreation	home																	
	street																	
	other																	
Child's play	home																	
	street																	
	playlot																	
	other																	
Any other activity (specify)																		
Travel to/from	work/further education																	
	school																	
	shops																	
	visiting																	
	recreation																	
entertainment																		
Go for a walk																		
Go for a drive																		
Any other travel (specify)																		

continued for 24 hour day ... →

Linked sedentary and travel activity tables are a modification of combined tables whereby sedentary activities and travel activities are recorded in one table, and travel activities are then recorded again in greater detail in another table. In this way more detailed data can be collected than in combined sedentary/travel activity tables. This form of diary was administered in a self-completion survey in Adelaide in 1980 over the course of a week (Barnard 1986). The relative advantage of linked sedentary and travel activity tables would appear to be that they are capable of recording greater detail on travel activities than combined tables. Their relative disadvantage is that the simultaneous

completion of two tables makes them more complicated to understand and thus present a greater respondent burden.

Figure 3.7 Example of a linked sedentary and travel activity diary table (after Barnard 1986:332-333)

Household member name: _____ Day: _____ Date: _____

GENERAL ACTIVITIES

Time activity started	Time activity finished	What were you doing?	Was a child < 12 with you at the time		How often do you do this (tick one)				If daily or weekly, do you usually do this at about this time? (tick one)			Where were you?	Money spent on activity		
			yes	no	about daily	about weekly	irregularly	none of these	yes	no	varies		\$	c	

continued for 24 hour day ... ↓

IF YOU TRAVELLED TODAY

Time trip started	Time trip finished	Method of travel (tick one)							Time spent walking to and from car or public transport (minutes)	If public transport used		If car or motorcycle used parking (tick one)						
		car driver	car passenger	car pool	motorcycle	taxi	train	bus		bicycle	walk	fare (cents)	number of transfers	waiting time (minutes)	number of people (inc. driver)	street parking	off street parking	home off street

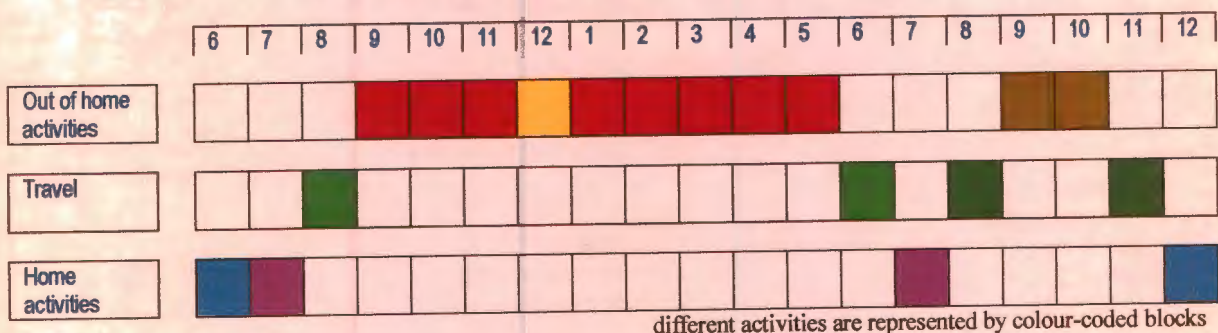
continued for 24 hour day ... ↓

In-depth interactive interviews involve establishing activity schedules and travel patterns, and asking household members how they would alter this if a change in the transport system, or in any other constraint on their daily activity schedule and travel behaviour, were to occur. A well-documented example is the *Household Activity-Travel Simulator (HATS)* developed by the Oxford TSU and first applied in 1976 (Jones 1979a 1979b, Jones *et al* 1983). In the HATS interview, the respondent is asked to plot his or her home activities, non-home activities and interlinking travel activities for the previous day, on a gameboard, using different coloured blocks. Having established the individual's actual activity-travel behaviour for a particular day, the individual is then asked to rearrange this represented activity-travel pattern in response to a range of hypothetical temporal or transportation supply changes (e.g. changing working hours, bus availability) through rearranging the blocks. The revised individual activity-travel patterns are then quantified and analysed. The relative advantage of in-depth interactive interviews would appear to be their ability to collect qualitative and predictive data. Their relative disadvantage is their complexity and inappropriateness for larger scale surveys.

Figure 3.8 *Example of an in-depth interactive interview and game simulation (after Jones 1979a:63)*



map of study area with coloured markers to show activity locations



Memory joggers and activity sheets are a form of survey instrument that have been developed and applied in the United States in the 1990s. The memory jogger is intended to get the respondent to either think through the 24 hour recall period and order activities in time, or to keep a brief record during the diary period to assist in more detailed recall later. Information on each activity identified in the memory jogger is then recorded on a separate sheet within a booklet. The level of detail of the questions regarding each activity depends on the objectives of the survey. In some cases the questions on the sedentary activity, and how (and if) the respondent travelled to the activity site, are separated onto two sheets (Cambridge Systematics 1996, Stopher 1992). Some diaries have been self-completed, while others have been completed through a computer-assisted telephone interview. An example is the two 24 hour day diary administered in Portland in 1994 (Cambridge Systematics 1996). The relative advantage of memory joggers and activity sheets would appear to be their ability to collect the most detailed data of any form of activity-based survey instrument. Their relative disadvantage is their inflexibility (if an activity is forgotten in the memory jogger it is difficult to insert later as activity sheets are numbered) and intimidating length. In paper form a single 24 hour diary booklet can be up to 25-30 pages long, depending on the amount of activities performed by the respondent.⁵³

⁵³ Recent innovations in the United States, in the form of more flexible 'day planner' diaries (without memory joggers), have however reduced booklets to 16 pages in total (Stopher and Wilmot 2000).

theories that underpinned conventional models. The time geographic theoretical framework could say a lot about how people arranged their lives in time and space to complete 'projects', but could say little about the societal relations that led to particular people undertaking particular kinds of projects in the first place. However, in my view, criticisms of the failure to produce more accurate link flow predictions were misconstrued. These criticisms failed to recognise the aforementioned shift from supply-side to demand-side policies in the 1980s, within which the activity-based methods had, either explicitly or implicitly, emerged. They evaluated these methods from a supply-side, or 'predict-and-provide', policy perspective, in which the solution to transport problems was increased infrastructure capacity. Hence a failure to produce information that assisted in the design of capacity improvements, was construed to be a major failure in the method. Nevertheless, in response to these criticisms, the 1990s saw a fairly rapid development of activity-based travel forecasting models that could provide more accurate link flow predictions, as well as the development of a more elaborate underlying theory.

The single defining feature of the activity-based travel forecasting models that emerged is perhaps that they attempt to predict travel behaviour by simulating changes in the daily 'activity schedules' of representative synthetic individuals, or households, in response to changes in the temporal, spatial and transportation environment.⁵⁴ In the case of some models at least (e.g. SAMS [*Sequenced Activity Mobility Simulator*], TRANSIMS [*Transportation Analysis and Simulation System*]), the trips that result from activity schedules are then aggregated and used as the basis for network assignments – thus providing link flow predictions. Most models however focus primarily on activity participation and scheduling.

3.3.3 Development and testing of survey method

A survey method and instrument was developed within the activity-based analytical framework discussed above to address the survey objectives discussed in section 3.2. This underwent a pilot survey, and a subsequent pre-test survey, before it was applied in the main survey.⁵⁵

3.3.3.1 Pilot survey

Given that the survey was to be conducted in parts of Cape Town where low levels of literacy and education are prevalent, the decision was made initially to adopt a form of self-completion diary table that would appear to be easiest to comprehend. Resources were not available to test various forms of

⁵⁴ Numerous approaches to activity schedule modelling have been developed, and it is not possible to describe a general model structure or theoretical framework in the same way it would if one were describing earlier four-stage models. Numerous authors have attempted to categorise the different modelling approaches, but most of these authors have ended up with quite different categorisations and labels. See Behrens (2000) for an overview of 'constraints-based', 'utility-based', 'rule-based' and 'hybrid' approaches to activity schedule modelling, as categorised by Theo Arentze, Frank Hofman, Nelly Kalfs and Harry Timmermans (1997).

⁵⁵ In addition, advice was sought in interviews, with ten experts in the fields of travel analysis and survey administration, conducted during the course of 1999 and 2000. This process culminated in a seminar with nine invited delegates in August 2000.

3.3.3.2 Pre-test survey

As a result of the problems experienced in the pilot survey, the following changes were made in the pre-test survey (see figure 3.11):

- household relationships were recorded in terms of the relationship to the youngest household member;
- childcare and housework were defined as occurring in normal working hours;
- a form of linked sedentary and travel activity diary was developed to distinguish between sedentary activities and travel activities, but in an attempt to keep the simplicity of a combined table however, both the sedentary and travel activity tables appeared on one page so that the link between the two was visible and repetition was unnecessary;
- the travel distance question was replaced with a travel time question (distances are then imputed in data analysis through the use travel speed assumptions for different modes); and
- the trip frequency question was asked in terms of 'how many times a week do you make this trip'.

Figure 3.11 Pre-test survey (linked sedentary and travel activity) diary table

Household member name: _____ Day: _____ Date: _____

WHAT DID YOU DO TODAY?					IF THE ACTIVITY YOU LISTED INVOLVED TRAVELLING ...										
Start time	What kind of activity was this? (describe the activity using only a couple of words, e.g. 'slept', 'got ready for school', 'travelled to school', 'cleaned house', 'shopped', etc.)	Where did you do it?	Which suburb?	End time	How did you travel?			How many minutes were spent travelling ?	Who, if anyone, did you travel with?	How many times a week do you make this trip?					
					by walking	by bicycle	by minibus taxi	by bus	by train	car driver	car passenger	?			

continued for 24 hour day ... ↓

The pre-test survey was conducted in August 2000 using 24 students recruited through the University of Cape Town's Job Opportunities Bureau as interviewers. Each interviewer underwent 2-3 hours of training prior to the survey. Training took the form of formal instruction, and mock questionnaire and diary completion.⁵⁶ Each interviewer was instructed to survey one randomly selected household. Due to fewer interviewers being available than initially hoped, the areas surveyed were limited to Rondebosch, Woodstock and Joe Slovo Park informal settlement in Langa. The interviewers were

⁵⁶ Prior to the pre-test survey the intention was to sample households in 8 sampling areas for 2-3 designated days, staggered over a 7 day week. At the time, the safety of the interviewers was a major concern. Apart from generally high levels of violent crime in Cape Town, one of the sampling areas, Mitchells Plain, was experiencing a flare up in an ongoing gang conflict, and in another, Khayelitsha, bus drivers and passengers were being attacked as part of a disagreement between minibus-taxi operators and the local bus company over access to passengers. For safety (as well as transportation and language) reasons, interviewers were sought who lived in the different areas and were thus more familiar with potential dangers, and those recruited travelled in groups of three or four with a designated supervisor.

instructed to make contact with the household in the early evening between 17h00 and 19h00, on three separate occasions. In the first contact the interviewer introduced him or herself, and the survey, to an adult in the household who, if possible, could read English. The adult was interviewed on the demographic and socio-economic situation of the household, and was shown how the individual activity diaries should be filled in. The adult household member was asked to show other household members how the diaries should be completed, and to assist those unable to complete the diaries themselves. In the subsequent two contacts, the interviewers checked that all household members were filling in their diaries correctly, and where necessary, provided assistance by correcting or redoing incorrectly completed diaries with the individual concerned. These contacts were made the day after the day on which the diary was kept.

The pre-test yielded poor results. Of the 24 students recruited, only 15 attended the training sessions. Two of the 15 interviewers dropped out during training, and another 2 during the pre-test survey, leaving 11 interviewers and thus 11 household surveys were returned at a cost of R110 each. Of these 11 surveys, only 2 were fully completed. Of the 9 remaining surveys, 7 contained information that could be used for data capturing – in total 19 personal 24 hour diaries that possibly could have been entered, with editing, into the data base and used to increase the sample size of specific individual traveller categories. The feedback received from interviewers, back-checks with households,⁵⁷ and questionnaire inspection indicated the following key problems:

- it was apparent that amongst many respondents, particularly from lower income households, (and indeed amongst some interviewers) there was a difficulty in reading and completing diary tables as a series of intersecting columns and rows – a common problem was the completion of travel details in the same row as a sedentary activity (e.g. the completed diary table might read that the first activity of the 24 hour day was sleeping, and this was done by minibus-taxi two to three times a week);
- a lack of symmetry between forward and return trips recorded in diary tables (e.g. the forward journey might include a walking trip to a bus station and a bus trip, whereas the return journey [between the same O-D pair] indicates only a bus trip);
- a failure to account for all time on the 24 hour diary table;
- a general respondent unwillingness to keep a diary for two consecutive days⁵⁸ – some household members who initially agreed to do this, subsequently failed to do so once the effort that was entailed became clear, while others agreed to keep diaries only if they were for one day.

In addition it became apparent that in the context of the current real or perceived crime rate and associated prejudices, it is important that interviewers and respondents are of the same race. In those

⁵⁷ In quality checks it became clear that some interviewers simply dropped off the questionnaire and asked the household to fill it in themselves, and did not undertake the initial household interview and diary explanation as instructed in the training sessions.

⁵⁸ International experience had suggested that, in the absence of substantial monetary incentives and supervisory networks, 48 hours was the maximum achievable diary period (Arentze *et al* 1997).

areas where this was not the case, and more specifically where 'black' interviewers were interviewing 'white' or 'coloured' respondents, very low response and co-operation was received. In Rondebosch, housing a predominantly 'white' population, only one in nine households agreed to be surveyed. In Woodstock, housing a mixed 'coloured' and 'white' population, one in five households agreed to be surveyed. The equivalent ratio in Langa, where interviewers and respondents were all 'black', was one in two. In Rondebosch and Woodstock many households refused to participate in the survey on the grounds that they would be providing information on when their homes would be empty and thus exposed to housebreaking, or that by providing information on the vehicles they owned this too would make them more vulnerable to theft. This attitude prevailed despite assurances of confidentiality, and a formal covering letter noting the approval of the survey received from Ward Councillors and relevant civic or resident organisations.

Surprisingly, problems were not encountered in describing activities in the space available on the questionnaire, and in time recall. With regard to the latter, given that some unemployed adults are unlikely to schedule their daily activities within prescribed time constraints in the same way that an employed worker or scholar would, it was expected that such respondents may have difficulty in recalling start and end times, and estimating activity durations. This was not the case, even though some respondents failed to account for all their time in the diary period and the reasons for this are unclear.

3.3.3.3 *Main survey*

Given the poor results yielded by the pre-test survey, an effort was made to determine how activity diaries had been administered in other developing world contexts. Only two such surveys were found, one in the Philippines (Villoria 1993) and the other in Indonesia (Roland Kager pers comm 2000).⁵⁹ It appears that both of these surveys took the form of recall interviews (as opposed to self-completion questionnaires), and as discussed earlier, South African applications amongst lower income 'black' respondents took the form of recall interviews as well (Morris 1986, Dierwechter 1999). Earlier time-use surveys in South Africa (Fourie and Morris 1985, Tshatsinde 1999), as well as the contemporaneous time-use study conducted by Statistics South Africa (Mpetsheni and Budlender 2000), have also been interviewer administered. As a result of this precedent, as well as of the problems experienced in the pre-test survey, four main changes were made:

- The 2-day diary period was replaced by previous 24-hour day recall (with concomitant impacts on data quantity and quality).
- The leave-behind self-completion questionnaire was replaced by recall interviews.
- The paper format of the survey instrument was converted to an electronic one, so that the interview could be conducted with the use of computer-assisted personal interviewing (CAPI)

⁵⁹ Another was found in Nagpur, India (Ranganathan *et al* 1988), but a copy of the paper was not acquired.

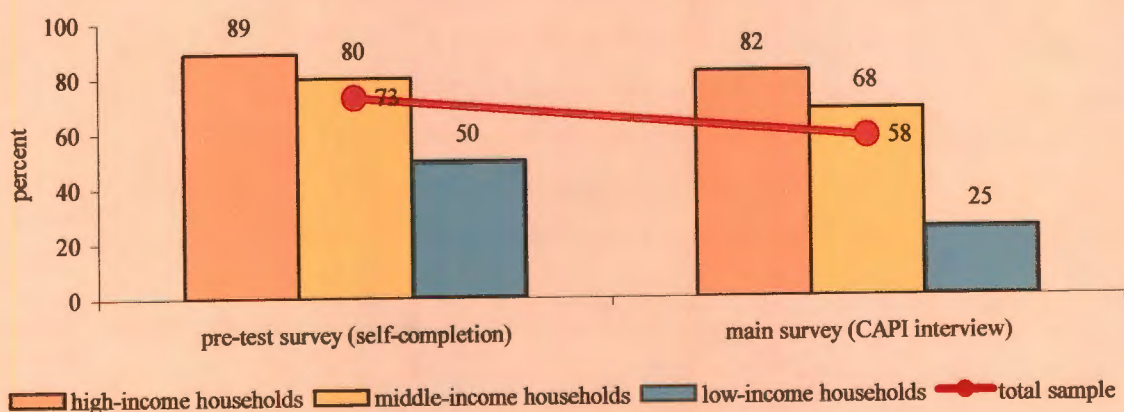
In2quest software, and the interview transcript was translated into the three main languages spoken in the study area (Afrikaans, English and isiXhosa – see appendix B for the English and Afrikaans CAPI transcripts). An advantage of CAPI interviews, in terms of the pre-test experience, is that the completion of tables is avoided altogether, interviewers can prompt respondents when it becomes apparent that trip segments or waiting times have been omitted, and logical checks can be put into place that prevent gaps in diary time or missing/beyond range data. A further advantage is that for most (but not all) database fields, data collection, coding and capturing is collapsed into one stage. Together, Kalfs and Saris (1997) contend that these advantages lead to increased speed, reduced costs and improved data quality, even though relative benefits have yet to be quantified empirically in a systematic way.

- The use of students as interviewers was discontinued, in favour of a more reliable and experienced market research company with professional interviewers of all racial groups (with concomitant impacts on cost and sample size);

Three market research firms were invited to tender for the main survey. The three firms quoted costs on a previous day recall interview at R280, R199 and R103 per collected, coded and captured household interview (excluding VAT). The firm *AC Nielsen MRA* was appointed to conduct the survey (at R199 per household interview). The CAPI interview was tested (in an observed panel test), ± 20 interviewers were briefed, and data was collected during school terms – between 23 October and 29 November 2000, and 26 January and 3 February 2001.

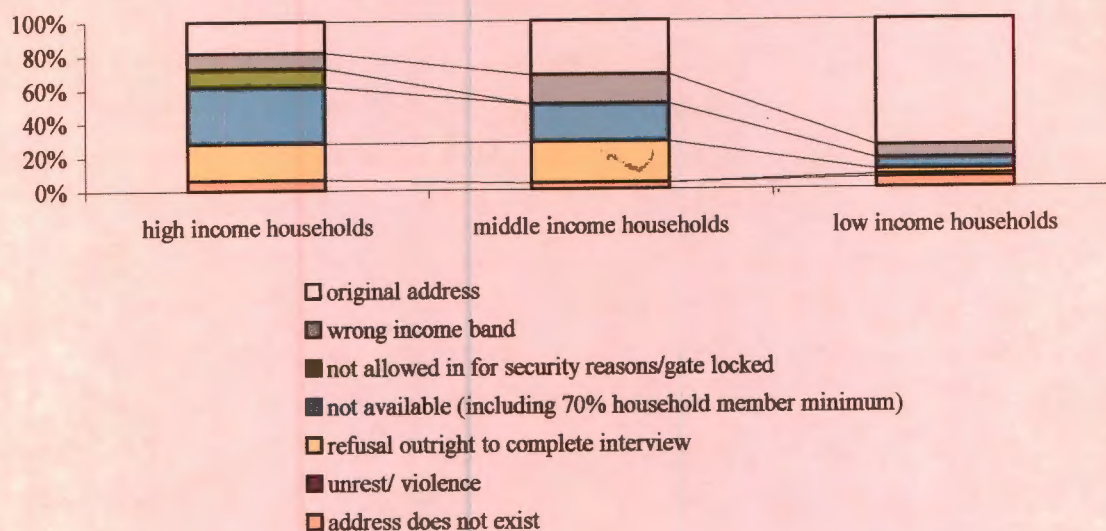
The changes made in the main survey resulted in reduced substitution rates, from 73% in the pre-test to 58% in the main survey (see figure 3.12).⁶⁰ Figure 3.13 illustrates that substitution was considerably higher amongst higher income households.

Figure 3.12 *Pre-test vs. main survey substitution rates by income band*



⁶⁰ The term 'substitution rate' refers to the percentage of randomly selected households who, for various reasons, were not interviewed and needed to be replaced by alternate randomly selected households. This rate refers only to the originally selected household, and not to the subsequent unavailable or unsuitable households who were approached in finding an alternate for the original household.

Figure 3.13 *Reasons for household substitution in main survey by income band*



3.4 SAMPLE SELECTION AND DATA LIMITATIONS

Given the general study objective articulated earlier – to demonstrate the diversity of travel need – the survey clearly needed to examine the travel patterns of metropolitan Cape Town’s population as a whole, and given the activity-based analytical framework selected, households⁶¹ clearly needed to be identified as the primary sampling unit. The National Census of 1996 (the most recent census data available at the time of writing) estimated that the population of the Cape Metropolitan Area (CMA) was 2 557 456 people (or 651 599 households) – which the Cape Metropolitan Council believe was closer to 2 683 000 people (or 681 000 households) (Dorrington 2000). Assuming an annual population growth rate of 3%, the CMA population in 2000 may therefore have been around 2,878 to 3,019 million people (or 732 000 to 768 000 households).

3.4.1 Sample selection

How then was the sample from the CMA population selected, what are its socio-economic and demographic characteristics, and what are its limitations with respect to addressing the research questions identified earlier?

3.4.1.1 Sample size

It was clear from the outset of the study that resources were not available with which to undertake a survey that would yield data that are statistically representative. In the context of limited research funds, the sample size was determined simply as the largest amount of sampling units affordable. As

⁶¹ A household is defined in this study as a person or group of people occupying a common dwelling space for at least four days a week, and who provide themselves with food and other essentials for living.

will be discussed later, six travel analysis zones were identified as sampling areas. Table 3.1 presents the target population (or 'universe') in each of the TAZs, the sample size that would be required to be 95% confident that the actual mean of a simple dichotomous (yes-no) variable falls within 5% on either side of the sample mean, the actual sample size, and the actual confidence interval at a 95% confidence level. The calculated values presented in the table illustrate that 95% confidence levels and 5% confidence intervals for each of the TAZs would have necessitated a total sample size of 1 797 households. Given the sampling unit costs discussed earlier, this would have necessitated almost nine times the resources available. With the available resources it was only possible to survey 204 households. The data collected and analysed is thus 'indicative' of diversity, rather than 'representative' of reality. In strict statistical terms the best that can be claimed is that one can be 95% confident that the actual mean of a simple dichotomous variable falls within 15.2% to 17.6% on either side of the sample mean, depending on the TAZ. Given the objectives of the survey this is justifiable. The data will not be used to calibrate a predictive model, nor make claims of statistical representivity. It will be used to investigate the diversity and size of gaps in understanding, and to explore a new research method in South Africa.

Table 3.1 *Confidence levels and intervals of sample (households)*

	TAZ 706	TAZ 1005	TAZ 203	TAZ 3008	TAZ 1203	TAZ 3214
target population (1996) ¹	918	1082	504	2 177	9 931	2 207
ideal sample size ²	271	284	218	327	370	327
actual sample size	34	31	34	41	31	33
actual confidence interval ³	16.5	17.4	16.3	15.2	17.6	16.9

Notes: 1= The target population in each TAZ is that portion of the entire population falling within the specified income band stratification. 2= The ideal sample size is calculated to have a confidence level of 95% and a confidence interval of 5%. 3= The actual confidence interval is calculated to have a 95% level of confidence.

3.4.1.2 *Sample stratification and clustering*

The sample of 204 households was stratified into three equally sized – high, middle and low – combined household (gross) income bands. The 1996 census data were analysed to determine the cut off points for these bands, and these 1996 values were then adjusted, using the Consumer Price Index (CPI), to relate more accurately to current incomes. The sample was distributed proportionately across these three bands. Thus after the rejection of sampling units with irredeemable errors, about 68 households in each income band were surveyed.

The sample of households was then clustered into selected neighbourhoods of the CMA (see figure 3.14). For each income stratification, two sampling areas were selected giving a total of six sampling areas in all. About 34 households were surveyed in each area (see table 3.2). The two sampling areas selected in each income band were selected on the basis of ease of access to commercial and employment opportunities. The first was a residential neighbourhood with a mixed pattern of land use, and an open, pedestrian-oriented street pattern. These 'inner location' sampling

areas have local access (meaning within a 2,5-3 km walking distance) to commerce and employment opportunities. The second was a residential neighbourhood with little or no local access to (formal) commerce and employment opportunities, and a closed, car-oriented street pattern. These are called 'outer location' sampling areas.

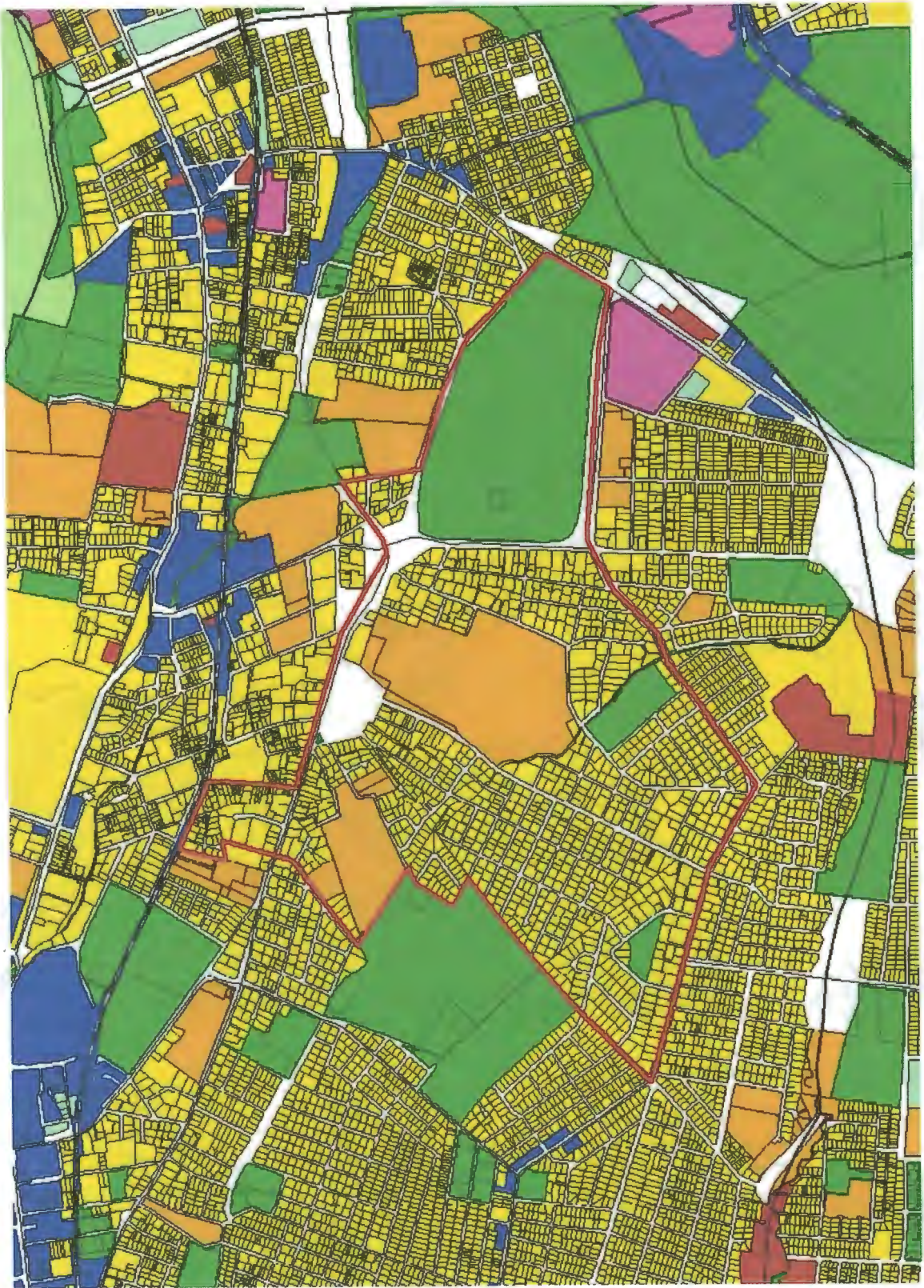
Figure 3.14 Location of sampling areas within metropolitan Cape Town



Table 3.2 Sampling areas

	HIGH-INCOME R5 501/month or more		MIDDLE-INCOME R1 801-R5 500/month		LOW-INCOME R1 800/month or less	
	inner loc. *1	outer loc. *2	inner loc. *3	outer loc. *4	inner loc. *5	outer loc. *6
suburb(s)	Rondebosch (TAZ 706)	Kleinbosch, Welgelegen (TAZ 1005)	Salt River, Woodstock (TAZ 203)	Rocklands, Westridge (TAZ 3008)	Langa (TAZ 1203)	Mfuleni (TAZ 3214)
number of people (1996)	4 337	5 163	4 216	20 416	46 505	10 036
no. households (1996)	1 224	1 591	1 440	4 187	14 187	2 904
mean h'hold size (1996)	3.54	3.25	2.93	4.88	3.28	3.46
h'holds within band (1996)	75%	68%	35%	52%	70%	76%

Figure 3.15 *Rondebosch (TAZ 706): land use and street pattern*

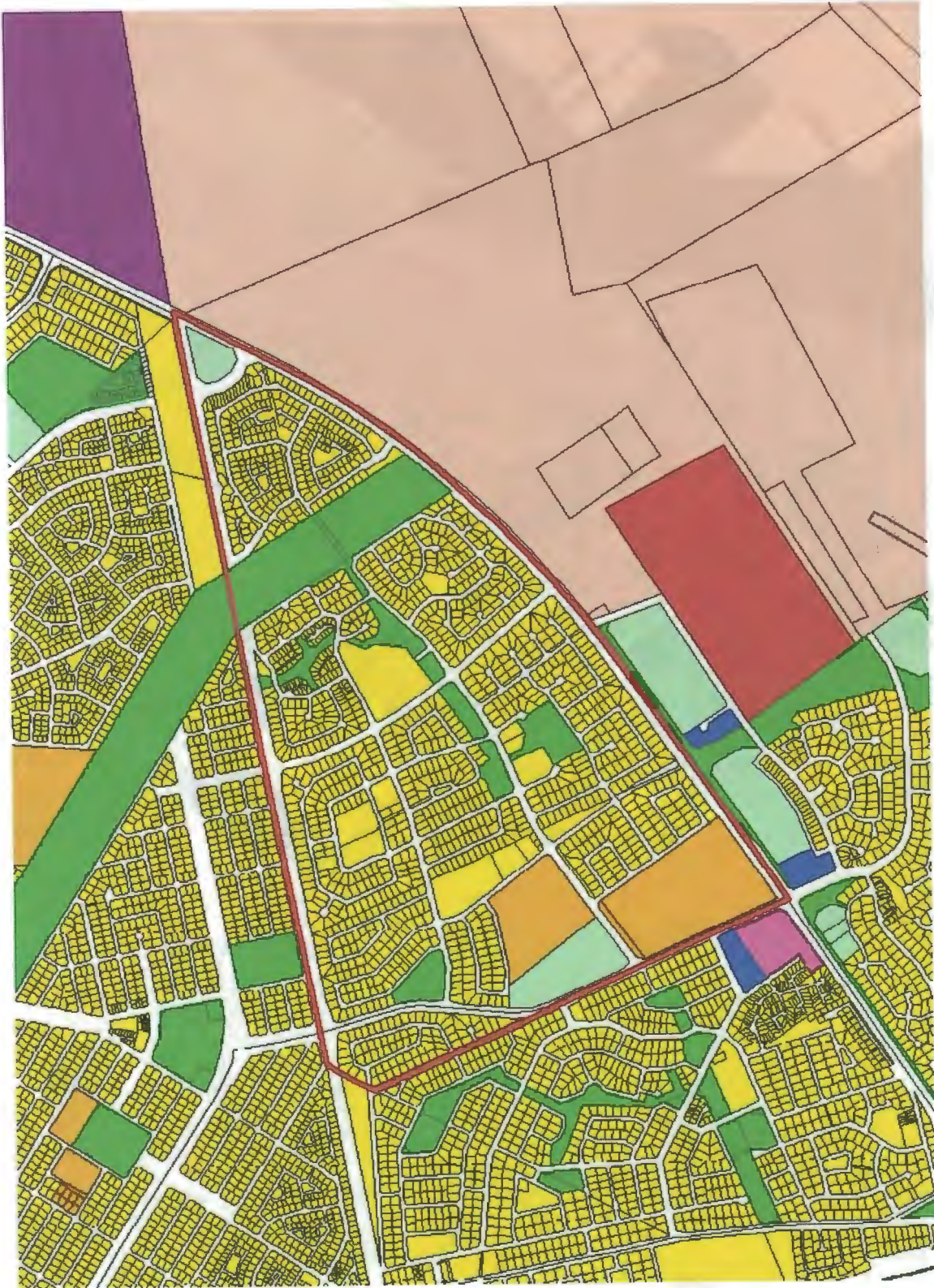


LEGEND:

SCALE: 1 : ± 20 000

	transport zone		class 1 road		class 2 road		railway line
	commercial		education		industrial		institutional
	conservation areas		health services		informal housing		public facilities
	residential		undeveloped land		urban open space		

Figure 3.16 *Welgelegen (TAZ 1005): land use and street pattern*



LEGEND:

SCALE: 1 : ± 20 000

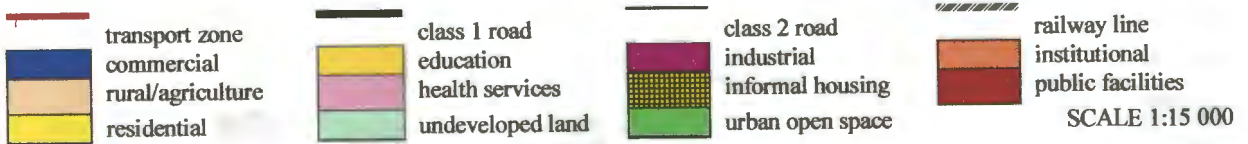


Figure 3.17 Woodstock (TAZ 203): land use and street pattern

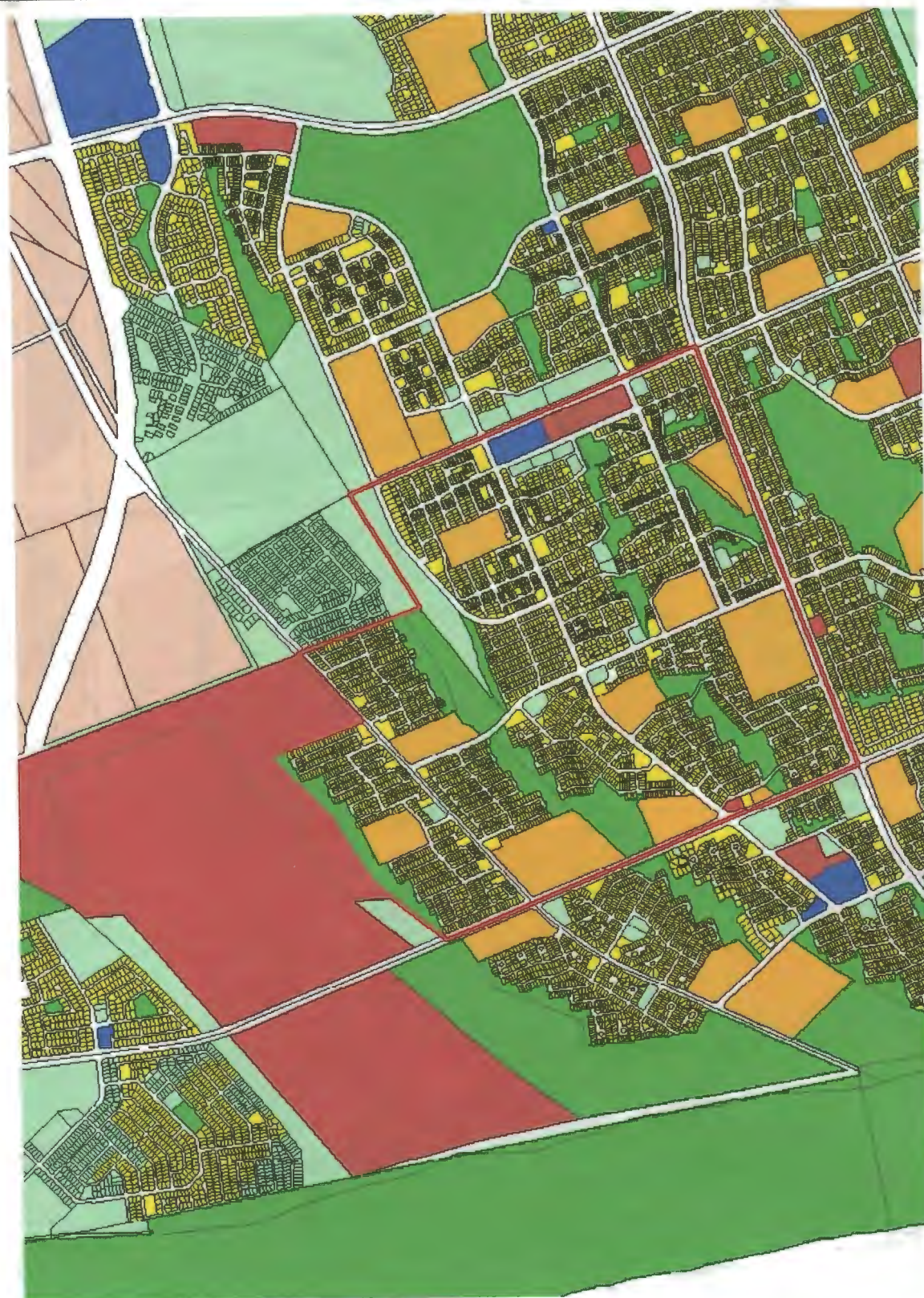


SCALE: 1 : ± 20 000

LEGEND:

	transport zone		class 1 road		class 2 road		railway line
	commercial		education		industrial		institutional
	conservation areas		health services		informal housing		public facilities
	residential		undeveloped land		urban open space		SCALE 1:15 000

Figure 3.18 Westridge (TAZ 3008): land use and street pattern

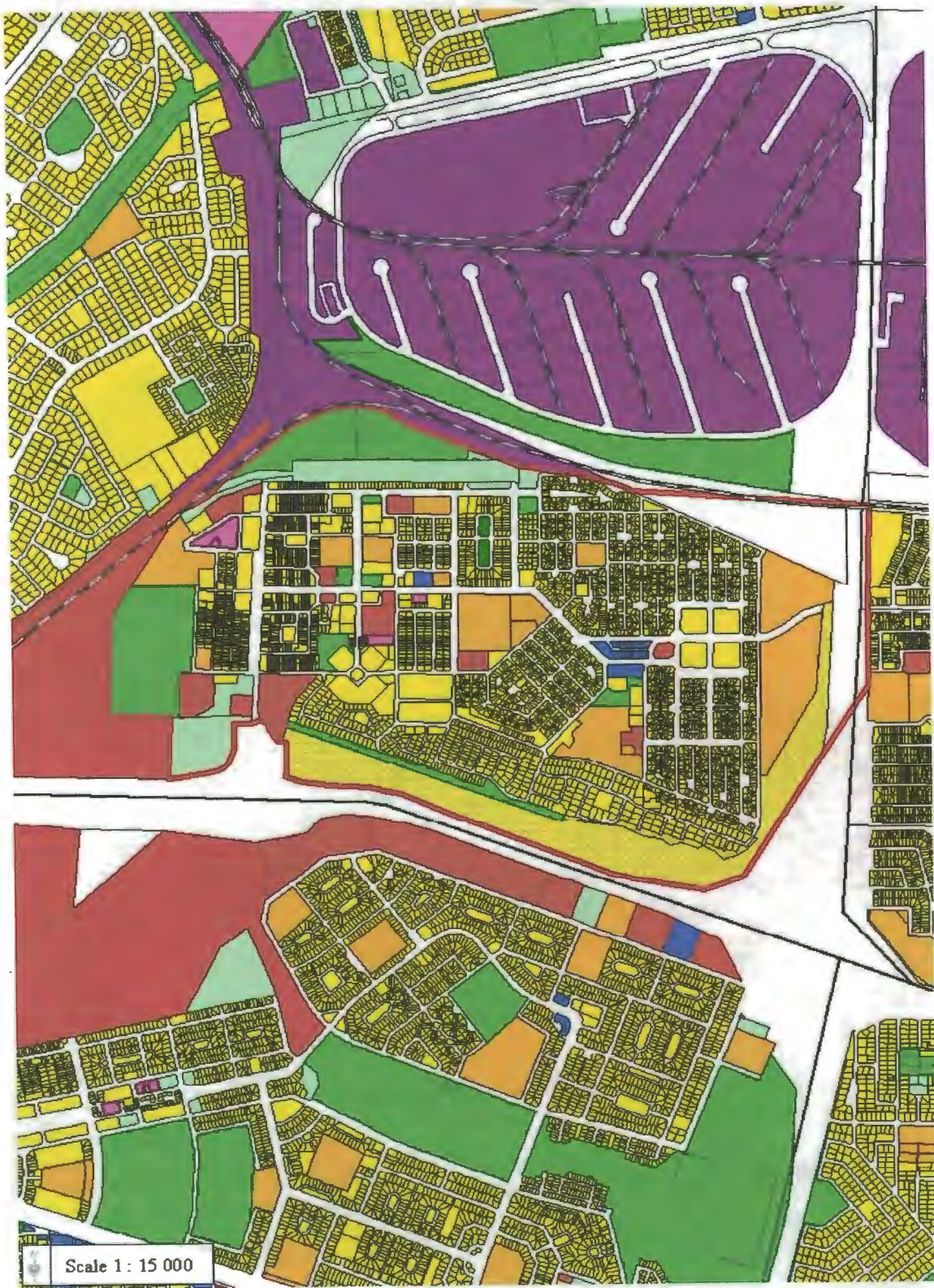


LEGEND:

- | | | | | | | | |
|--|-------------------|---|------------------|---|------------------|---|-------------------|
|  | transport zone |  | class 1 road |  | class 2 road |  | railway line |
|  | commercial |  | education |  | industrial |  | institutional |
|  | rural/agriculture |  | health services |  | informal housing |  | public facilities |
|  | residential |  | undeveloped land |  | urban open space | | SCALE 1:15 000 |

SCALE: 1 : ± 20 000

Figure 3.19 Langa (TAZ 1203): land use and street pattern

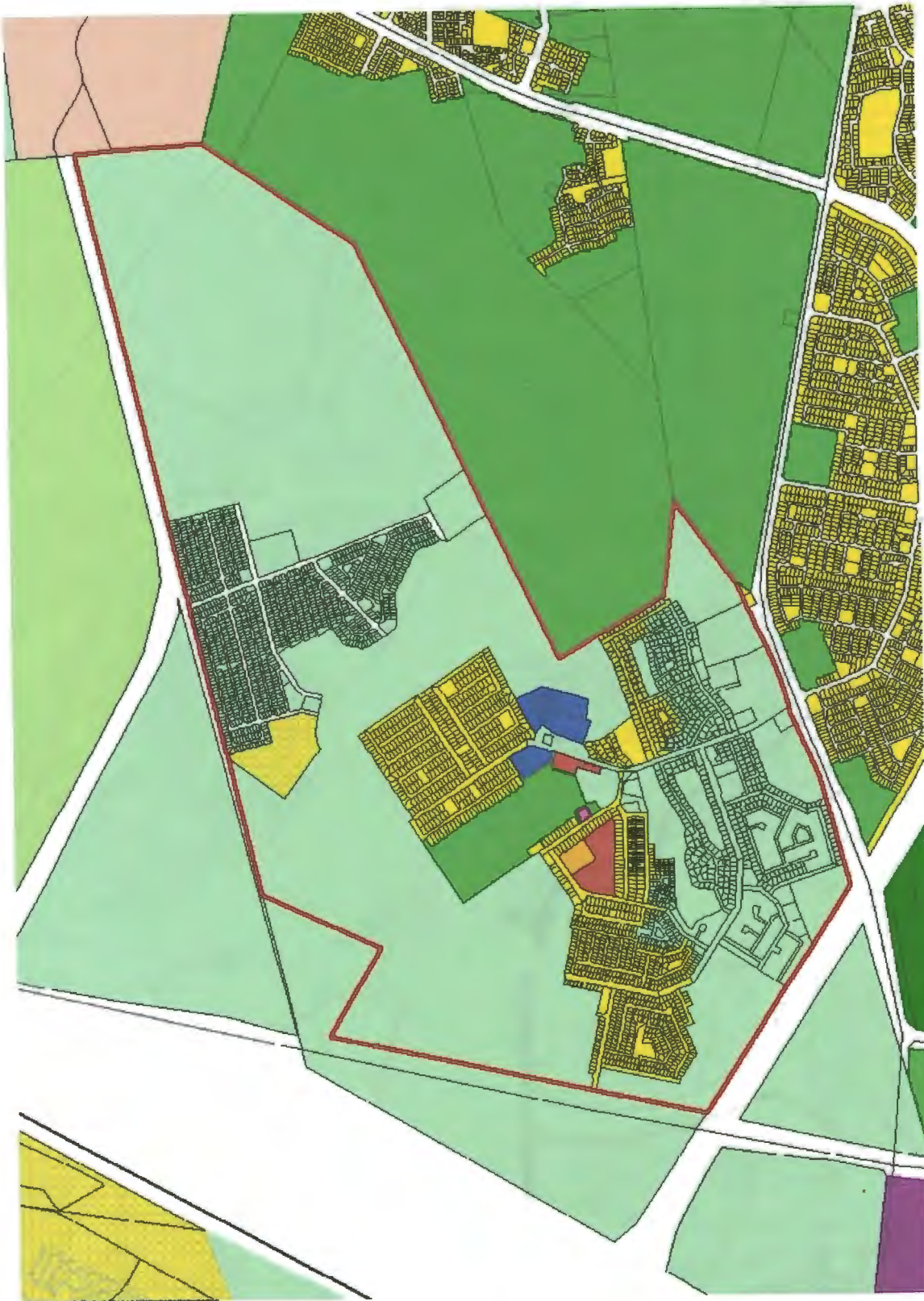


LEGEND:

SCALE: 1 : ± 20 000

	transport zone		class 1 road		class 2 road		railway line
	commercial		education		industrial		institutional
	conservation areas		health services		informal housing		public facilities
	residential		undeveloped land		urban open space		SCALE 1:15 000

Figure 3.20 Mfuleni (TAZ 3214): land use and street pattern

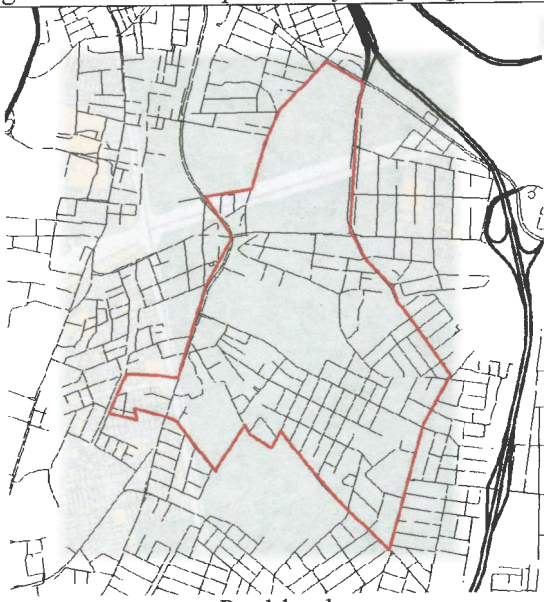


LEGEND:

- | | | | | | | | |
|--|-------------------|---|------------------|---|------------------|---|-------------------|
|  | transport zone |  | class 1 road |  | class 2 road |  | railway line |
|  | commercial |  | education |  | industrial |  | institutional |
|  | rural/agriculture |  | health services |  | informal housing |  | public facilities |
|  | residential |  | undeveloped land | | urban open space | | SCALE 1:15 000 |

SCALE: 1 : ± 20 000

Figure 3.21 Comparison of sampling area (centre-line) street patterns



Rondebosch



Welgelegen



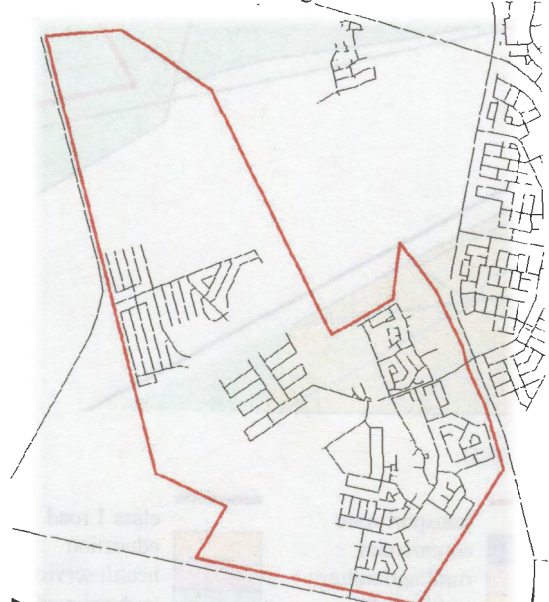
Woodstock



Westridge



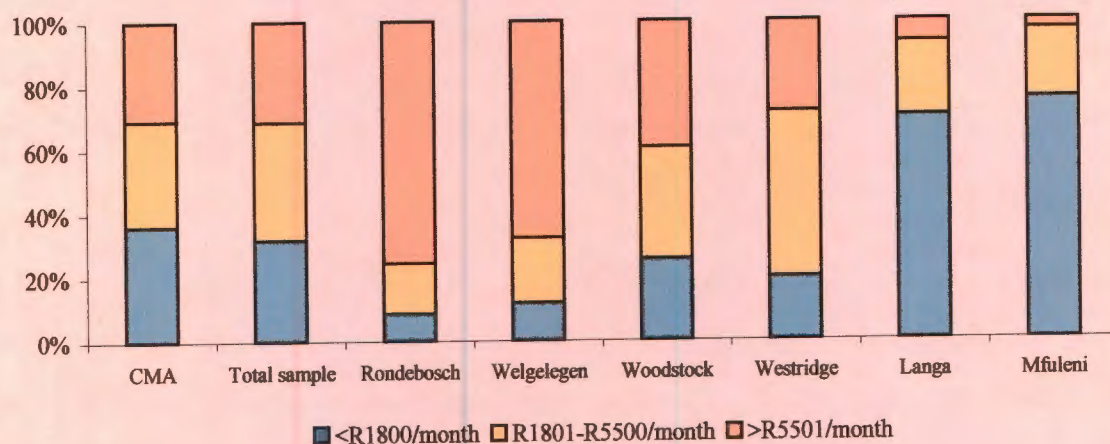
Langa



Mfuleni

Sampling area boundaries coincide with TAZs used by transport planning authorities, and enumerator areas (EAs) used by Statistics South Africa. Candidate sampling areas were analysed using 1996 census data to ensure that the majority of households fell within the appropriate income band. This was the case in all the chosen sampling areas, with the exception of Woodstock where the different income bands are evenly distributed (see table 3.2 and figure 3.22). Households were selected at random from a sampling frame in each of the sampling areas. The sampling frame took the form of an inventory of street or shack addresses. Only households falling within the appropriate income band were interviewed. Randomly selected households who fell into the wrong band were substituted, as were households unable to provide previous day recall diaries for at least 70% of household members (who were either independently mobile or generated their own individual activity schedule). Thus, in summary, the sample may be described as randomly selected, proportionately stratified and quasi-clustered.

Figure 3.22 *Distribution of (CPI adjusted) household income bands within sampling areas*



Source: 1996 National Census, Statistics South Africa

In instances where the proportion of samplings units across different sample groupings is uneven – as for instance is the case in household income bands and days of the week – bias in mean calculations is avoided by calculating weighted as opposed to simple aggregate values.

3.4.2 Selected demographic characteristics of the sample population

The sample of 204 households comprised a total 721 persons (at a mean household size of 3.53), of whom 94% (678) provided diary information in CAPI interviews. Of the persons interviewed 55% were female, and 45% male. Persons of all ages are represented fairly evenly in the sample (see table 3.3). A categorisation of the persons sampled into types – based on age, employment status and divisions of childcare responsibilities – is indicated in table 3.4. The households sampled are fairly evenly distributed across life-cycle stages (see table 3.5). These gender, age, person type and life-cycle categorisations are used later, in the analysis of aggregated and disaggregated travel behaviour.

Table 3.3 *Age distribution*

AGE BAND	PERSONS	PERCENTAGE
≤5 years	43	6%
6-10 years	57	8%
11-15 years	57	8%
16-20 years	66	10%
21-25 years	76	11%
26-30 years	68	10%
31-35 years	58	9%
36-40 years	42	6%
41-45 years	40	6%
46-50 years	47	7%
51-55 years	33	5%
56-60 years	39	6%
61-65 years	19	3%
≥66 years	33	5%

Table 3.4 *Person type distribution*

PERSON TYPE	PERSONS	PERCENTAGE
pre-school children (0-5 years)	43	6%
junior school children (6-12 years)	85	13%
senior school children (13-18 years)	66	10%
tertiary education students	17	3%
formally employed females with childcare responsibilities	21	3%
formally employed females without childcare responsibilities	99	15%
informally employed females with childcare responsibilities	3	0%
informally employed females without childcare responsibilities	5	1%
houseworking mothers/females	95	14%
formally employed males with childcare responsibilities	12	2%
formally employed males without childcare responsibilities	127	19%
informally employed males with childcare responsibilities	1	0%
informally employed males without childcare responsibilities	4	1%
houseworking fathers/males	10	1%
retired adults	62	9%
unemployed (economically active ≥15 years) females (not houseworking)	27	4%
unemployed (economically active ≥15 years) males (not houseworking)	1	0%

Table 3.5. *Household life-cycle stage distribution*

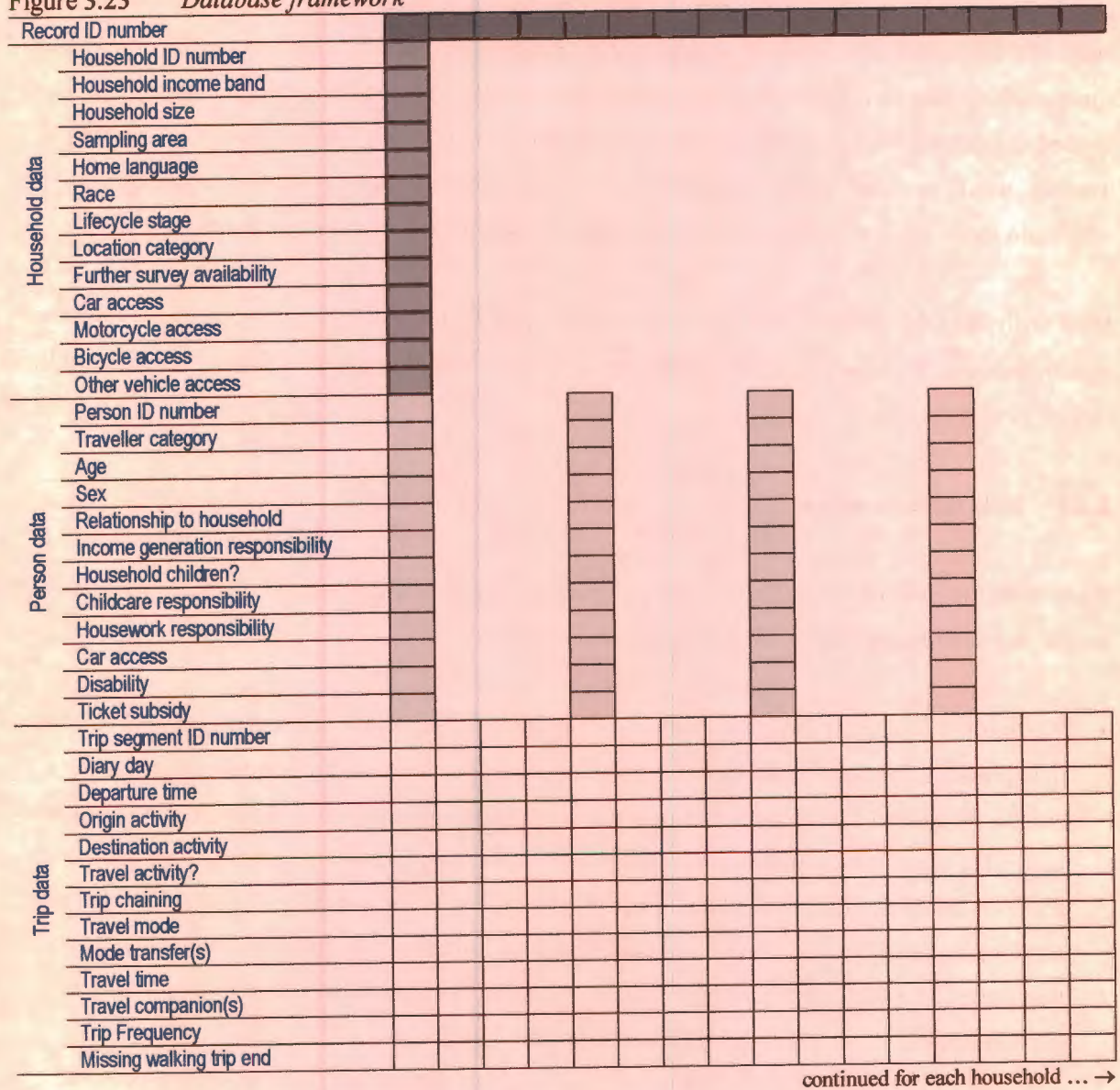
LIFE-CYCLE STAGE	HOUSEHOLDS	PERCENTAGE
younger adults (≤40 years) with no children	35	17%
adults with pre-school children (≤6 years)	20	10%
adults with younger school children (7-12 years)	15	7%
adults with older school/adult children (≥13 years)	32	16%
adults with mixed aged children	54	26%
older adults (≥40 years) with no children	23	11%
mixed younger and older adults	25	12%

3.4.3 Data management

The database, within which the sample data were captured, is relational, in that trip data are nested within personal data, which are in turn nested within household data. The database fields are therefore divided into three groups. Household data fields enable questions to be asked of the travel behaviour of different kinds of households. Personal data fields enable questions to be asked of the travel

behaviour of different kinds of travellers. Trip data fields enable questions to be asked of different kinds of trips. Even though the database is relational in nature, for the sake of simplicity it is however recorded in flat-line form (see figure 3.23). Thus household and personal data are copied into all database records. In this way filtered trip data continues to be related to household and personal data fields, and similarly, filtered personal data continues to be related to household data fields.

Figure 3.23 Database framework



The records in the database take the form of trip segments.⁶² Had the data collected in this study been intended for the calibration of an activity scheduling model, records would have taken the form of activities more generally (i.e. including both sedentary and travel activities, and disaggregating the different activities undertaken in one place to a far greater extent). Because the objectives of the study

⁶² Trip segments are defined as one-way movements by a single mode that involve travelling to or from a point of modal interchange, and leaving or arriving at an activity site or another point of mode interchange. Trips are defined as modally discrete movements, or series of linked modally discrete one-way movements, between an origin activity and a destination activity. A trip can therefore comprise a number of trip segments, or, if involving just one travel mode, can represent a single trip segment.

were limited to understanding travel behaviour, this level of time-use data was not required, and the associated difficulties in ensuring that respondents define and report on 'activities' in the same way were avoided (Axhausen 1997).⁶³

The coding of database fields is fairly straightforward. The only field codings that perhaps require explanation are those relating to trip chaining and mode transfer(s). With regard to trip chaining⁶⁴ the code describes the position of the trip in the chaining order. For instance, the second trip within a chain of three linked trips would be coded as [2.3]. This enables the data to be compared with other surveys where data on only the final trip within the chain were recorded. A similar coding system is applied to mode transfer(s). Thus the first mode used in a trip in which four modes were used, for instance, would be coded as [1.4]. In order to enable comparison with other surveys where data on only main mode use was recorded, a [.m] is added to that trip segment covering the greatest distance.

Most analysis of the database took the form of filtered cross-tabulation, using the pivot table function within *Microsoft Excel* software. The time geographic analytical techniques of time-space paths and ranges were also used.

3.4.4 Data limitations

Apart from the obvious limitation of small sample sizes and large confidence intervals as discussed earlier, the main limitations of the survey data are as follows:

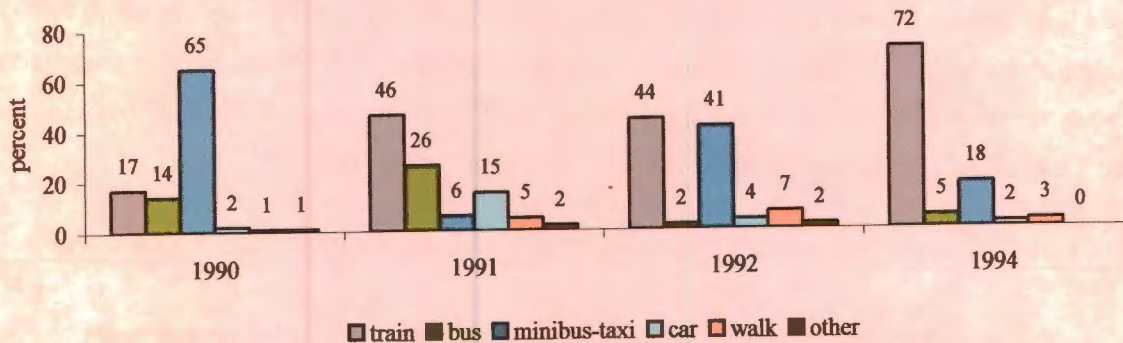
- The limited number of sampling areas in the survey (6) reduces the representativeness of the data in aggregated form (with respect to the CMA population). There are too few sampling areas to effectively control for the myriad of external variables that may affect travel in different locations within the metropolitan area (e.g. proximity and connectivity to land use activities and public transport services, quality of public transport services, etc.). The unavailability of passenger rail services in one of the two low-income sampling areas (Mfuleni) for instance, distorts the aggregated data findings regarding relative proportions of public transport mode use within this income band.
- The data collected are cross-sectional and thus incapable of analysing inter- and intra-personal variability in travel patterns over time, as well as seasonal or event-related variations in group behaviour. Amongst public transport users the latter have been quite considerable in Cape Town in recent years – usually associated with conflicts and service disruptions within the minibus-taxi and bus industries (see figure 3.24 for modal split trends amongst 'black' commuters in the early

⁶³ The contemporaneous 24 hour time-use survey of 2 members from 10 000 households administered by Statistics South Africa provides far richer data on sedentary activities (Budlender *et al* 2001), and could potentially be mixed with the data collected in this and other studies, should these be required for explorations into activity-based travel demand modelling in South Africa.

⁶⁴ A trip chain is defined as a series of sequential one-way trips where the intermediate destination activity(ies) both influence route choice to the final destination activity, and take less than 10 minutes to complete.

1990s). Despite a pseudo form of panel analysis involving life-cycle stages, the data are incapable of revealing changing, or ‘churning’, behaviour in a satisfactory way. The data essentially provide a behavioural ‘snap shot’ in time.

Figure 3.24 ‘Black’ commuter modal split trends in Cape Town: 1990-1994

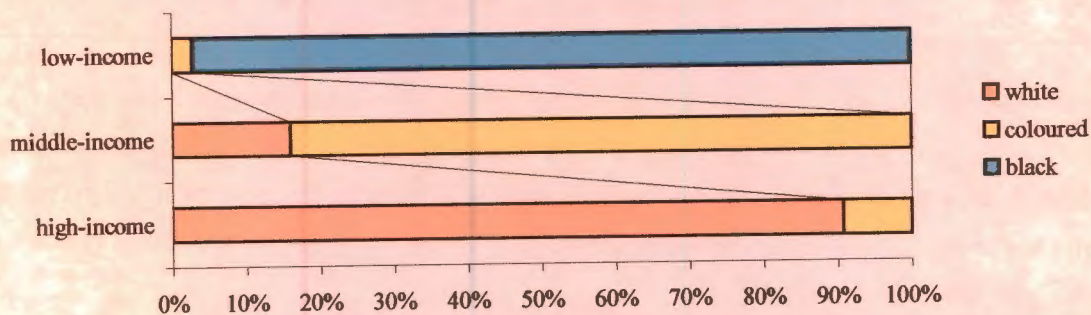


Source: van der Reis 1995:68

- The requirement that 70% of household members should be interviewed in the household survey probably had the unintended effect of larger households being substituted more often than smaller households, because it was probably more difficult to meet this requirement in larger households. Of the households substituted in the survey, 36% were substituted because of insufficient or no members at home on the day of the interview. As a result, the mean household size in the survey is smaller than in the 1996 census (3.53 vs. 3.93). This has probably led to biases in the data. Household trip generation rates for instance are likely to have been underestimated.

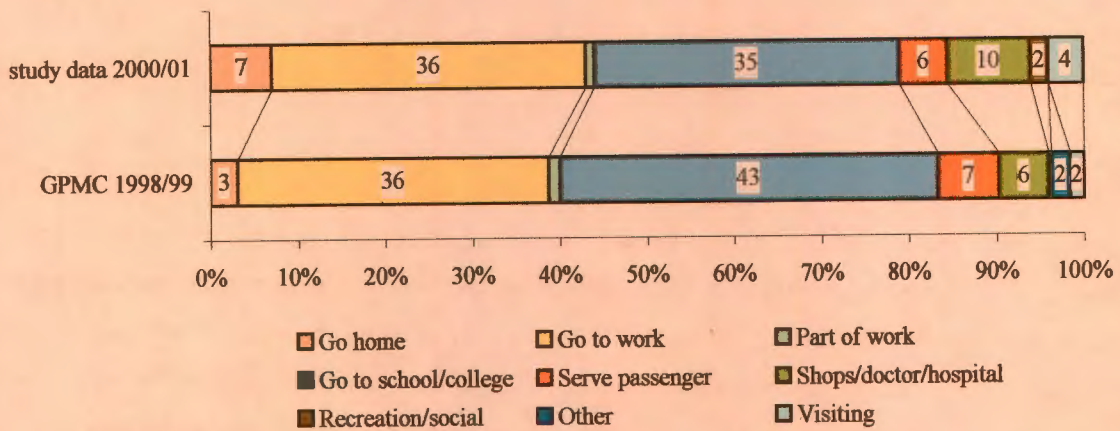
Despite the above-mentioned limitations, a comparison of the study’s findings with other most recent surveys in Cape Town (or elsewhere in South Africa where necessary) reveals a fairly high level of consistency in some key measures of travel behaviour. In comparing data with those of other surveys it was often necessary to use household income band as a proxy for race. While not ideal, such comparisons are possible given the high correlation found in the study between income and race (see figure 3.25).

Figure 3.25 Proportional relationship between household income band and race (n = 204 h)



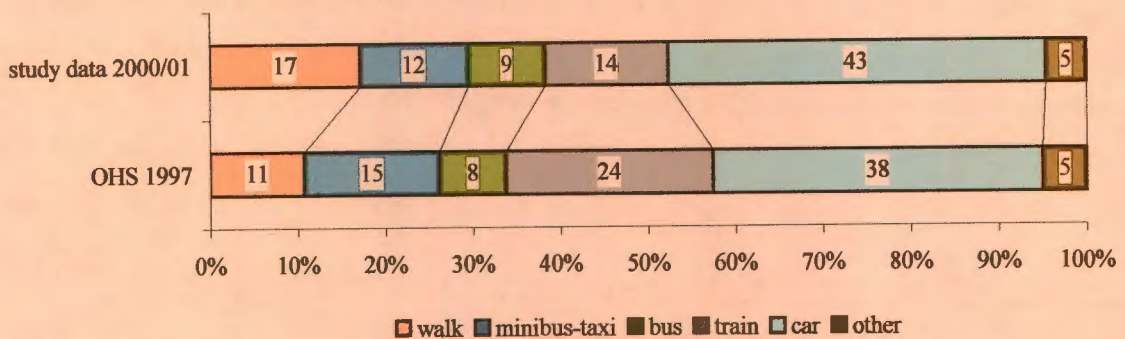
Numerous comparisons were made, centring mainly around vehicle availability, peak and commuter travel (these are attached as appendix C). For instance: Comparisons of car availability findings with surveys in Cape Town in 1991/92, 1994 and 1999 revealed consistency amongst high-income households (9% vs. 6% without access), middle-income households (57% vs. 50% without access), low-income households (95% vs. 97% without access) and with the population as a whole (46% vs. 50% of households without access). Comparisons of morning peak period trip purposes with 1998/9 data from Pretoria also revealed consistent distributions (see figure 3.26). Comparisons of commuter (main) mode use with the October Household Survey of 1997 revealed similar distributions (see figure 3.27), as did comparisons of mean commuting time (43 vs. 41 minutes).

Figure 3.26 Comparison with 1998/99 morning peak period trip purpose data from Pretoria



Source: TRC Africa 1999

Figure 3.27 Comparison with commuter modal split data from the 1997 October Household Survey in Cape Town



Given this level of consistency in measures around which there is comparable data, it is more likely than not that the study's findings regarding measures around which there are no comparable data would not diverge too widely from those of a larger sample with higher levels of statistical probability. Nevertheless in strict statistical terms, the data have large confidence intervals, and claims of statistical representivity cannot be made.

3.5 TRAVEL CHARACTERISTICS OF THE SAMPLE POPULATION

In aggregate, the 678 24-hour person diaries collected in the survey yielded 1 704 trips (comprised of 2 317 trip segments and covering 20 736 km), of which 289 (17%) involved transfers between two or more travel modes and 100 (6%) were linked to (45) trip chains. Diaries were completed for all the days of the week – the distribution of household and person diary days across the week is indicated in table 3.6. Some of the key findings of the survey with regard to the aggregate travel characteristics of the sample are discussed below, in terms of: trip generation, trip purposes, trip timing, mode use and travel time.

Table 3.6 *Diary day distribution*

DAY	HOUSEHOLDS	PERCENTAGE	PERSONS	PERCENTAGE
Monday	36	18%	104	15%
Tuesday	27	13%	98	14%
Wednesday	26	13%	81	12%
Thursday	31	15%	110	16%
Friday	28	14%	99	15%
Saturday	15	7%	49	7%
Sunday ¹	41	20%	137	20%

Note: ¹ = The relatively large proportion of diaries kept on Sunday was unintended, and the result of an administrative error on the behalf of the market research firm.

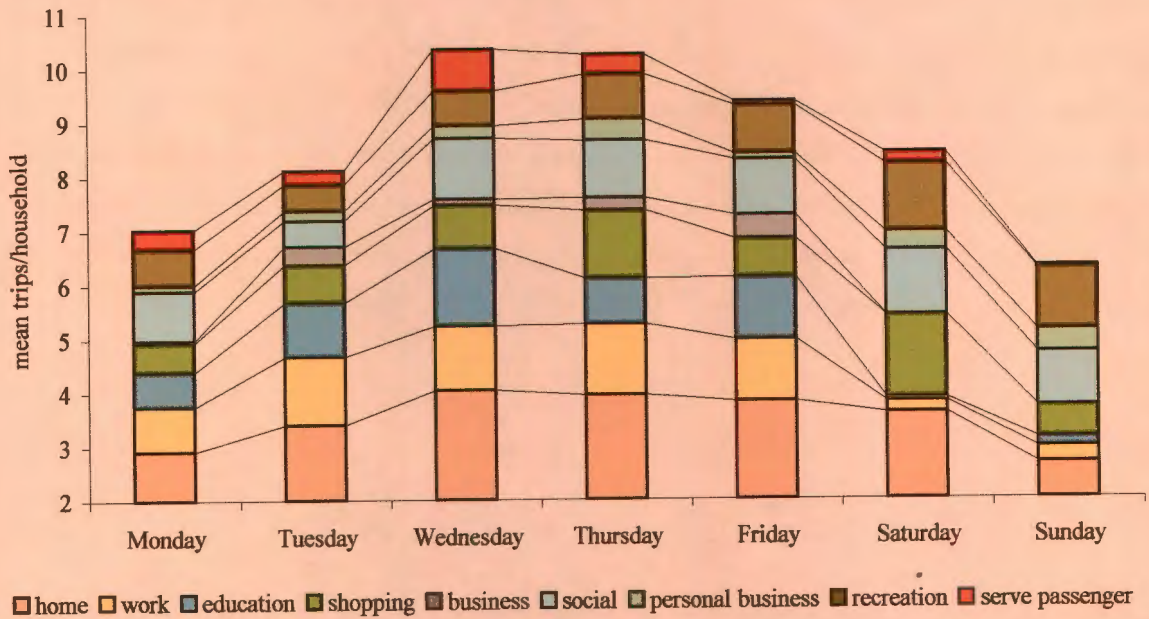
3.5.1 Trip generation

The mean 24 hour weekday household trip generation finding is 9.67 trips/weekday (or 2.74 person trips/weekday), and 8.35 trips/day (or 2.37 person trips/day) for the entire 7-day week. The weekday household generation rate is generally higher (by between 18% and 35%) than those of other earlier South African travel surveys that used trip diary (as opposed to activity diary) instruments. As discussed earlier, given the findings of the international literature that has compared trip recall in activity diaries and trip diaries, this increased trip generation was expected. Despite improved trip recall however, in a surprisingly high number of person diaries, the household member reported that he or she did not travel at all on the diary day – 127 out of 678 (19%).

3.5.2 Trip purposes

Figure 3.28 illustrates the rate and distribution of trip destination activity purposes over the week. The figure suggests that trip generation declines only slightly over weekends relative to 'typical' weekdays (as defined in section 3.5.3). As one would expect, this decline is due to significantly fewer work and education trips over weekends, and marginally more social and recreational trips.

Figure 3.28 *Aggregate weekly trip destination activity purpose distribution (n = 204 h)*



Figures 3.29 and 3.30 illustrate day and weekday trip purpose distributions – the former with trip purposes defined by destination activity, and the latter with trip purposes defined by home-based and non-home-based classifications. Figure 3.29 suggests that work, education and shopping destination activity purposes account for broadly the same proportion of trips. Figure 3.30 suggests a similar pattern with home-based trip purpose classifications, only shopping trips decline – suggesting perhaps that shopping trips are more likely to be situated at the end of trips chains and thus not indicated as home-based trips. These findings are consistent with those of recent surveys in Durban and Pretoria (see figure 3.26) which revealed broadly equal amounts of work and education trips. This distribution is however atypical of most developed world cities which have significantly fewer scholars relative to workers – in the United States and West Germany for instance education trips account for just 6% and 9% of all trips respectively (Meyer and Miller 1984, Monheim 1990). In terms of establishing the extent of gaps in understanding, these home-based trip purpose data indicate that analyses of travel behaviour in Cape Town that focus exclusively on commuting, exclude some 80% of trip-making.

Figure 3.29 *Aggregate day and weekday trip destination activity purpose distribution (n = 204 h)*

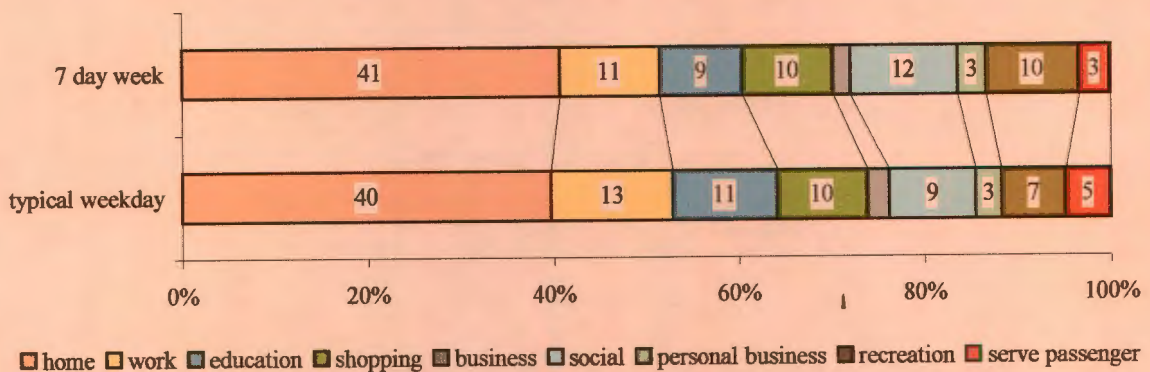
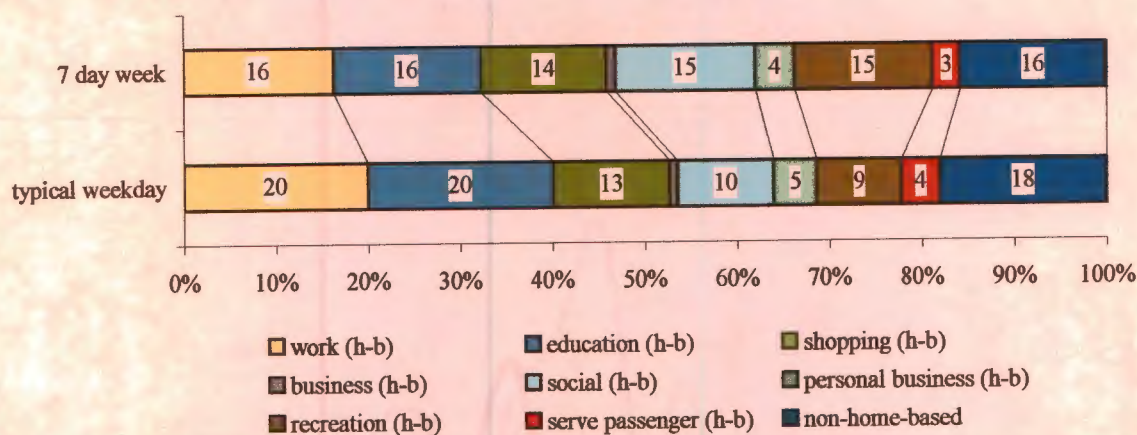


Figure 3.30 *Aggregate day and weekday home-based trip purpose distribution (n = 204 h)*

3.5.3 Trip timing

Analysis of weekend trip departure time profiles suggests that both weekend days experience a fairly symmetrical and gradual peak period, that spikes at around 10h00 on Saturdays and 12h00 on Sundays (see figure 3.31). Analysis of weekday trip timing suggests that profiles for Mondays and Fridays are different from other weekdays. The morning peak period on Mondays appears to be spread over a longer period and therefore exhibits less of a spike during the peak hour, and the afternoon peak period on Fridays begins sooner. Tuesdays to Thursdays were therefore selected for typical weekday trip timing analysis. Figure 3.32 illustrates weekday (all travel mode) trip timing by trip destination activity purpose. This profile suggests that across the day, four peaks occur: one in the morning (associated with trips to schools and work) and the remaining three in the afternoon. This triple afternoon peak – which is atypical of developed world cities (see for instance Papacostas and Prevedouros 1993: figure 8.2.2) presumably due to equal proportions of education and work trips in the South African context – involves a smaller peak around lunch time, a second larger peak around 14h00 when most school days end, and a third peak around 17h00-18h00 when most working days end. In terms of establishing the extent of gaps in understanding, these weekday trip timing data indicate that analyses of travel behaviour in Cape Town that focus exclusively on the conventional 06h00-09h00 and 16h00-19h00 peak periods, exclude some 54% of trip-making.

The fact that the second of the afternoon peaks mentioned above (i.e. trips departing 14h00-14h59) is generally not reflected in congestion patterns in Cape Town can be attributed to the fact that most school to home trips are undertaken by foot. Figure 3.33 illustrates trip timing by motorised and non-motorised modes, and here it can be seen that the timing profile of motorised trips resembles more closely those of developed world cities, and reflects more closely the timing of observable congestion patterns. As might be expected, figure 3.34 indicates that the 14h00-14h59 peak in non-motorised trip departures is reflected in the timing of child pedestrian road accident casualties. While not corresponding exactly with the non-motorised trip timing profile indicated in figure 3.33, and clearly illustrating that pedestrian casualties are greatest in the evening when visibility is poor, these data do

indicate that national urban pedestrian casualties amongst children occur earlier in the day than other age groups, and this is probably associated with home-based education trips.

Figure 3.31 *Aggregate weekend hourly trip timing (n = 56 h)*

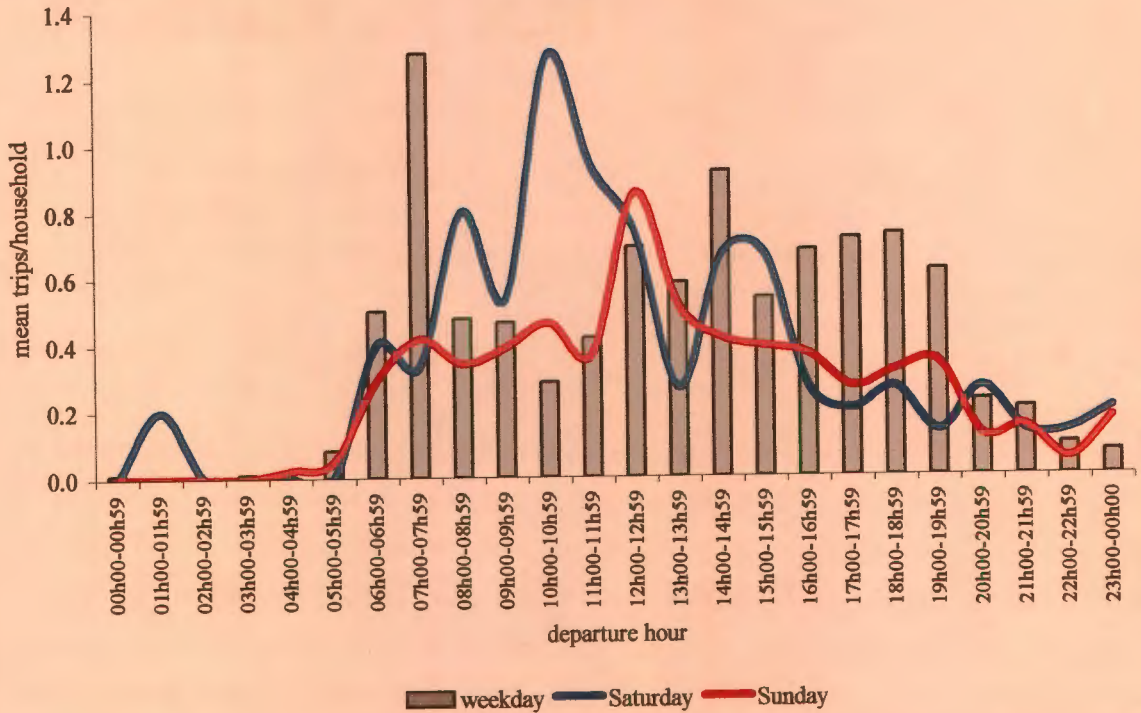


Figure 3.32 *Aggregate weekday hourly trip timing by destination activity purpose (n = 84 h)*

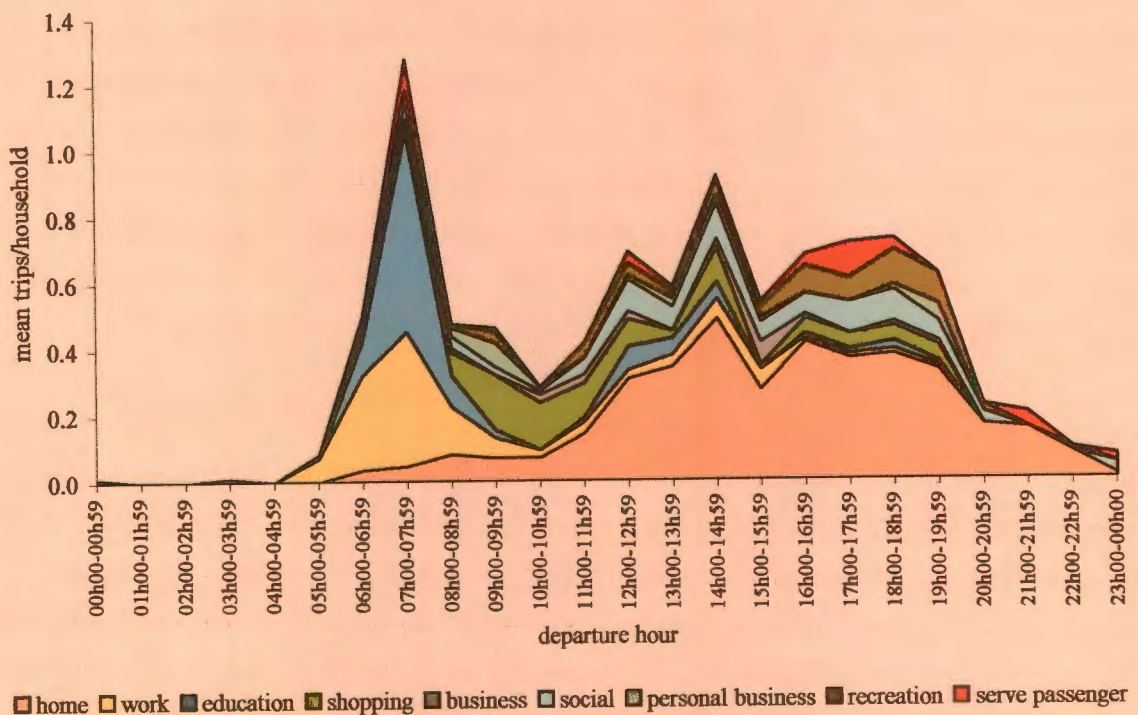


Figure 3.33 *Aggregate weekday hourly trip timing by motorised and non-motorised modes (n = 84 h)*

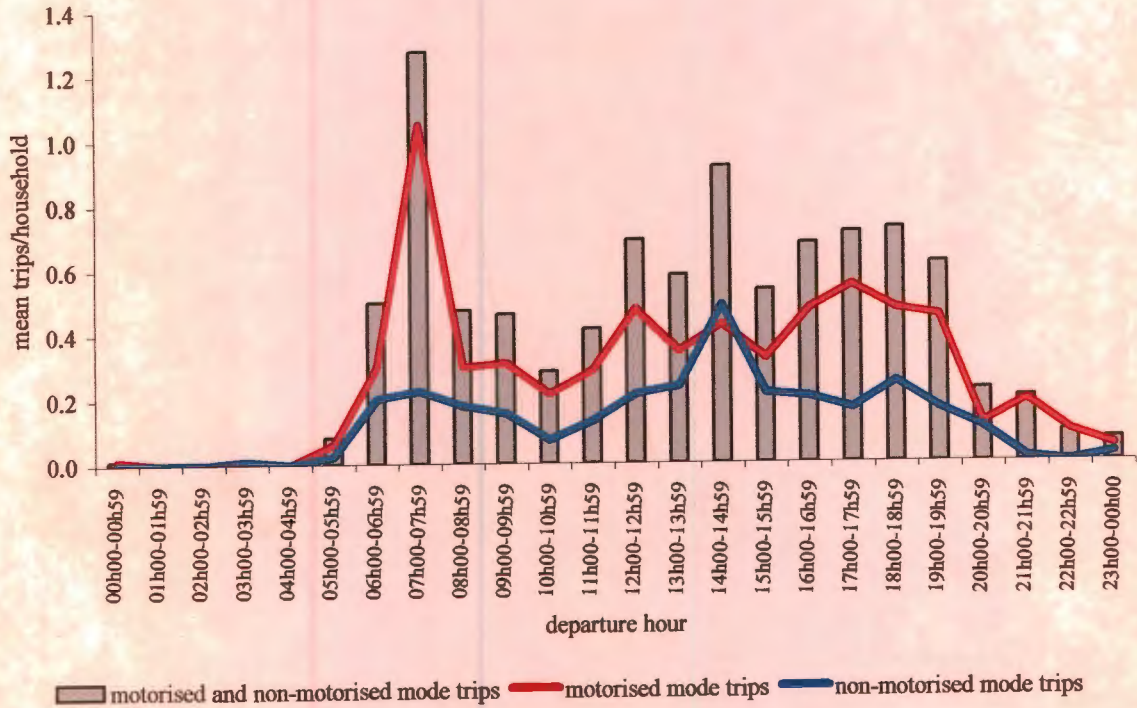
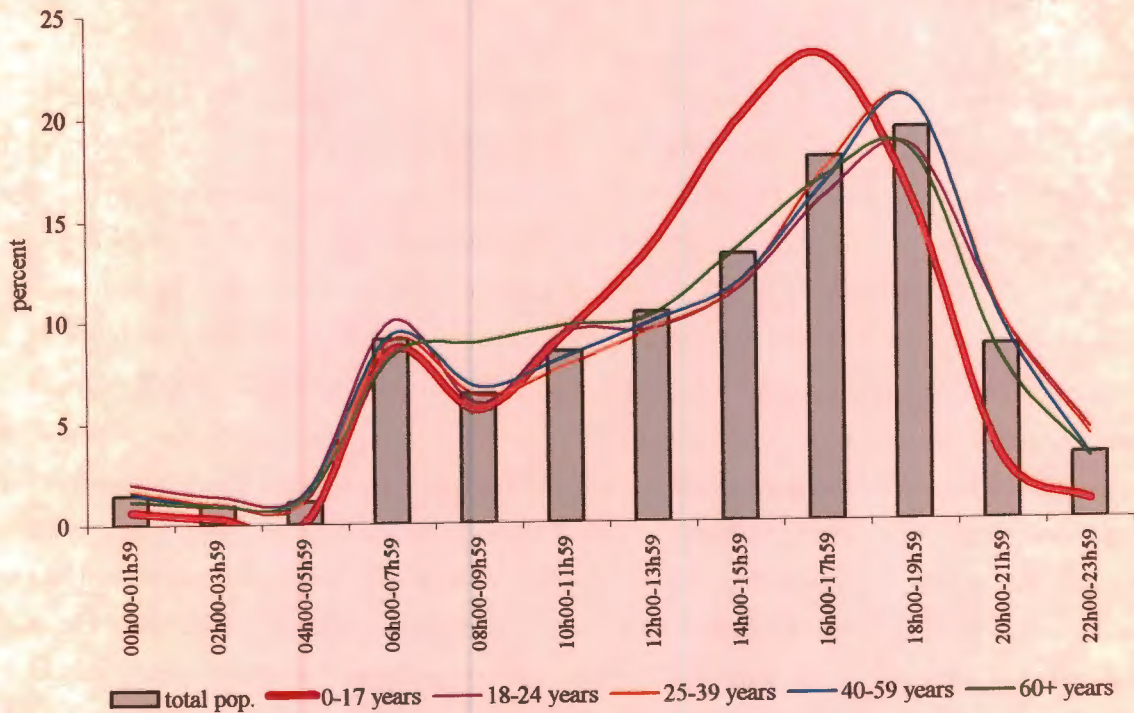


Figure 3.34 *National urban pedestrian casualties by age and known time of day (1997)*

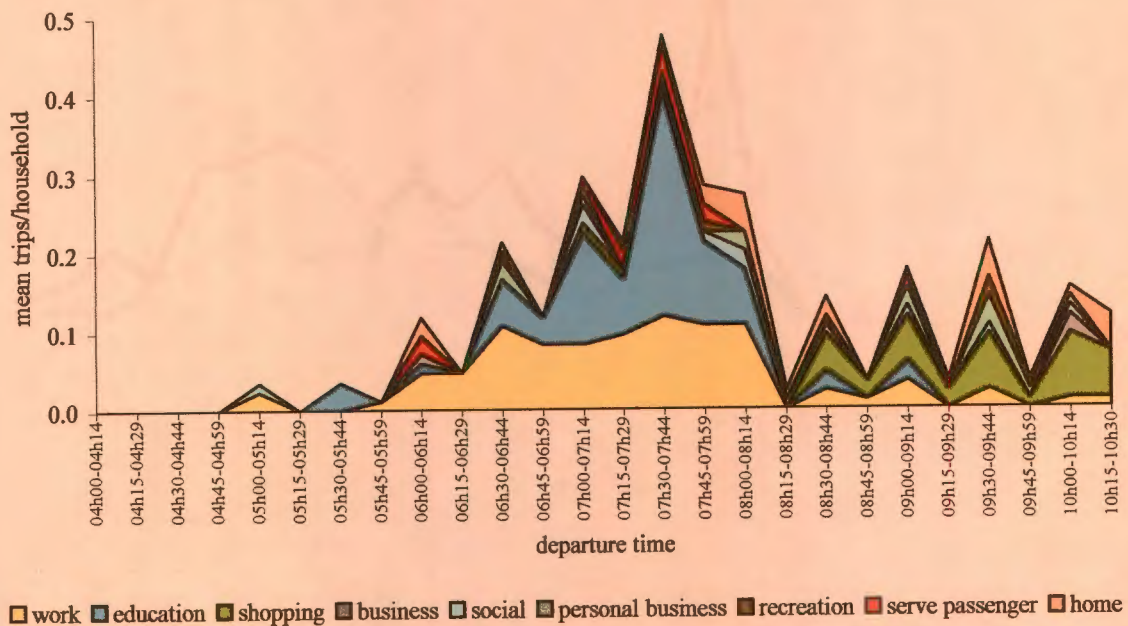


Source: Makhanya et al 1998:3

Figure 3.35 illustrates weekday morning peak period trip timing on a quarter-hourly basis. The figure indicates that departure times for trips to education activities are clustered more closely (around

07h30-07h45) than trips to work – perhaps suggesting possibilities for staggered school start times as a demand management measure to reduce the intensity of this spike in congested networks.

Figure 3.35 *Aggregate weekday quarter-hourly morning peak period trip timing by destination activity purpose (n = 84 h)*



3.5.4 Mode use

Of the households surveyed, the majority – 51% – do not have access to the use of a motor car for any trip purpose, while 28% have access to the use of one car and 21% have access to the use of more than one car. The ratio of 218 cars/1000 people calculated from the data, while higher than the 170 cars/1000 people estimated by the CMC (1998), is nevertheless significantly lower than most developed world countries – e.g. 740 in the United States, 610 in Australia, 570 in Germany and 410 in the United Kingdom, in 1998 (Vasconcellos 2001:15). Interestingly – given that 28% of the 49% of households with car access have access to just one car, and that many household members would therefore presumably not have regular car access – figure 3.36 indicates that 48% of all trips are undertaken by the car as the main travel mode (as either driver or passenger). This suggests that once a household gains access to a car, its members switch modes extensively. The aggregate data indicate therefore that the motor car is the single most utilised main mode in Cape Town. The second largest main mode is walking (36%), while public transport is the main mode for 16% of all trips. The relative importance of walking as a travel mode is however underestimated in main mode use analysis as walking trip segments are invariably attached to both ends of public transport trips and sometimes to one end of motor car trips as well. Table 3.7 indicates that walking is the most common main mode in trips to education, social, personal business and recreational activities, while the motor car is the most common main mode used for all other trip purposes. The table suggests that the collective share of public transport main modes increases significantly (to 35%) in the case of trips to work activities –

comparisons with earlier commuter surveys in Cape Town (see table 2.13) suggest that this share is underestimated, and is more likely to be in the region of 45% (this may be the result of consolidating formal and informal work activities in work trip analysis). In terms of establishing the extent of gaps in understanding, these main mode use data indicate that analyses of travel behaviour in Cape Town that focus exclusively on motorised modes, exclude some 36% of trip-making.

Figure 3.36 *Aggregate main mode use for all trip purposes (n = 204 h)*

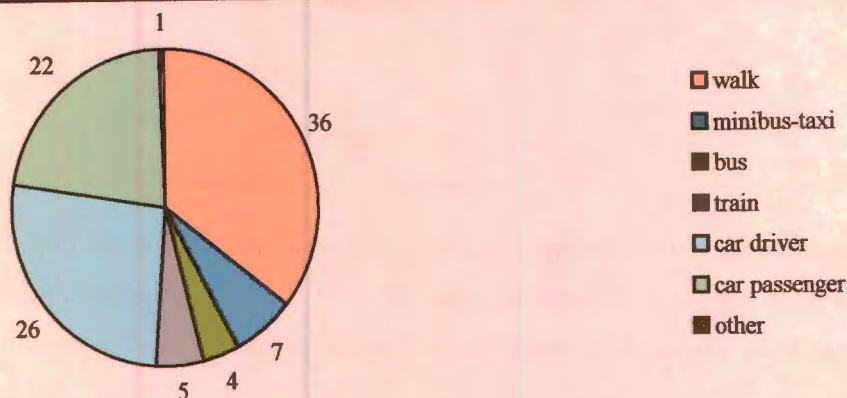


Table 3.7 *Aggregate percentage main mode use by trip destination activity purpose (n = 204 h)*

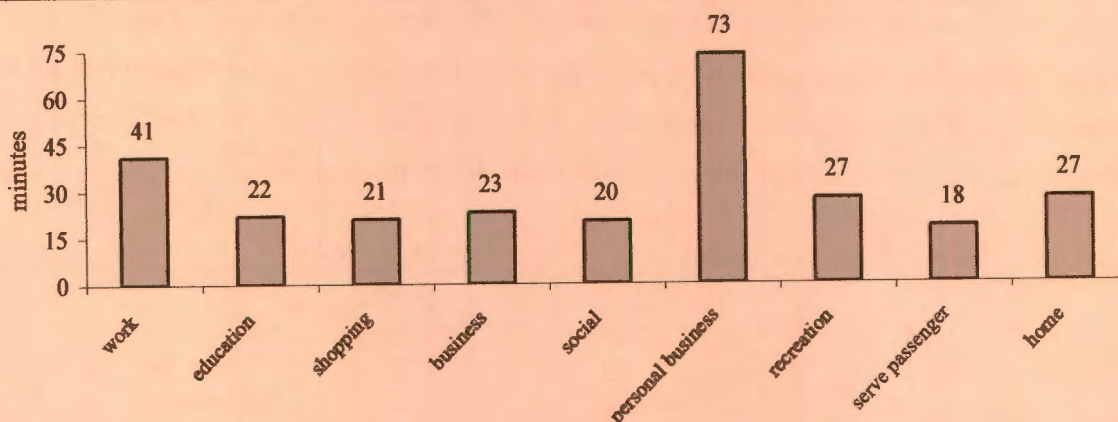
	WORK	EDUC.	SHOP.	BUS.	SOC.	PERS. BUS.	REC.	SERVE PASS.	HOME
walk	16.9	41.8	33.1	6.3	52.0	28.9	39.8	12.3	37.9
bicycle ¹	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
taxi	11.5	10.5	5.4	0.0	1.5	19.2	4.7	0.0	6.8
bus	9.8	5.2	2.4	0.0	0.5	0.0	1.8	0.0	4.5
train	13.7	3.3	1.2	6.3	0.5	13.5	2.9	0.0	5.5
car dr.	34.4	16.3	34.9	68.8	19.4	21.2	23.4	54.4	23.3
car pass.	10.4	22.2	22.9	18.8	26.0	17.3	27.5	33.3	21.5
other	3.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.6

Note: ¹ Despite a bicycle ownership ratio of 77 bicycles/1000 people, no bicycle use was recorded in the survey.

3.5.5 Travel time

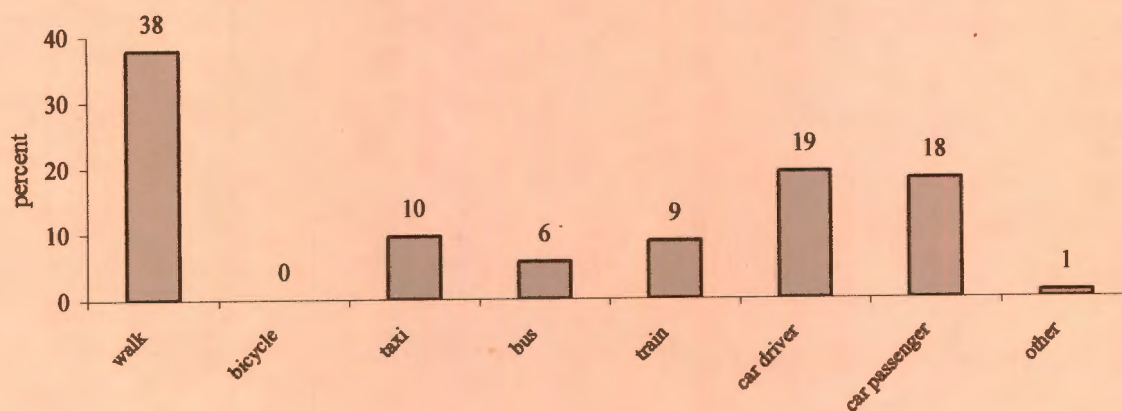
Figure 3.37 illustrates the findings of the study with regard to mean trip travel time. The figure supports the notion that acceptable travel times are lower amongst 'discretionary' trips where a choice of possible destinations exist. Trips to work activities take considerably longer (by between 14 and 23 minutes). The exception is personal business trips to health and other social services. Aggregate mean travel times for these trips are greatly increased as a result of residents in the low-income sampling areas having to walk long distances to access these facilities (see figure 3.47).

Figure 3.37 *Aggregate mean trip travel time by destination activity purpose (n = 204 h)*



The survey data suggest that on average 5% of daily personal time (72 minutes over a 24-hour period) is taken up on travel activities. Walking accounts for about 38% of this time, and the motor car for 37% (see figure 3.38). The average time spent walking per person daily is therefore in the region of 28 minutes.⁶⁵

Figure 3.38 *Aggregate relative time-use by travel mode (n = 204 h)*



3.6 INFLUENCE OF HOUSEHOLD INCOME ON TRAVEL BEHAVIOUR

As mentioned earlier the sample was stratified proportionally on the basis of combined gross household income. High-income households earn more than R5 500/month, middle-income households earn between R1 801 and R5 500/month, and low-income households earn R1 800/month or less. Some of the key findings of the survey with regard to the impact of these income bands on travel behaviour are discussed below, in terms of: trip generation, trip purposes, mode use and travel time.

⁶⁵ Comparison of these findings with the findings of the national 2000 time-use survey (which included both urban and rural respondents), indicates that in metropolitan Cape Town people spend relatively less time travelling generally (72 vs. 86 minutes/day), and significantly less time walking in particular (28 vs. 53 minutes/day), than people in country as a whole (Budlender *et al* 2001:78).

3.6.1 Trip generation

Given the fairly constant mean household size found across income bands (see table 3.2), the greater private mobility and spending power of wealthier households appear to result in relatively higher out-of-home activity participation and therefore higher trip generation rates amongst these households. Trip generation declines steadily with decreasing income. In fact the survey found that significantly more lower income household members undertook no travel activity at all on their diary day, than high-income household members (22% and 21% amongst middle and low-income household members vs. 5% amongst high-income household members). The survey data suggest that mean household trip generation is around 11.11 trips/weekday amongst high-income households, 9.69 trips/weekday amongst middle-income households, and 8.21 trips/weekday amongst low-income households. Personal trip generation was also found to decrease with household income – from 3.44 trips/weekday amongst high-income household members, to 2.37 and 1.97 trips/weekday amongst middle and low-income household members respectively.

3.6.2 Trip purposes

Figures 3.39 and 3.40 illustrate 7-day week trip purpose distributions across the three income bands. Figure 3.39 suggests that the proportion of trips to work and education activities remains fairly similar and constant across income bands, while higher income households undertake relatively more shopping and business trips at the expense of social and personal business trips. Figure 3.40 indicates that trip purposes defined on a home-based basis offer a similar pattern, only home-based work trips are relatively smaller amongst higher income households – due probably to greater trip chaining associated with journeys to work. As a result of greater (and more flexible) private mobility, the proportion of non-home-based trip-making generally appears to increase as incomes rise.

Figure 3.39 *Trip destination activity purpose distribution by household income (n = 204 h)*

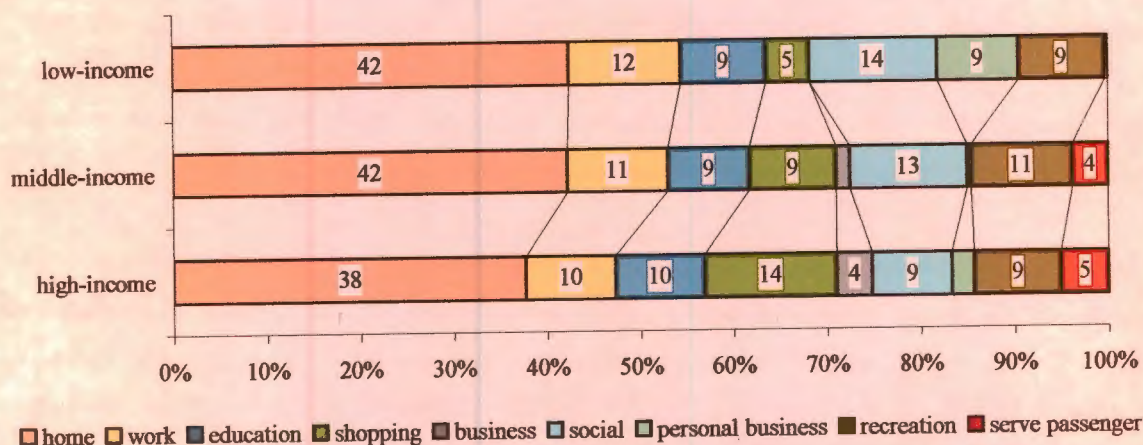
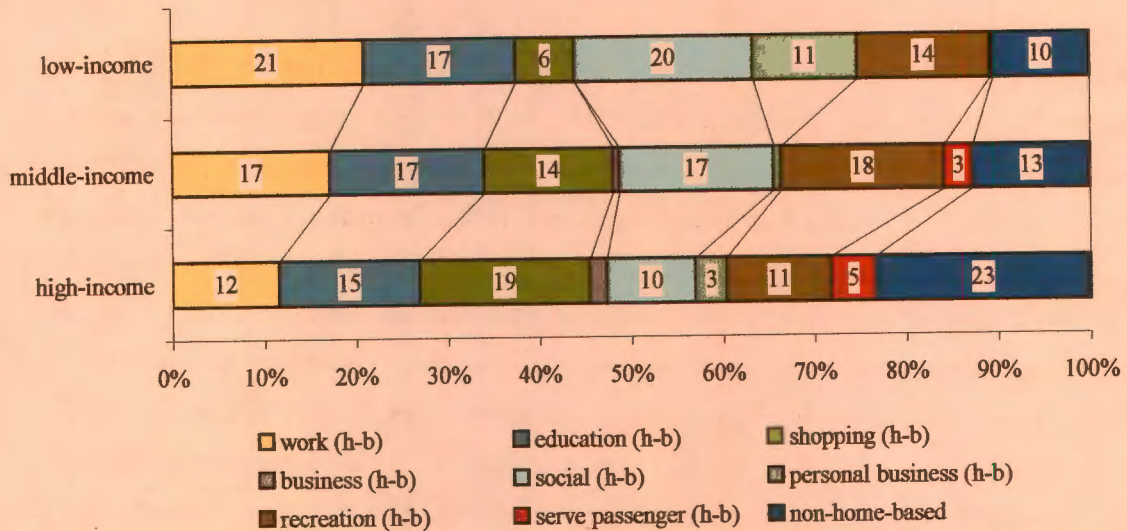


Figure 3.40 *Home-based trip purpose distribution by household income (n = 204 h)*

3.6.3 Mode use

As one would expect the survey data indicate that vehicle availability declines sharply with reduced income. Amongst the high-income households surveyed, 58% have access to the use of two or more motor cars, 36% have access to one motor car, and 6% are without access. Amongst middle-income households 39% have access to one motor car, and 50% are without access. Amongst low-income households 97% are without access. Bicycle availability is generally low – 3%, 9% and 28% in low, middle and high-income households respectively. This highly differentiated pattern of private mobility is reflected strongly in mode use findings. Figures 3.41 and 3.42 illustrate main mode use for trips to all and work activities (and tables 3.8 to 3.10 indicate main mode use for all trip destination activities). Figure 3.41 indicates that car use as the main mode increases dramatically as household incomes rise. Around 88% of all trips by high-income households appear to be undertaken by car (as either driver or passenger). This figure also indicates that walking as the main mode increases rapidly as household incomes decline, as does public transport ridership to a lesser extent. Around 61% of all trips by low-income households appear to be undertaken on foot (as the main travel mode). With regard to the objective of establishing the extent of knowledge gaps, analyses of travel behaviour in Cape Town that have focussed exclusively on motorised modes are therefore particularly ineffectual in understanding travel behaviour amongst middle- and low-income households.

Figure 3.42 indicates that in the case of trips to work activities, walking as the main mode amongst middle and low-income households declines (relative to all trip mode use) in favour of public transport modes. The survey data suggest that amongst high-income households a high proportion of trips continue to be undertaken by car (86%), only the relative contribution of car driver trips increases from around 56% to 79%.

Table 3.9 *Percentage main mode use by trip destination activity purpose: middle-income households (n = 75 h)*

	WORK	EDUC.	SHOP.	BUS.	SOC.	PERS. BUS.	REC.	SERVE PASS.	HOME
walk	19.2	63.2	47.2	16.7	53.2	75.0	44.0	17.9	45.4
bicycle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
taxi	18.7	11.1	9.1	0.0	2.3	0.0	4.8	0.0	8.2
bus	14.1	3.6	8.7	0.0	0.9	0.0	1.1	0.0	6.9
train	10.1	1.3	2.2	0.0	0.0	0.0	4.8	0.0	3.6
car dr.	22.2	6.1	17.0	47.6	13.7	25.0	14.8	52.5	14.8
car pass.	15.8	14.6	15.8	35.7	30.0	0.0	30.6	29.7	20.7
other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3

Table 3.10 *Percentage main mode use by trip destination activity purpose: low-income households (n = 64 h)*

	WORK	EDUC.	SHOP.	BUS.	SOC.	PERS. BUS.	REC.	SERVE PASS.	HOME
walk	23.4	62.4	73.2	0.0	91.7	38.3	73.2	100.0	61.1
bicycle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
taxi	18.3	7.5	8.3	0.0	2.4	25.0	11.2	0.0	10.5
bus	10.5	12.9	0.0	0.0	0.0	0.0	6.7	0.0	5.7
train	30.3	11.8	7.1	0.0	1.5	22.5	2.3	0.0	14.5
car dr.	1.7	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.5
car pass.	3.5	5.4	11.3	0.0	4.4	14.2	3.3	0.0	5.8
other	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9

As one would expect, given greater use of public transport modes, the data suggest that multi-mode trips (including walking trip segments) across a 7-day week are more prevalent amongst middle and low-income households (see figure 3.43). Multi-mode trips appear seldom to exceed three transfers. Figure 3.44 indicates that multi-mode trips are most likely to be those to and from work and education activities. In addition, and while not necessarily clearly noticeable in aggregated analysis, the process of coding personal activity diary data indicated that some middle and low-income commuters take the quickest but more expensive public transport mode(s) to work, and then take a cheaper slower mode(s) home (and in a number of cases this involved walking home for some 2-3 hours). Less unexpectedly, scholars in high- and middle-income households were also found to use different modes in forward and return trips.

Figure 3.43 *Multi-mode trips by sampling area (n = 204 h)*

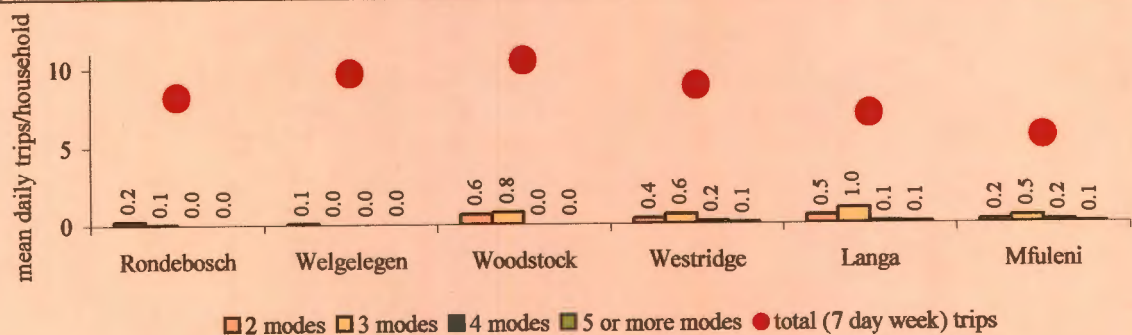
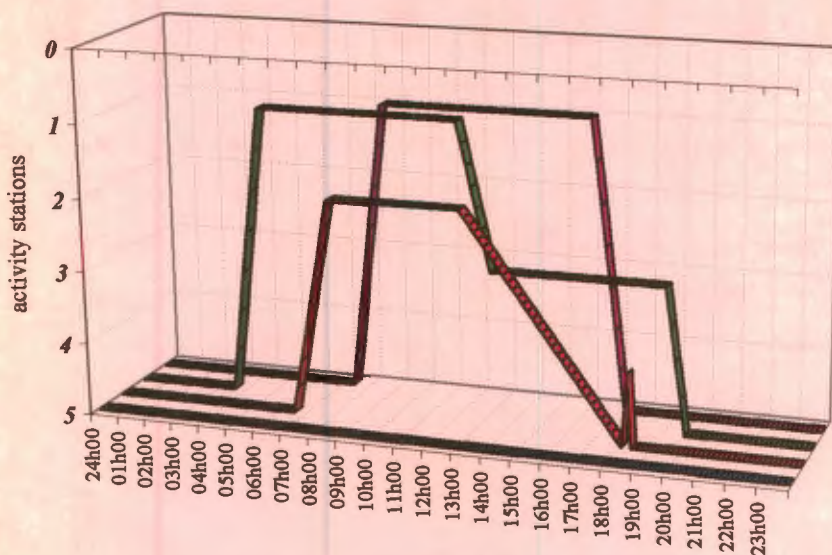


Figure 3.44 *Multi-mode trips by destination activity (n = 204 h)*



Figure 3.45 illustrates a particularly acute example, derived from the database, of an asymmetrical forward and return trip. In this instance an unemployed 33 year old man living in Langa travelled by foot and train (as the main mode) for a total of 70 minutes to an employment centre to look for work (coded as a ‘personal business’ activity), and then walked home in the afternoon for 5 hours 50 minutes.

Figure 3.45 *Case study household time-space path illustrating asymmetrical forward and return trip mode use*



■ unemployed sister (23 yr) ■ unemployed brother (33 yr) ■ employed brother (30 yr) ■ employed sister (26 yr)

Note: The time-space paths represented are constructed from the diaries kept by a 4 person low-income household living in Langa, on a Wednesday. The household is composed of adult siblings, and does not have access to a motor car. The 33 year old brother and 23 year old sister are unemployed. The 30 year old brother is employed as a morning shift worker, and the 26 year old sister has employment during normal working hours. The employed brother walked (for 60 minutes) to and from work, stopping off at a recreational facility on the way home. The employed sister travelled to and from work by foot, minibus-taxi and train, while the unemployed sister stayed at home for the entire 24-hour diary period. [Activity stations: 5= home, 4= social activity, 3= recreational activity, 2= personal business, 1= work; Database R/ID= 824-842]

Scan

3.6.4 Travel time (and distance)

Figure 3.46 illustrates the findings of the survey with regard to mean trip time by destination activity purpose for sampling areas in each of the income bands – high-income (Rondebosch and Welgelegen), middle-income (Woodstock and Westridge) and low-income (Langa and Mfuleni). The figure indicates clearly that poorer people spend more time travelling than wealthier people. This finding reflects the greater mobility of higher income households associated with higher levels of car availability, and the greater ‘capability constraints’ placed on poorer households. The figure suggests that across all income bands more time is spent on trips to work and personal business activities (which include healthcare and other social welfare services) than other trip destination activity purposes. Figure 3.47 indicates that low-income household members in particular are prepared to (and probably have no alternative but to) walk for considerably longer when accessing these activity sites.

Figure 3.46 Mean trip time to destination activity purposes by sampling area (n = 204 h)

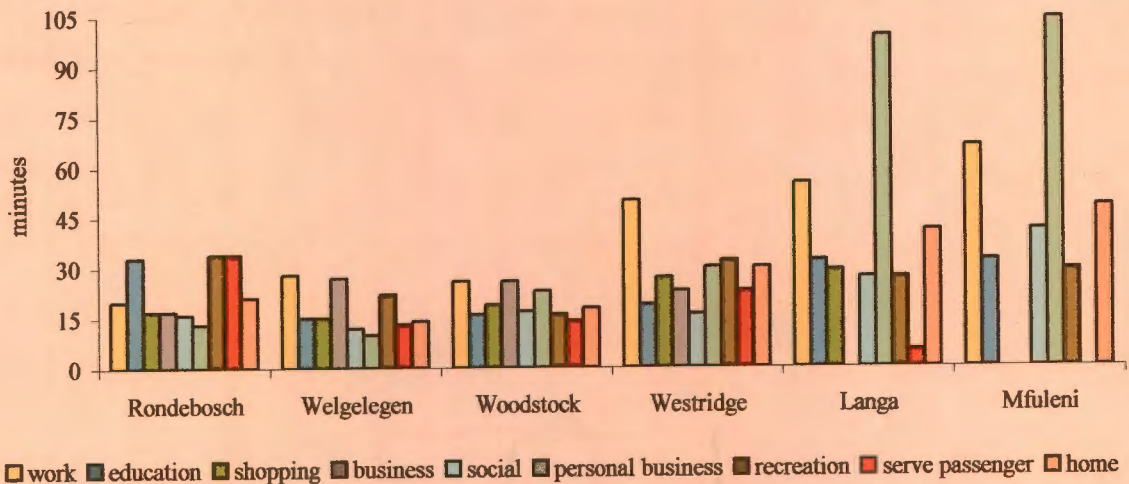


Figure 3.47 Mean (main mode) walking trip time to destination activity purposes by sampling area (n = 204 h)

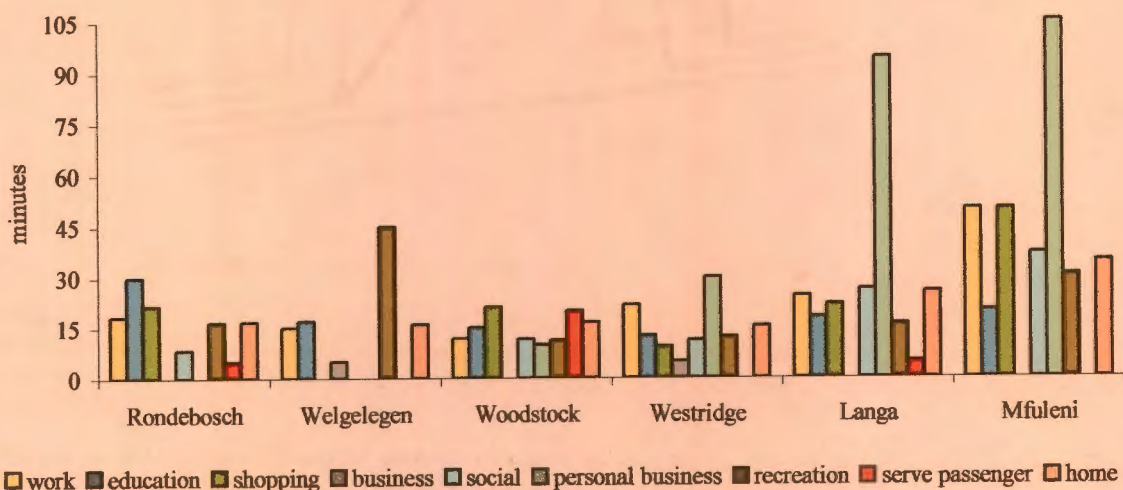


Figure 3.48 Mean daily household time-use by mode and trip destination activity purpose: Rondebosch (n = 34 h)

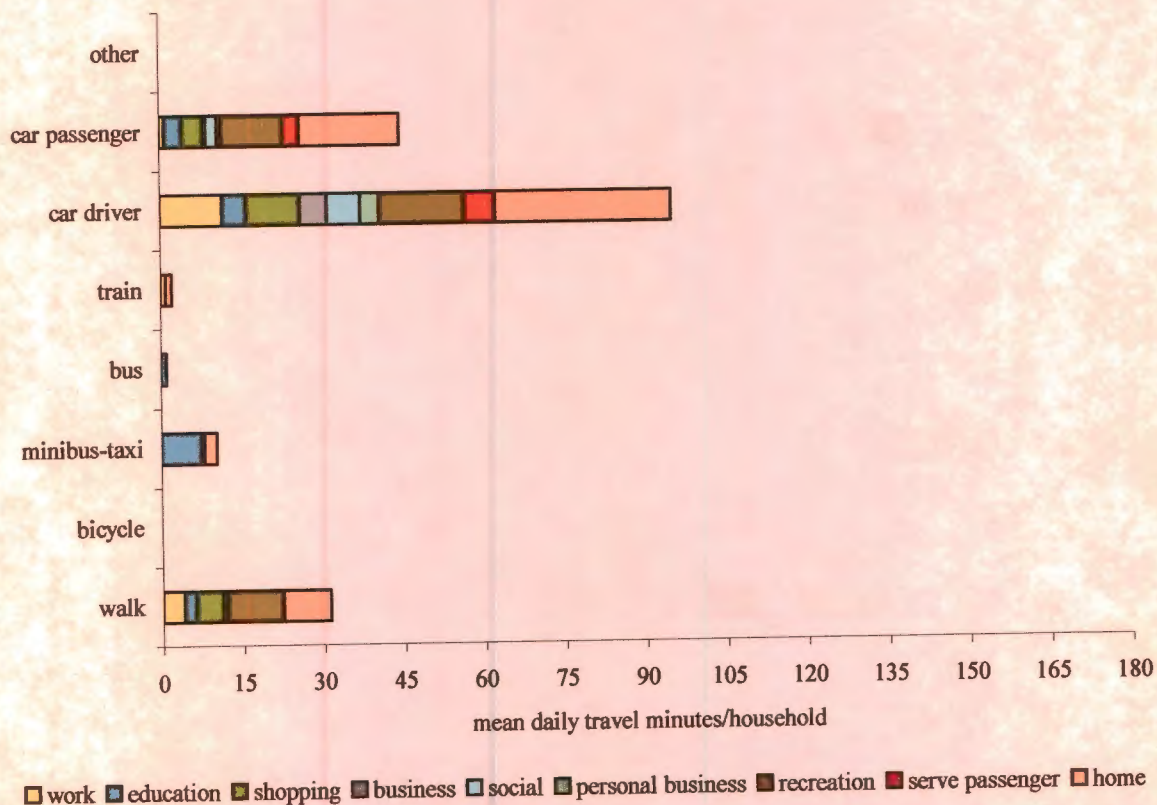


Figure 3.49 Mean daily household time-use by mode and trip destination activity purpose: Welgelegen (n = 31 h)

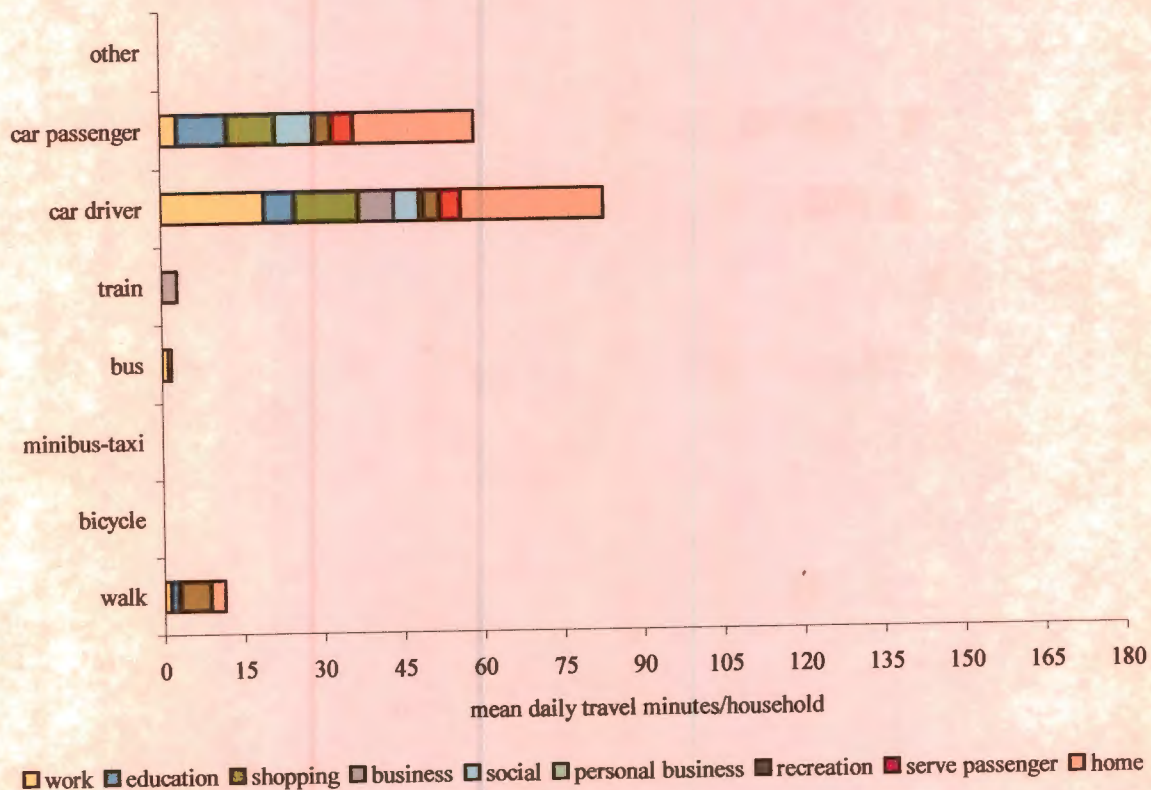


Figure 3.50 *Mean daily household time-use by mode and trip destination activity purpose: Woodstock (n = 34 h)*

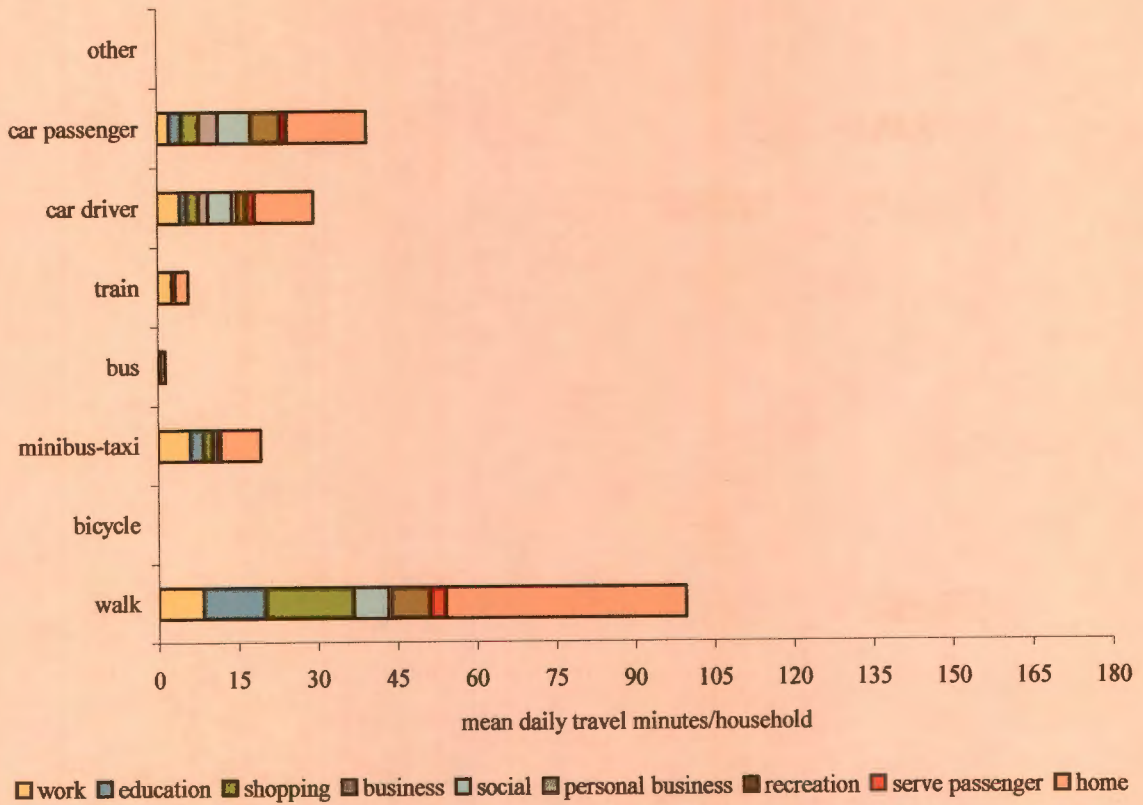
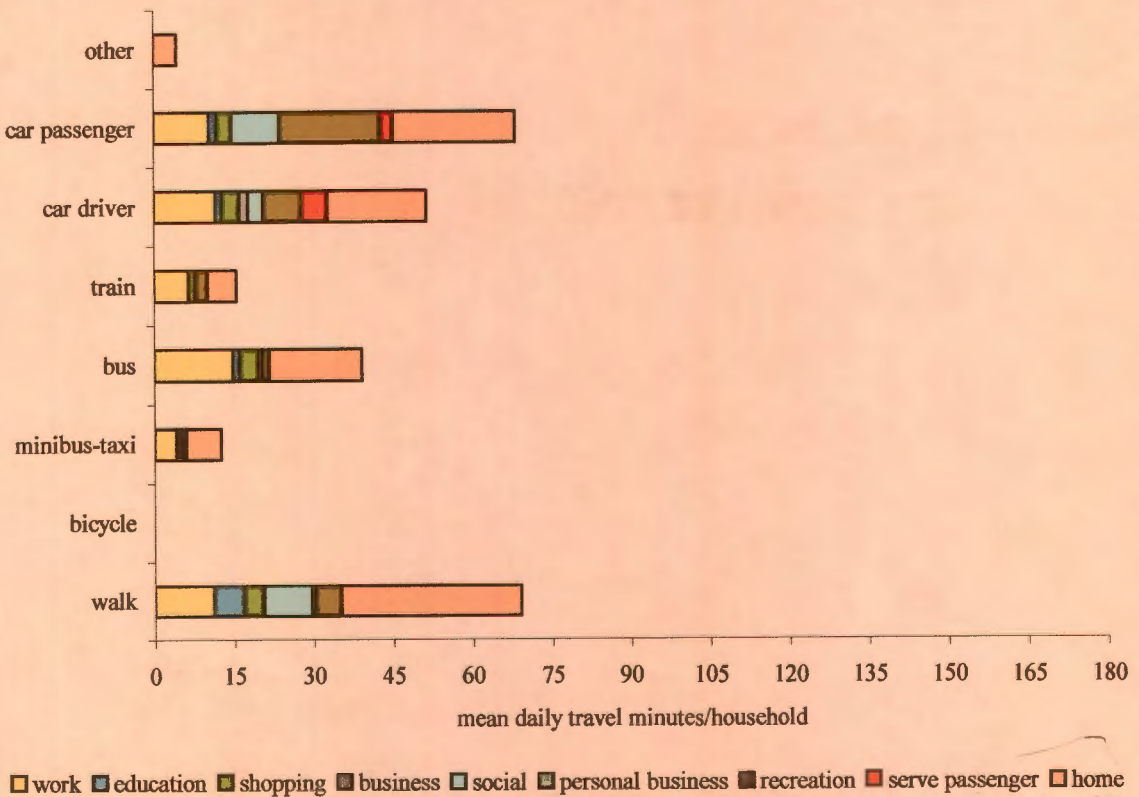


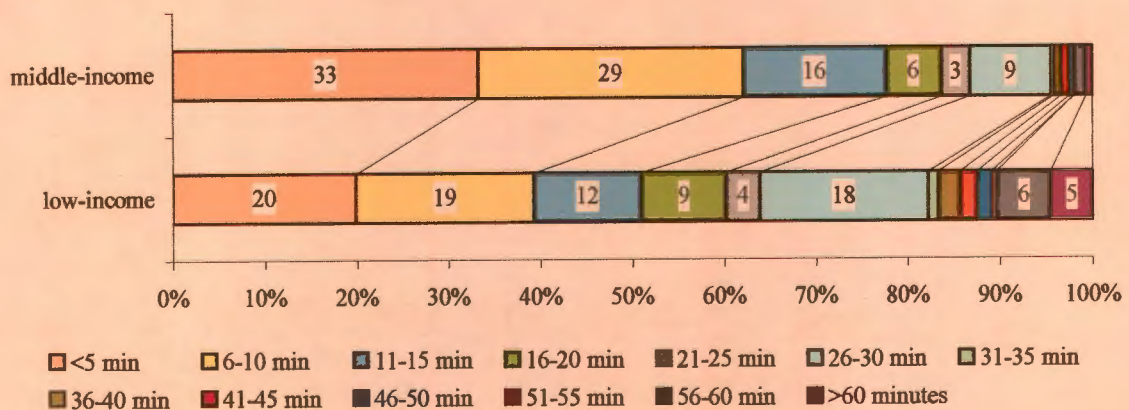
Figure 3.51 *Mean daily household time-use by mode and trip destination activity purpose: Westridge (n = 41 h)*



Different levels of access to private and public mobility across the income bands inevitably impacts on time spent travelling. Figures 3.48 to 3.53 indicate mean daily household time-use by mode and trip destination activity purpose for each of the sampling areas. As one would expect the data indicate that higher income households spend more time travelling by car, and lower income households spend more time travelling on foot. The importance of walking as a travel mode amongst lower income households is illustrated clearly in these figures. Public transport travel time-use in Langa and Mfuleni illustrates the impact an absence of passenger rail services has on public transport mode share in Cape Town's lower income neighbourhoods.

In terms of the prevailing network configuration and management assumptions concerning maximum walking times and safe parallel arterial frequency discussed in chapter 1 and in more detail in chapter 4 (i.e. that maximum acceptable walking trip times are 5-10 minutes, that walking trip destinations are local neighbourhood centres or public transport stops, and that higher speed arterials spaced at 1.5-2 km intervals minimise pedestrian conflict), figure 3.54 suggests that only 20% and 39% of low-income household walking trip segments are less than 5 and 10 minutes respectively. Thus the majority (61%) of walking trip segments in this income band are longer than 10 minutes, and some 18% of trip segments are longer than 30 minutes – in fact 8 respondents in the sample recorded walking trips in excess of 3 hours. Amongst middle-income households, 33% and 62% of walking trip segments are less than 5 and 10 minutes respectively. In this income band 38% of walking trip segments last longer than 10 minutes, but the majority (96%) are less than 30 minutes. As discussed earlier, amongst high-income households walking as a travel mode is less significant (see figure 3.41), and the most common walking trip purpose is recreational (see table 3.8). These data, while not necessarily implying that all walking trips traverse neighbourhood boundaries, do suggest that the walking trip assumptions that underpin conventional parallel arterial frequency and safe neighbourhood delimitation, do not hold true in middle- and low-income local areas in Cape Town.

Figure 3.54 *Walking trip segment travel time by household income (n = 139 h)*



It is possible, with the use of assumptions regarding mean travel speed,⁶⁶ to convert data on travel time into data on travelled distance. Figure 3.55 estimates mean trip distance to discretionary trip destinations (i.e. shopping, recreation and social activities) by income band. While obviously crude, this figure indicates that while poorer households might spend more time travelling and are often forced to travel long distances to work and other activities around which they have limited or no trip destination choice, their lower private mobility results in smaller notional discretionary trip ranges than wealthier households. Conversely, figure 3.56 indicates that poorer households (living in Langa and Mfuleni) have considerably larger notional walking trip ranges. Given the definition of a 'local area' provided in chapter 1 – the area covered by walking distances from a point of origin – the figure illustrates that poorer households have significantly larger 'local areas' than wealthier households.

Figure 3.55 *Mean imputed (all mode) trip distances (metres) to discretionary destinations by household income (n = 204 h)*

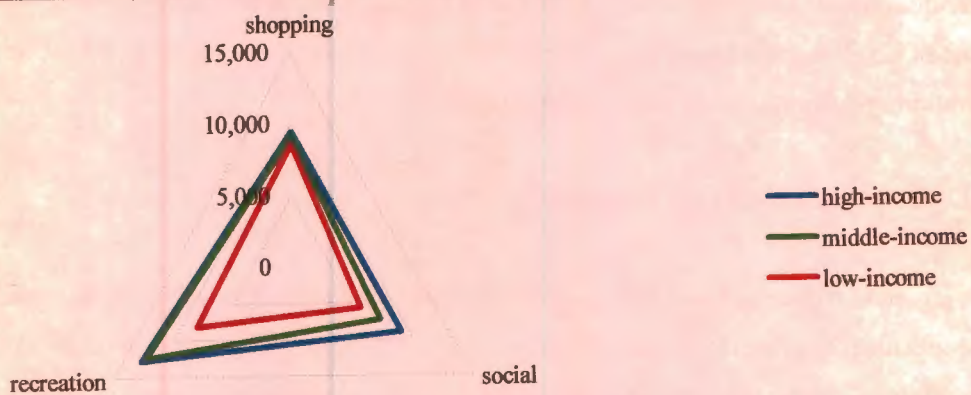


Figure 3.56 *Mean imputed (main mode) walking trip distance (metres) by destination activity purposes and sampling area (n = 204 h)*



⁶⁶ The following mean travel speeds are assumed: pedestrians= 4 km/h (67 m/min); bicycles= 16 km/h (267 m/min); motor cars= 40 km/h (667 m/min); minibus-taxis= 50 km/h (834 m/min); buses= 30 km/h (500 m/min); and trains= 40 km/h (667 m/min).

3.7 INFLUENCE OF NEIGHBOURHOOD FORM AND LOCATION ON TRAVEL BEHAVIOUR

In addition to income stratifications, as mentioned earlier, the sample was clustered into 'inner locations' and 'outer locations'. As far as possible inner location sampling areas are characterised by close proximity to commercial and employment opportunities and well connected street patterns, and outer location sampling areas by peripheral positions relative to non-residential land uses and poorly connected street patterns inconvenient for pedestrians. The former areas therefore resemble as closely as possible conventional suburban neighbourhoods, and the latter, the 'pedestrian pockets' and 'transit-oriented developments' discussed later in chapter 4. Selecting sampling areas that conform broadly to these requirements was not always possible however. More specifically, whilst enjoying close proximity to employment opportunities and public transport services, Langa's street network is highly disconnected from its surrounds. Some of the key findings of the survey with regard to the impact of neighbourhood form and location on travel behaviour are discussed below, in terms of: trip generation, trip timing, mode use and travel time.

3.7.1 Trip generation (and chaining)

With regard to trip generation, the survey found that households in inner locations make about 6% more trips than households in outer locations (8.59 vs. 8.06 mean household trips/weekday) – suggesting an inverse relationship between neighbourhood accessibility and trip generation. The study data also indicate that chaining across a 7-day week is more prevalent in outer locations, and particularly so amongst high-income households with greater private mobility (see figure 3.57). The data suggest that chaining is not particularly common however, and chains seldom exceed three trips. As one would expect, figure 3.58 indicates that chains are most likely to include serve passenger trips. These generation and chaining findings suggest that outer location households compensate for poorer accessibility by multi-purposing and linking trips into chains, whereas inner location households with superior access to destination activities are more likely to undertake trips as and when the need arises – a set of conclusions broadly consistent with the empirical studies of the behavioural impacts of local network configuration and land use distribution reviewed later in chapter 5.

Figure 3.57 *Trip chaining by sampling area (n = 204 h)*

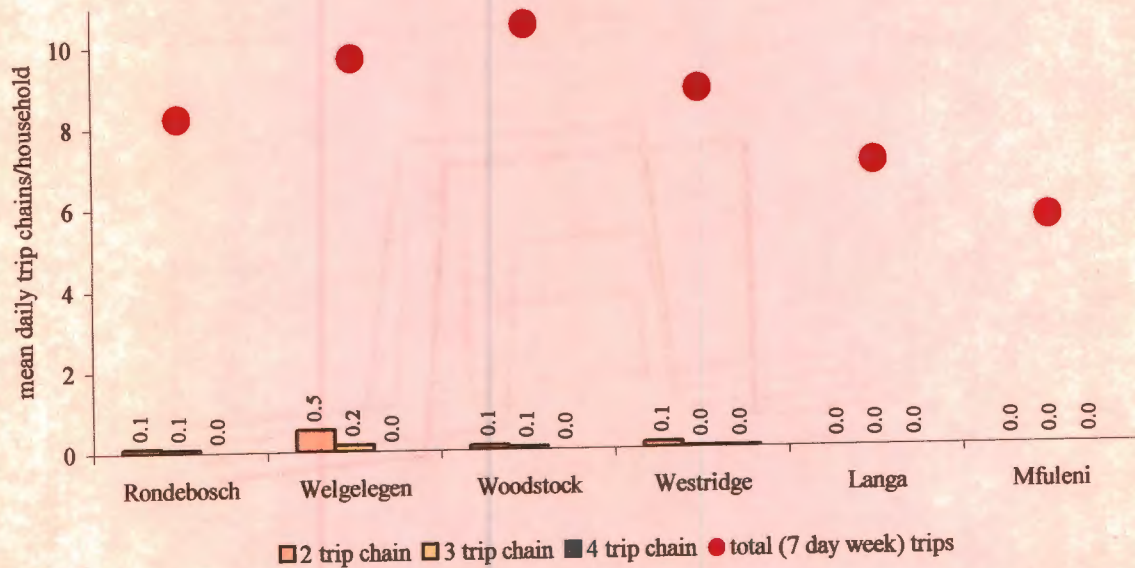
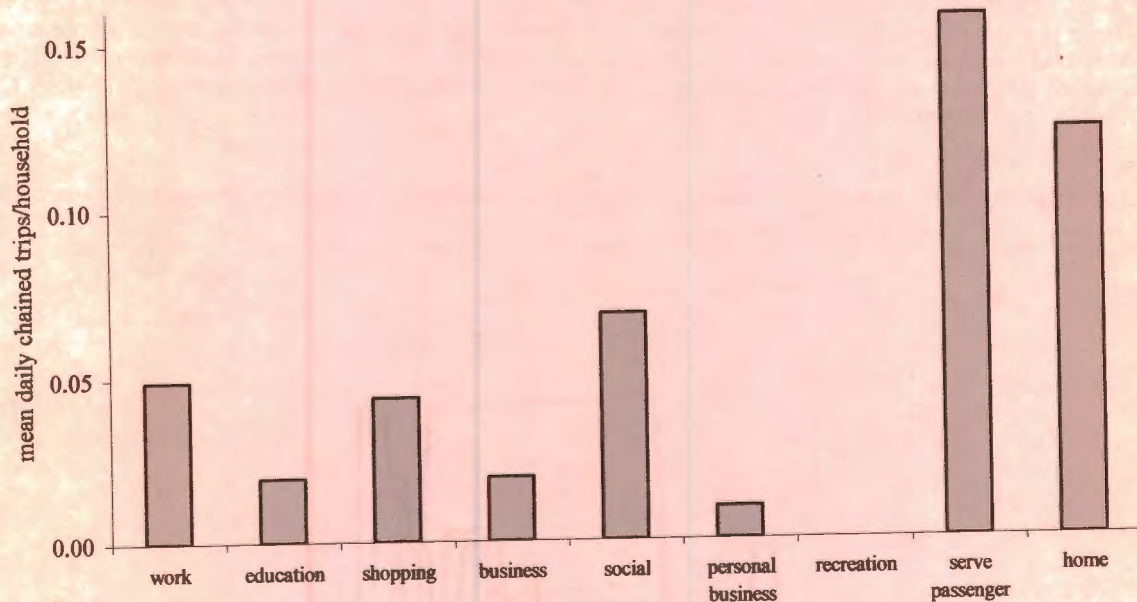
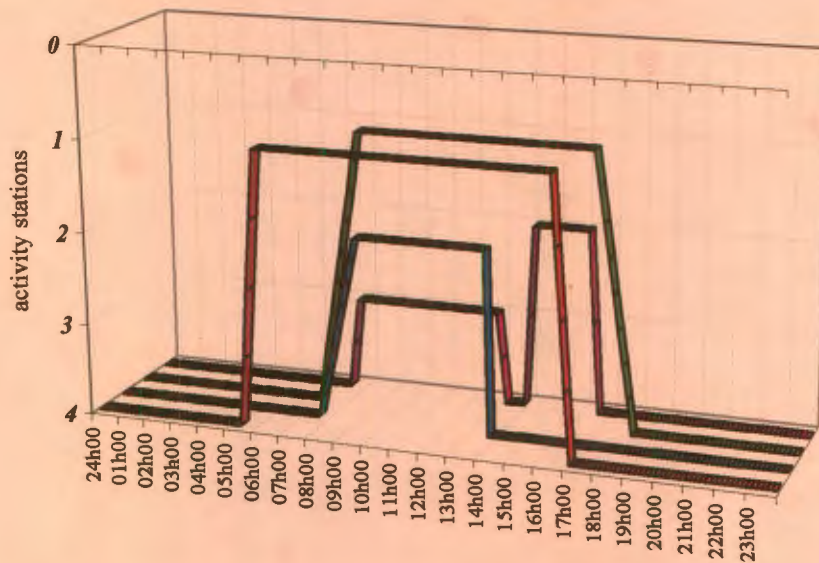


Figure 3.58 *Trip chaining by destination activity (n = 204 h)*



Figures 3.59 and 3.60 present two household time-space path case studies, from the database, that illustrate the ability of households with superior accessibility to undertake home-based trips (largely on foot) when the need or desire arises. Both households contain four members, and neither has access to a motor car. In the first case study (figure 3.59) a household living in the outer location sampling area of Westridge makes just 10 home-based trips on their diary day, of which 40% are undertaken on foot as the main travel mode. In the second case study (figure 3.60) a household living in the inner location sampling area of Woodstock makes 20 home-based trips on their diary day, of which 75% are undertaken on foot as the main mode.

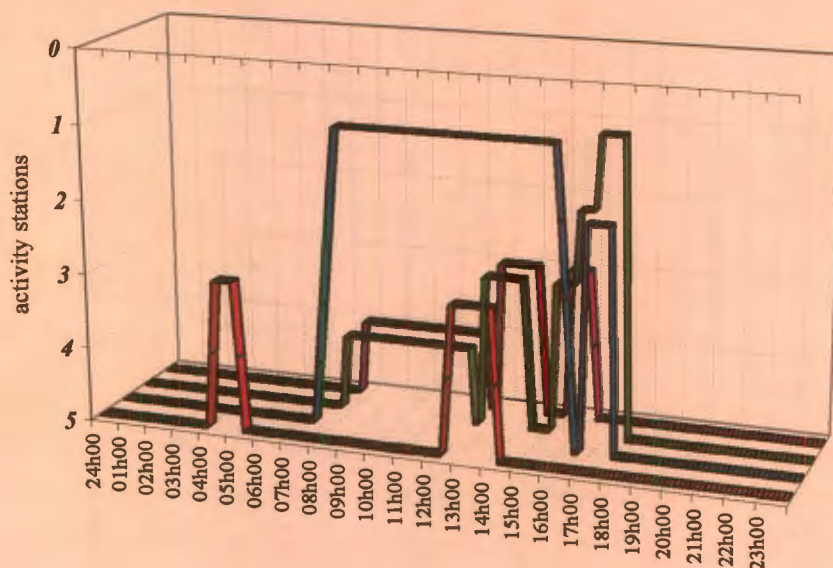
Figure 3.59 Case study household time-space path illustrating lower home-based trip generation in outer locations



■ employed father (43 yr) ■ houseworking mother (41 yr) ■ employed daughter (23 yr) ■ daughter (15 yr)

Note: The time-space paths represented are constructed from the diaries kept by a 4 person middle-income household living in Westridge, on a Thursday. The household is composed of an employed father (43 years), a houseworking mother (41 years), an employed daughter (23 years) and a school-going daughter (15 years), and does not have access to a motor car. The father commutes to and from work by minibus-taxi. The houseworking mother travels to the shops by train as the main mode, and home again by bus. The employed daughter commutes to and from work by bus, while the 15 year-old daughter walks unaccompanied to and from school and the shops. [Activity stations: 4= home, 3= education activity, 2= shopping activity, 1= work; Database R/ID= 370-388]

Figure 3.60 Case study household time-space path illustrating higher home-based trip generation in inner locations



■ retired grandfather (72 yr) ■ employed mother (36 yr) ■ son (12 yr) ■ son (10 yr)

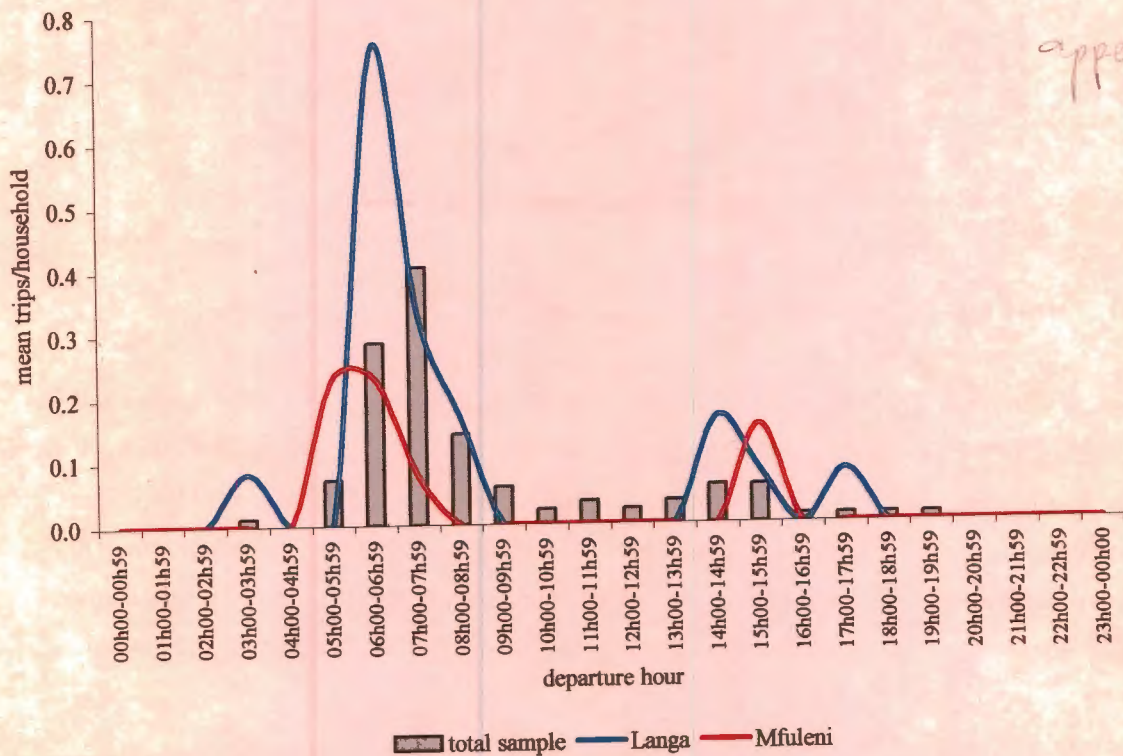
Note: The time-space paths represented are constructed from the diaries kept by a 4 person middle-income household living in Woodstock, on a Friday. The household is composed of a retired grandfather (72 years), an employed mother (36 years) and two school-going sons (12 and 10 years), and does not have access to a motor car. The grandfather goes for an early morning walk for exercise in the morning, and then accompanies the two boys in the early afternoon to a sports activity. The mother commutes to work by minibus-taxi and walks home, after which she goes shopping on foot. The two boys walk to and from school and to sports activities, while the older (i.e. 12 year son) walks to and from an odd-job as well, stopping

on the way to buy something at the shops. [Activity stations: 5= home, 4= education activity, 3= recreation activity, 2= shopping activity, 1= work; Database R/ID= 1020-1039]

3.7.2 Trip timing

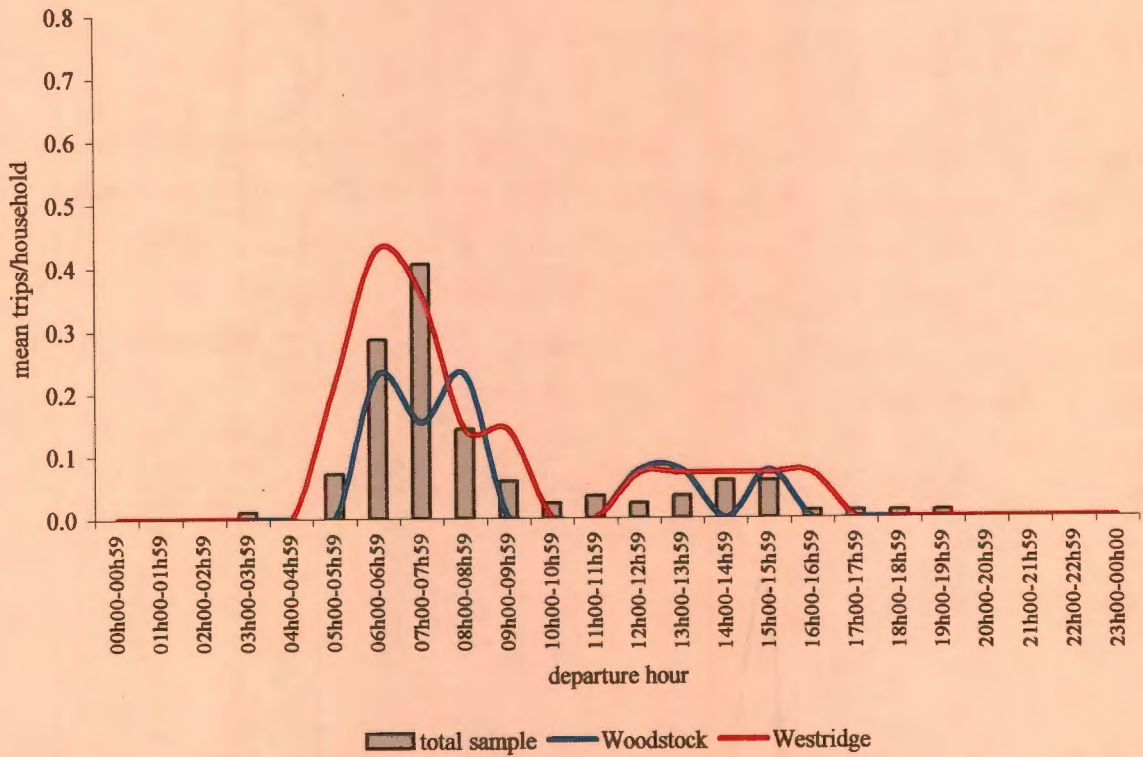
Analysis of weekday work trip timing profiles indicates that, particularly amongst public transport users, location has a significant impact on trip departure times. Figures 3.61 and 3.62 indicate that amongst middle- and low-income households, outer location sampling areas (i.e. Westridge and Mfuleni) have earlier morning commuter peaks than inner location sampling areas (05h30-06h00 vs. 06h00-07h00). A similar trip timing profile is not noticeable in education trips, presumably because schools are distributed more closely within or near the sampling areas.

Figure 3.61 *Weekday hourly trip to work timing amongst low-income households (n = 25 h)*



Note: The greater number of work trips per household in Langa relative to Mfuleni is presumably due to higher levels of employment in this area.

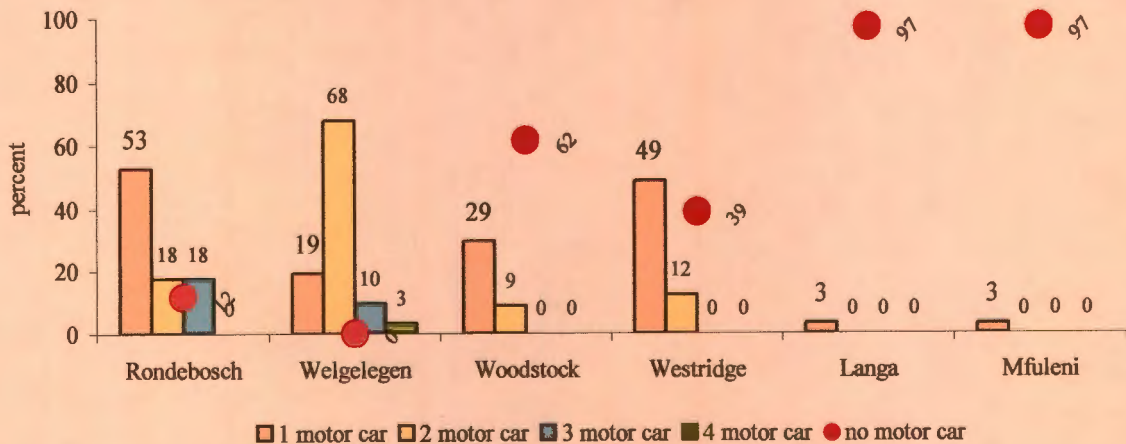
Figure 3.62 Weekday hourly trip to work timing amongst middle-income households (n = 27 h)



3.7.3 Mode use

Location would also appear to have an influence on vehicle availability, and therefore inevitably on mode use patterns as well. Figure 3.63 indicates that within the same income bands, with the exception of the low-income band where car ownership is ubiquitously unaffordable, households in outer locations consistently have greater access to motor cars than households in inner locations. This supports the argument that peripherally located households are forced to spend greater amounts of household resources on car ownership in order to participate in urban socio-economic systems.

Figure 3.63 Household vehicle availability by sampling area (n = 204 h)



Figures 3.64 and 3.65 illustrate the impact household car availability has on trip generation and mode use. Households with greater access to cars were found to generate more trips in both location categories, but interestingly inner located households without a car, and those with access to just one car, were found to have the same trip generation rate. This suggests that a lack of private mobility is less of a hindrance in these areas, and is compensated for by greater walking. In outer locations, households without a car are unable to substitute car trips with walking trips to the same extent, and as a result generate fewer trips.

Figure 3.64 *Main mode use amongst inner location households by vehicle availability (n = 99 h)*

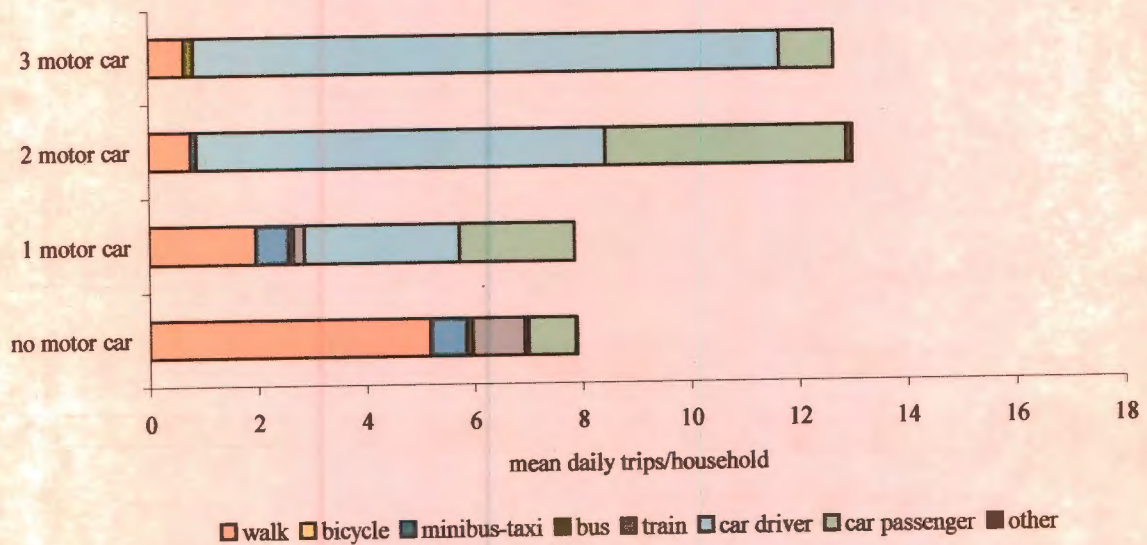
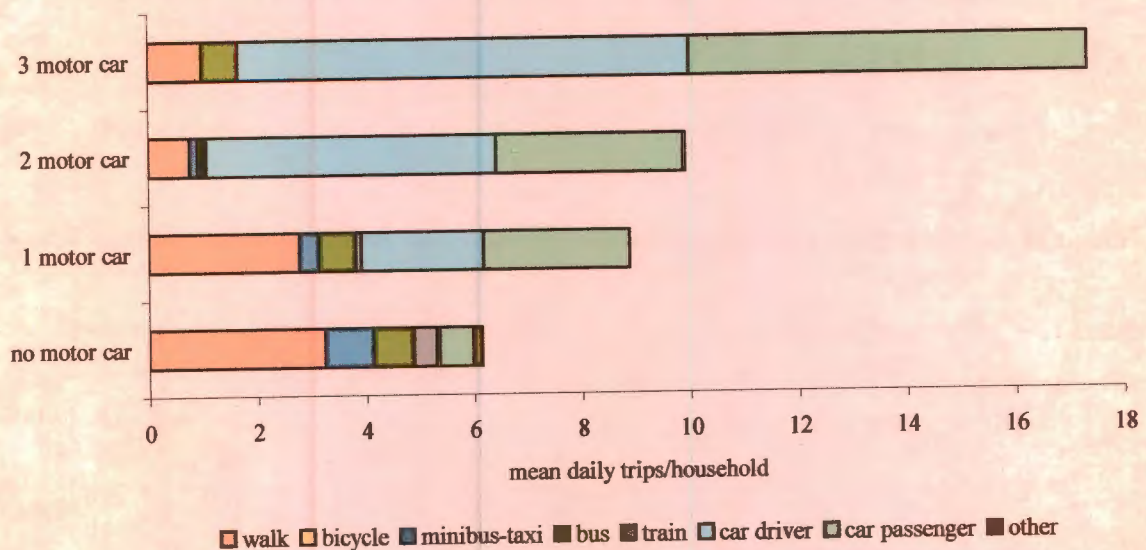


Figure 3.65 *Main mode use amongst outer location households by vehicle availability (n = 105 h)*



The survey found that within the same income bands, households in inner locations consistently walk (as the main travel mode) more than households in outer locations (see table 3.11). This finding supports the conclusions of the literature to be reviewed in chapter 5 – that even though greater

Table 3.13 *Percentage main mode use by trip destination activity purpose: outer locations*
(*n = 105 h*)

	WORK	EDUC.	SHOP.	BUS.	SOC.	PERS. BUS.	REC.	SERVE PASS.	HOME
walk	11.9	46.6	36.6	21.2	49.6	43.3	38.0	0.0	33.9
bicycle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
taxi	11.6	6.6	8.5	0.0	2.2	16.7	6.6	0.0	7.8
bus	16.6	8.3	5.8	0.0	0.6	0.0	5.2	0.0	7.7
train	8.7	0.0	1.5	9.1	0.0	1.7	2.2	0.0	3.5
car dr.	34.3	13.6	26.0	69.7	19.1	22.2	21.7	41.4	23.0
car pass.	10.0	24.0	21.8	0.0	28.5	16.1	26.3	25.3	22.8
other	7.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	1.5

3.7.4 Travel time (and distance)

With regard to travel time, location relative to centres of employment and commerce clearly results in longer trip travel times for more peripherally located households. Figure 3.46 indicates that within the same income band outer location commuters tend to spend around 50% more time on trips to work than inner location commuters. Other trip purposes appear to generally follow a similar, but less pronounced, pattern. Figure 3.67 indicates the amount of time households in inner and outer locations (as well as those in different income bands) spend travelling. The figure suggests, somewhat surprisingly, that outer location households travel for only slightly longer periods of the day than inner location households – the greater time spent travelling by motorised modes in outer locations would appear to be offset by greater walking time in inner locations. The figure also suggests that income has a greater influence on daily time use than location – due to the considerable increase in the use of walking as a travel mode amongst lower income households.

Figure 3.67 *Daily household travel time by location and income band (n = 204 h)*

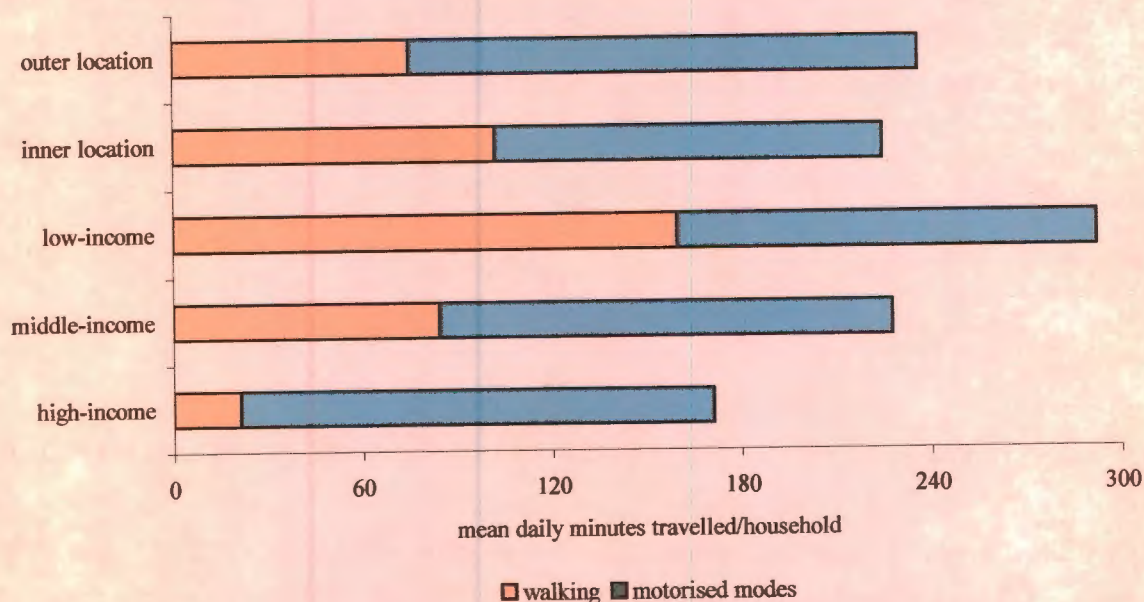


Figure 3.68 indicates mean daily household travelled distances for inner and outer locations, as well as for income bands. The figure indicates that outer location households are forced to travel further per day than inner location households. It also indicates, as discussed earlier, that whereas wealthier households have considerably wider daily ranges when travelling by motorised modes, poorer households have wider walking ranges. This suggests that in poorer areas travel to local destinations is relatively more important than in wealthier areas, and that income has a greater influence on the choice of walking as a travel mode than location and neighbourhood form. Table 3.14 estimates mean trip distance by destination activity purpose and sampling area.

Figure 3.68 *Imputed daily household travelled distance by location and income band (n = 204 h)*

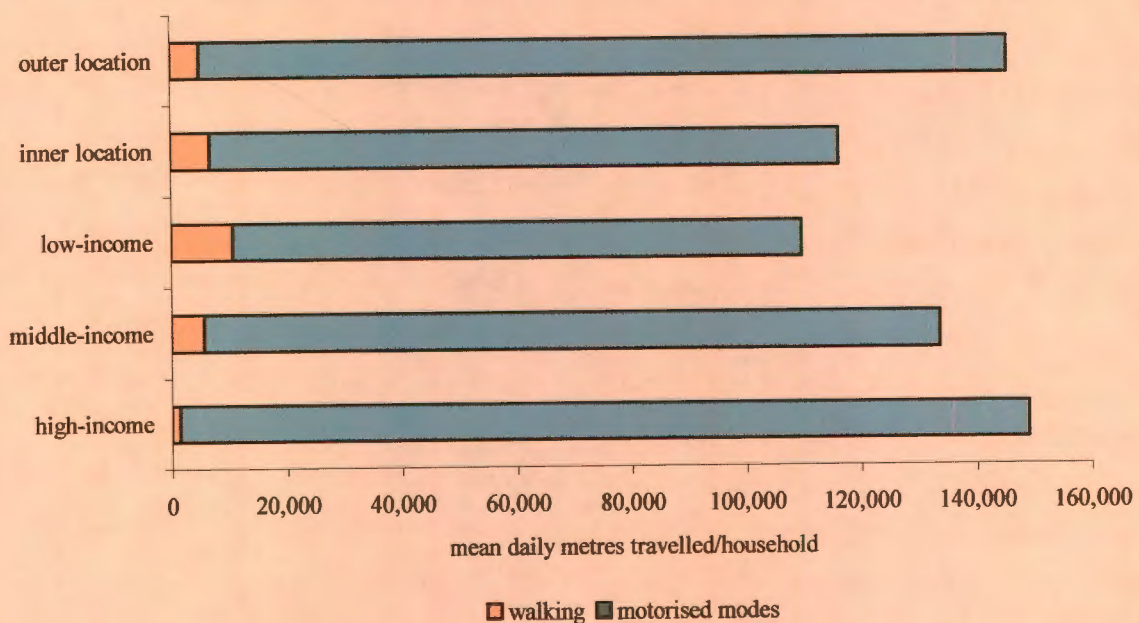


Table 3.14 *Mean imputed trip distance (metres) by trip destination activity purpose and sampling area (n = 204 h)*

	WORK	EDUC.	SHOP.	BUS.	SOC.	REC.	SERVE PASS.	ALL TRIPS
Langa	22,299	8,651	6,021	na	4,192	8,269	333	13,218
Mfuleni	29,330	12,581	11,257	na	7,115	7,870	na	19,567
Woodstock	12,992	4,732	5,137	17,151	7,776	6,385	4,859	6,973
Westridge	25,869	5,931	13,157	14,563	6,692	18,342	15,136	14,067
Rondebosch	10,798	21,461	8,845	11,218	9,917	16,938	22,270	12,841
Welgelegen	17,854	8,840	10,160	17,918	8,071	8,553	8,338	10,110
total sample	19,911	9,402	8,900	15,133	7,026	12,535	11,093	12,169

3.8 INFLUENCE OF HOUSEHOLD LIFE-CYCLE STAGE ON TRAVEL BEHAVIOUR

As was discovered in the seminal household activity diary study undertaken by Oxford University's Transport Studies Unit in the late 1970s (Jones *et al* 1983), this study also found life-cycle stage to be an important determinant of household travel behaviour – particularly of trip generation rates and trip

purpose distributions. Figure 3.69 indicates the mean weighted rate and purpose of trip-making across households from the entire sample. From this figure it can be seen that the presence of children within the household has a significant impact on travel behaviour. While children have travel needs in their own right, as can be seen in the relatively high amount of education and recreation trips amongst households with child members, they also alter the travel patterns and constraints of other household members. The latter is evidenced in a significantly larger proportion of 'serve passenger' trip purposes amongst households with young children who, as will be discussed later, have low levels of independent mobility. Age is also found to impact upon household travel behaviour – the household life-cycle stage generating the least amount of trips is that which includes retired and elderly persons.

Figure 3.69 *Trip generation and destination activity purpose by life-cycle stage (n = 204 h)*

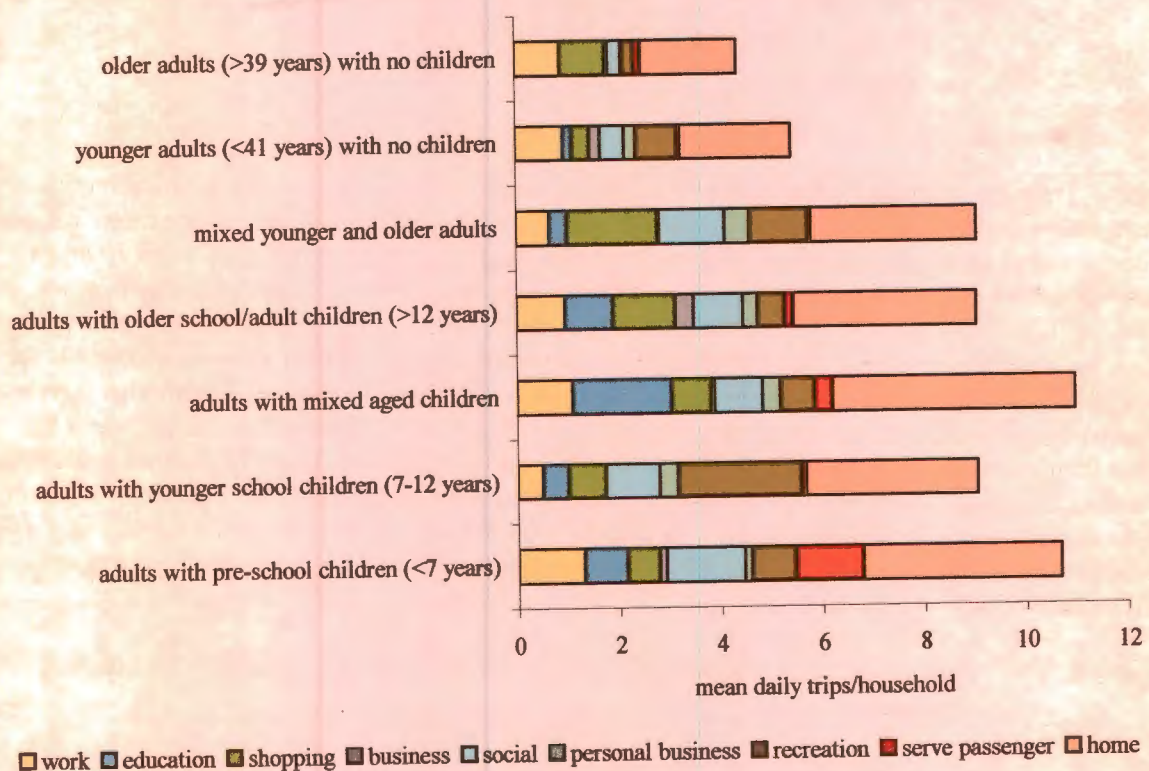
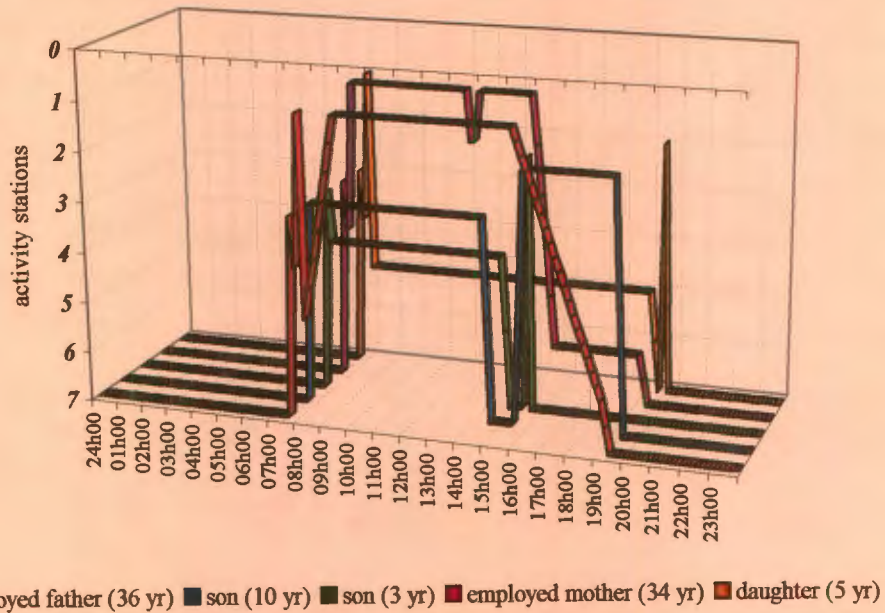


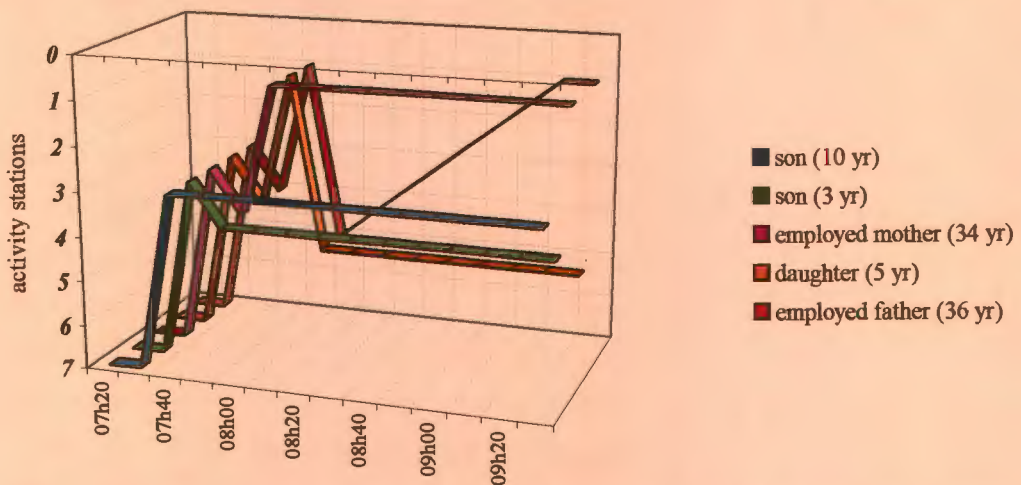
Figure 3.70 presents a household time-space path case study, from the database, which illustrates clearly the impact that young children have on the daily activity schedule and travel pattern of a middle-income household living in Westridge, and of the 36 year old father with access to the household's only motor car in particular. In this instance the father's coupling constraints require that he drop all the household children at their respective educational and childcare activity destinations on his way to work, as well as dropping and fetching his wife. While undertaking just one home-to-home journey during the diary period, he undertakes 2 trip chains and a total of 7 trips (compared to the mean personal trip rate for this income band of 2.37 trips/weekday). Figure 3.71 illustrates the complex coupling and chaining associated with his morning commute with greater clarity, from his time of departure from home to his time of arrival at work.

Figure 3.70 *Case study household time-space path illustrating the impact of young children on parent travel patterns*



Note: The time-space paths represented are constructed from the diaries kept by a 5 person middle-income household living in Westridge, on a Thursday. The household has access to one motor car, and is composed of an employed father (36 years) and mother (34 years), two sons aged 3 and 10 and a daughter aged 5 years. The father has access to the household's motor car, and on his way to work provides the other household members with lifts to their respective first trip destinations – first he drops the older son at school, then the younger son at crèche, then the mother at work, and finally the daughter at pre-school. His entire morning trip chain lasts for 1 hour 45 minutes. The mother travels from work to an informal income generating activity by foot and bus, from where she is given a lift home with her returning husband at 19h00. Arrangements are made with adults from other households to ensure that, when the parents are unable, the children travel in the company of an adult at all times of the day. [Activity stations: 7= home, 6= informal work activity, 5= first education activity site, 4= second education activity site, 3= third education activity site, 2= social activity, 1= work; Database R/ID= 1928-1952]

Figure 3.71 *Time-space paths illustrating coupling and chaining associated with the morning commute*



Note: Activity stations: 7= home, 6= informal work activity, 5= first education activity site, 4= second education activity site, 3= third education activity site, 2= social activity, 1= work; Database R/ID= 1928-1952

3.9 INFLUENCE OF PERSONAL CIRCUMSTANCES ON TRAVEL BEHAVIOUR

As mentioned earlier 678 persons, who were either independently mobile or generated their own daily activity schedule, were surveyed in the study. For the purposes of investigating the influence of personal circumstances on travel behaviour, these persons were categorised on the basis of gender, age and a person type classification based on a combination of age, employment status and childcare responsibilities (see table 3.4). Some of the key findings of the survey with regard to the impact of these personal circumstances on travel behaviour are discussed below, in terms of: trip generation, mode use and travel coupling.

3.9.1 Trip generation

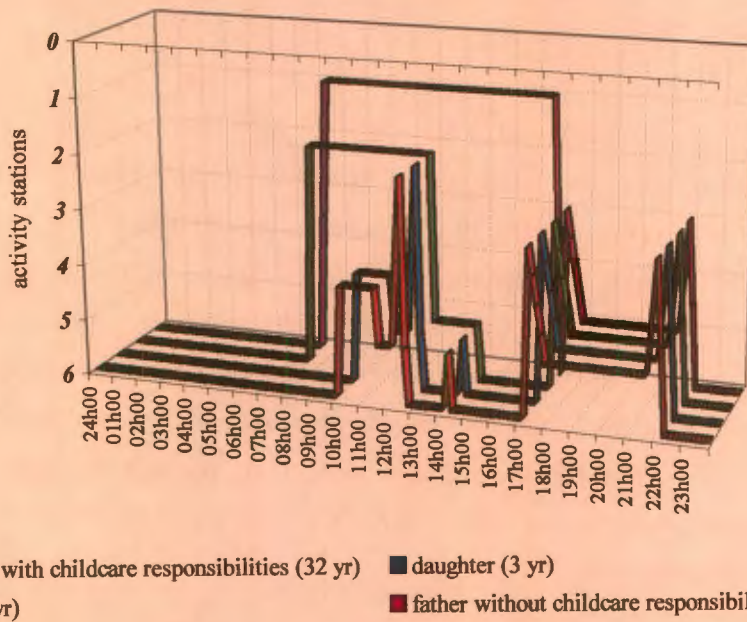
With regard to trip generation, disaggregated analysis of the survey data suggests that personal circumstances lead to considerable variation in travel behaviour. Table 3.15 indicates personal trip generation across the three income bands. The table suggests that amongst higher income households, where independent child mobility is comparatively low, adult females with childcare responsibilities generate the greatest number of daily trips and are likely therefore to have the busiest activity schedules (see for instance the case presented in figure 3.72). A quite different pattern however is indicated amongst middle and low-income households where independent child mobility is higher and adult-child travel coupling is therefore lower. The survey data suggest that informally employed and unemployed adults within these income bands generate the greatest number of daily trips (see for instance the case presented in figure 3.73).

Table 3.15 *Mean daily trips per person type by income band (n = 678 p)*

	HIGH-INCOME	MIDDLE-INCOME	LOW-INCOME
pre-school children (0-5 years)	3.36	1.25	1.00
junior school children (6-12 years)	2.21	2.64	2.29
senior school children (13-18 years)	2.67	2.40	2.11
tertiary education students	4.33	2.80	2.00
formally employed females with childcare responsibilities	5.00	2.75	2.64
formally employed females without childcare responsibilities	4.28	2.73	2.14
informally employed females with childcare responsibilities	2.00	2.50	na
informally employed females without childcare responsibilities	3.00	1.00	na
houseworking mothers/females	3.41	1.39	1.55
formally employed males with childcare responsibilities	1.50	2.75	3.00
formally employed males without childcare responsibilities	3.84	3.17	2.38
informally employed males with childcare responsibilities	na	0.00	na
informally employed males without childcare responsibilities	0.50	3.50	na
houseworking fathers/males	na	2.33	2.25
retired adults	2.59	1.30	1.17
unemployed (economically active ≥15 years) females (not houseworking)	3.00	2.67	2.33
unemployed (economically active ≥15 years) males (not houseworking)	na	na	5.00
all persons (weekday)	3.44	2.37	1.97

Figure 3.72 presents a household time-space path case study, from the database, which illustrates the impact of childcare responsibilities on the personal trip generation of the 34-year old mother in a high-income household living in Welgelegen. In this instance the mother's childcare responsibilities require that she is accompanied at all times by her 3-year old daughter, and that she fetches and delivers her 5-year old son from and to various education and social activities. She undertakes a total 10 trips throughout the diary period (compared to the mean personal trip rate of 3.44 trips/weekday for the high-income band, and the 2.74 trips/weekday for the sample as a whole).

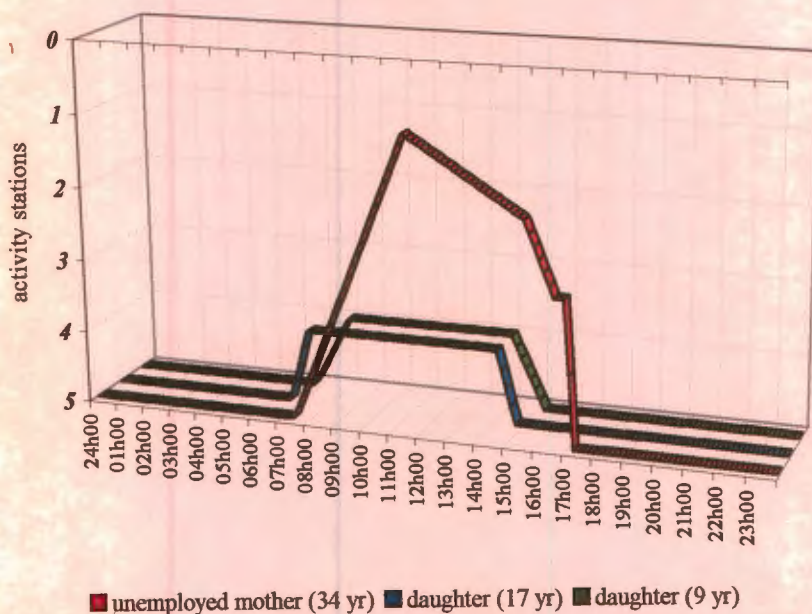
Figure 3.72 *Case study household time-space path illustrating the impact of childcare responsibilities on coupling and trip generation*



Note: The time-space paths represented are constructed from the diaries kept by a 4 person high-income household living in Welgelegen, on a Wednesday. The household has access to two motor cars, and is composed of an employed father (35 years), a houseworking mother with childcare responsibilities, a son (5 years), and a daughter (3 years). The father commutes to and from work at the beginning and end of normal working hours by car, stopping on his way to work to drop his son off at pre-school, and in the evening accompanies the family on a social activity. The mother is accompanied by the 3 year old daughter throughout the diary period. She goes shopping in the mid-morning, collects her son from pre-school at 12h00 and drops him off at a friend's house, returns home, collects the son at 14h10, returns home, and then departs with the entire household for an out-of-home social activity at 17h00 (collecting an additional person on the way). She travels throughout the diary period by car. The household returns home shortly after 22h00. [Activity stations: 6= home, 5= social activity, 4= shopping activity, 3= serve passenger, 2= education activity, 1= work; Database R/ID= 1800-1830]

Figure 3.73 presents a household time-space path case study, from the database, which illustrates the impact of job-seeking on the personal trip generation of the 34-year old single mother in a low-income household living in Mfuleni. In this instance the mother spends her day travelling from employment centre to employment centre looking for work. She undertakes 4 trips during the diary period (compared to the mean personal trip rate of 1.97 trips/weekday for the low-income band), and spends a total of 9 hours 5 minutes travelling (of which 5 hours 41 minutes are on foot). About 38% of her 24 hour day time-use budget is therefore taken up by travel activities – compared to 5% for the sample as a whole.

Figure 3.73 Case study household time-space path illustrating the impact of job-seeking on personal trip generation



Note: The time-space paths represented are constructed from the diaries kept by a 3 person low-income household living in Mfuleni. The household does not have access to a motor car, and is composed of a single unemployed mother (34 years) and her two school-going daughter aged 17 and 9 years. The older daughter walks to and from school, and the younger daughter travels (unaccompanied) to and from school by foot and bus. The mother spends her day looking for work. She travels to three employment centres in her search for employment. She travels to the first by mini-bus-taxi (as the main mode), to the second on foot (walking for 4 hours 20 minutes), and to the third by mini-bus-taxi (as the main mode). She walks home at the end of the working day. [Activity stations: 5= home, 4= education activity, 3= third employment centre, 2= second employment centre, 1= first employment centre; Database R/ID= 860-874]

3.9.2 Mode use

Tables 3.16 to 3.18 indicate main mode use by person type for all trips (excluding all person type categories for which the database presented fewer than five persons in the respective household income band samples). The tables indicate a general pattern of increased reliance on car passenger modes amongst higher income children, retirees and adult females, and of increased reliance on non-motorised transportation amongst lower income children and non-working adults generally.

Table 3.16 Percentage main mode use by person type: high-income band ($n = 169$ p)

	WALK	TAXI	BUS	TRAIN	CAR D.	CAR P.	OTHER
pre-school children (0-5 years)	0	0	0	0	0	97	3
junior school children (6-12 years)	10	0	0	0	13	77	0
senior school children (13-18 years)	9	0	3	0	3	84	0
tertiary education students	35	15	0	0	42	8	0
employed females	2	1	1	0	69	26	0
houseworking mothers/females	7	0	0	0	66	28	0
employed males	12	2	0	2	73	10	1
retired adults	7	0	0	0	59	34	0

Table 3.17 *Percentage main mode use by person type: middle-income band (n = 304 p)*

	WALK	TAXI	BUS	TRAIN	CAR D.	CAR P.	OTHER
pre-school children (0-5 years)	35	0	0	0	5	60	0
junior school children (6-12 years)	75	4	2	0	0	19	0
senior school children (13-18 years)	60	14	0	2	0	24	0
tertiary education students	32	7	7	7	11	36	0
employed females (childcare)	36	9	14	14	0	27	0
employed females	21	8	12	4	20	37	0
houseworking mothers/females	60	2	8	2	0	28	0
employed males (childcare)	18	9	14	0	45	14	0
employed males	23	10	4	6	42	14	0
houseworking fathers/males	71	14	0	0	0	7	7
retired adults	60	6	9	6	20	0	0

Table 3.18 *Percentage main mode use by person type: low-income band (n = 205 p)*

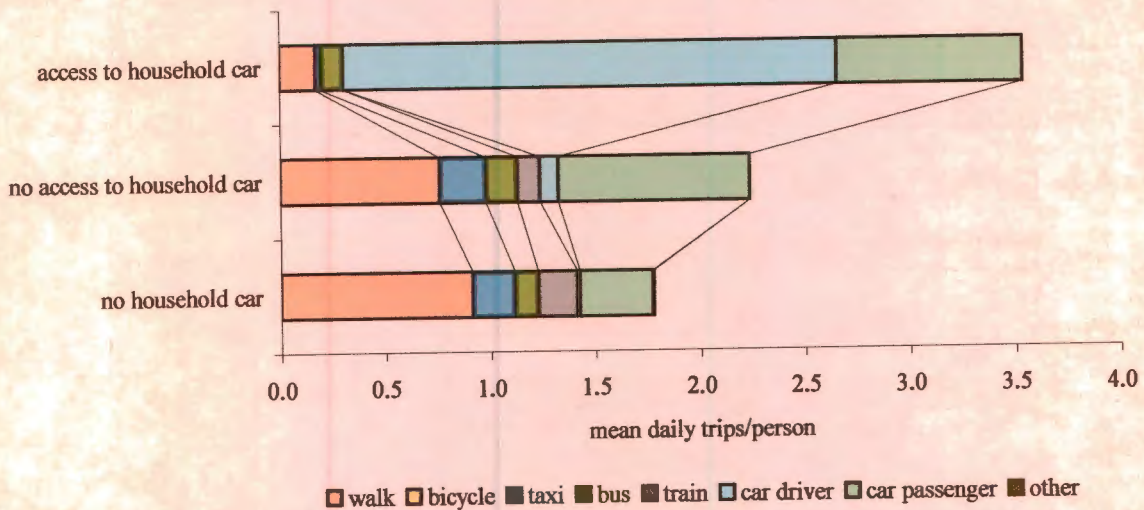
	WALK	TAXI	BUS	TRAIN	CAR D.	CAR P.	OTHER
pre-school children (0-5 years)	88	13	0	0	0	0	0
junior school children (6-12 years)	69	4	25	2	0	0	0
senior school children (13-18 years)	68	15	0	13	0	5	0
employed females (childcare)	45	7	14	7	0	28	0
employed females	38	23	0	26	0	11	2
houseworking mothers/females	68	15	0	8	0	10	0
employed males	42	10	3	31	3	0	11
retired adults	76	0	0	0	5	19	0
unemployed females	80	6	0	14	0	0	0

Figure 3.74 indicates that across all income bands male access to motor cars is consistently higher than that of females, and particularly so in the middle-income band where households with vehicle availability tend to have access to only one car (see figure 3.63). This finding supports the argument that male household members very often take preference over females in the allocation of limited household car resources. Figure 3.75 indicates that this skewed pattern of car access is reflected in trip generation and main mode use amongst adult females. Adult females without access to the household car(s) appear to generate considerably less trips than those with access. Their trip generation is in fact closer to adult females in households without any car availability – suggesting the existence of what has sometimes been referred to as a ‘green widow’ effect in outlying areas, whereby female household members without access to private or adequate public mobility are stranded in their suburban homes.

Figure 3.74 *Gender access to motor cars by sampling area (n = 678 p)*



Figure 3.75 *Adult female trip generation and main mode use by motor car access (n = 261 p)*



3.9.3 Travel coupling

As mentioned earlier, the survey found an inverse relationship between increasing household income and decreasing independent child mobility. Figures 3.76 to 3.78 illustrate travel coupling findings amongst children aged 0-5, 6-12 and 13-18 years. Figure 3.76 indicates that children 0-5 years old, across all income bands, seldom if ever travel alone – high-income 0-5 year olds however appear more likely to be accompanied by an adult household member than by other household children or non-household adults. Figure 3.77 indicates that amongst 6-12 year olds independent travel, or travel with other children, increases significantly amongst middle and low-income households. Figure 3.78 indicates that high-income 13-18 year olds continue to be accompanied by an adult household or non-household member on most trips they make. Given the available data on scholar mode use from past surveys in Cape Town (see section 2.4.6), and assuming a strong correlation between racial and income stratification, it is likely therefore that higher income households have followed a pattern of declining independent child mobility over past decades similar to that reported in parts of the developed world (Hillman *et al* 1990).

Figure 3.76 *Trip coupling amongst 0-5 year old children by sampling area (n = 43 p)*

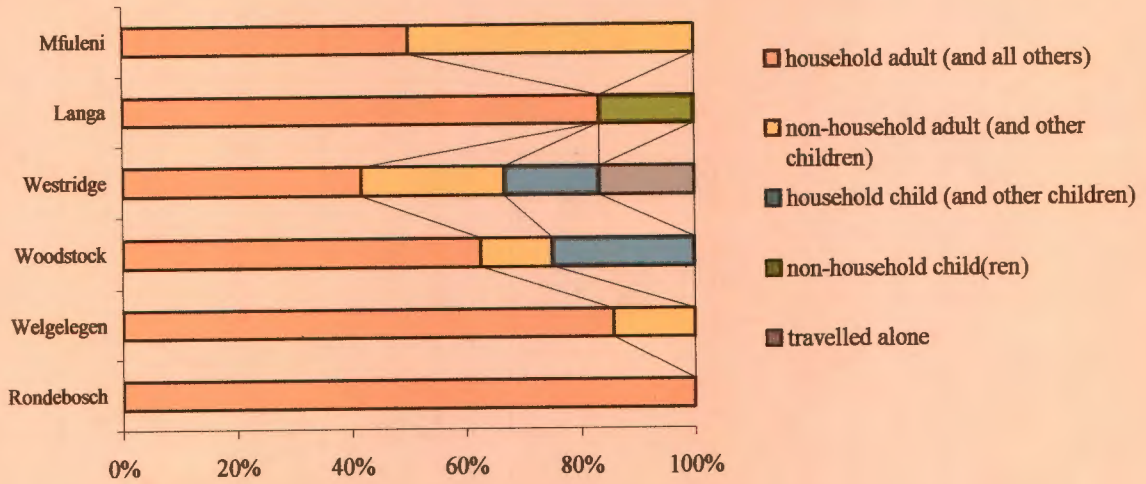


Figure 3.77 *Trip coupling amongst 6-12 year old children by sampling area (n = 85 p)*

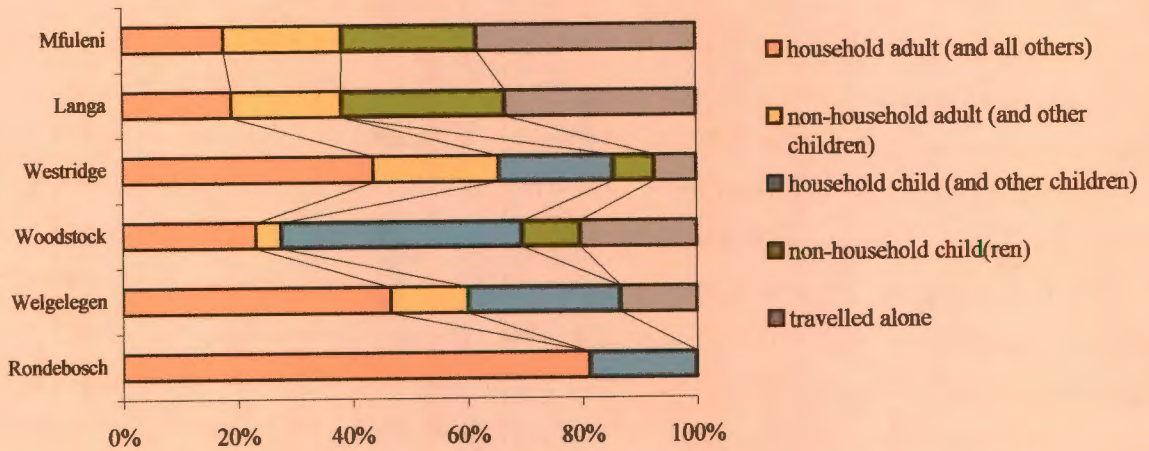
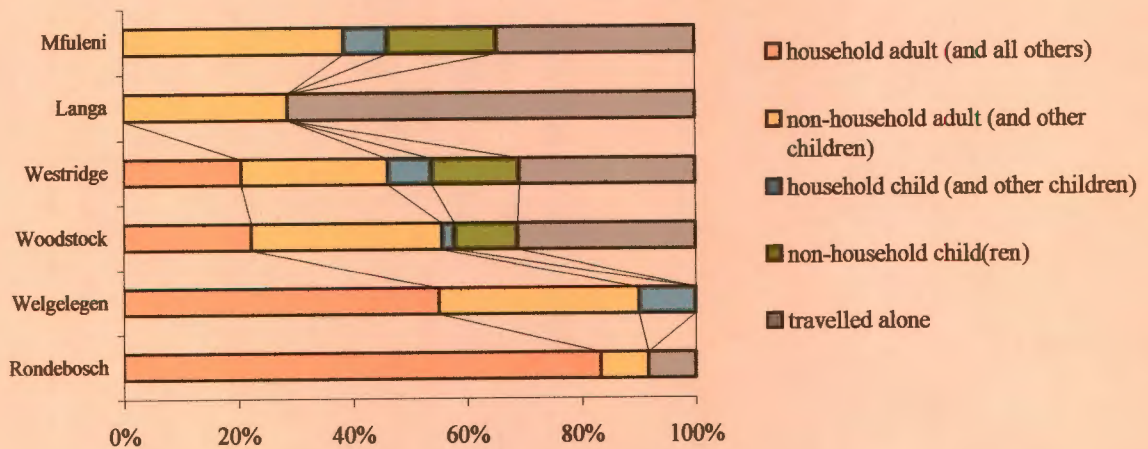


Figure 3.78 *Trip coupling amongst 13-18 year old children by sampling area (n = 66 p)*



3.9.4 Travel distance

Figure 3.79 estimates mean (main mode) trip distance to discretionary trip destinations (i.e. shopping, recreation and social activities) by person type and household income band. The figure indicates, as would be expected given their lower private mobility, that persons from lower income households have consistently smaller notional discretionary trip ranges than persons from higher income bands. Disregarding 0-5 year children on the grounds they are seldom independently mobile, the data suggest that adult females have the largest discretionary trip ranges, while 6-12 year old children and the elderly appear to have the smallest. Conversely, figure 3.80 indicates that persons from lower income households have consistently larger notional mean (main mode) walking trip ranges than persons from higher income households. Again adult females appear to have the largest geographical range, with walking ranges declining as persons get younger or older. Not only does the extent of ‘local areas’ vary according to income, it therefore also varies quite considerably according to person type.

Figure 3.79 *Mean imputed (main mode) trip distances (metres) to discretionary destinations by person type and household income (n = 678 h)*

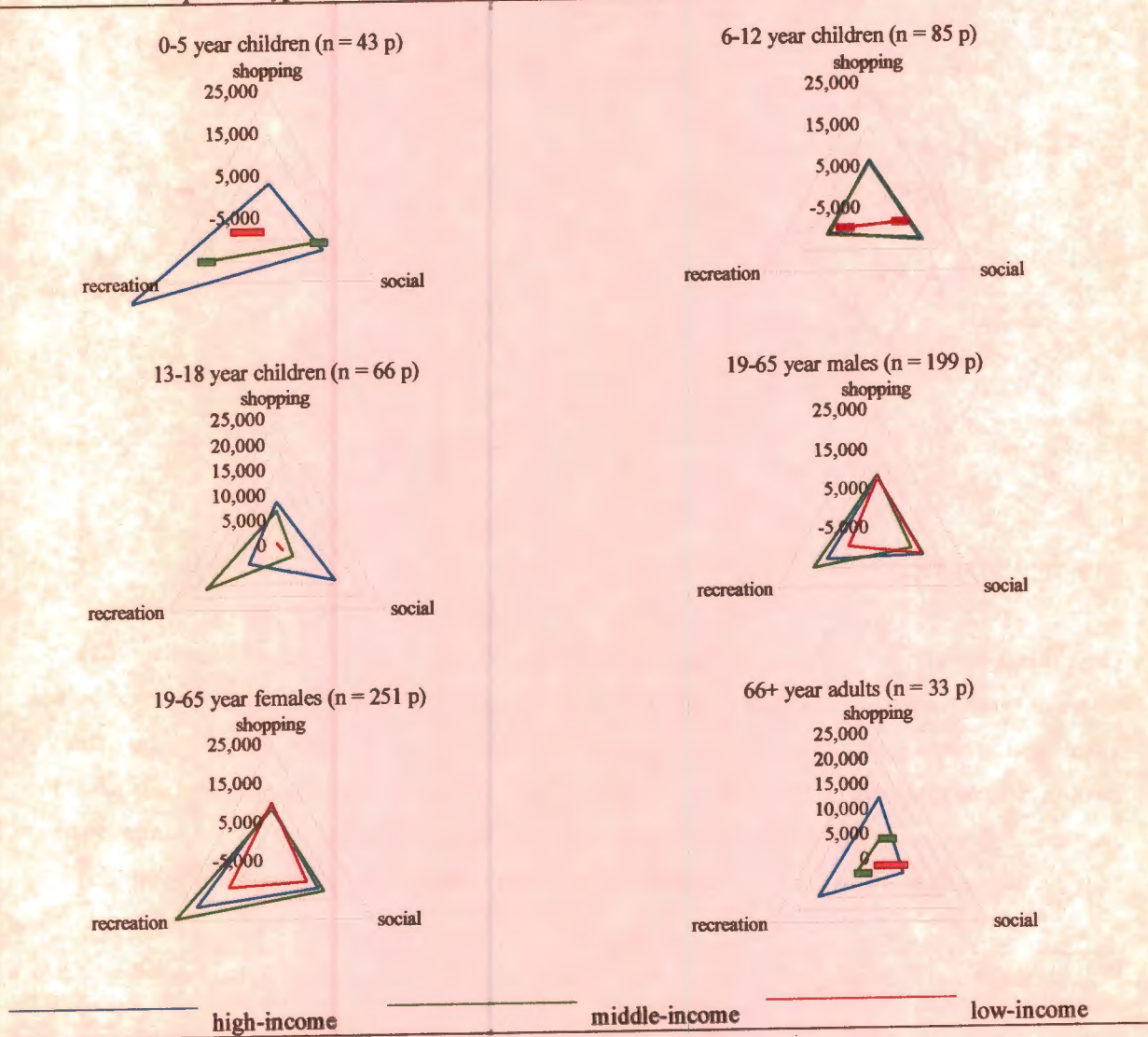
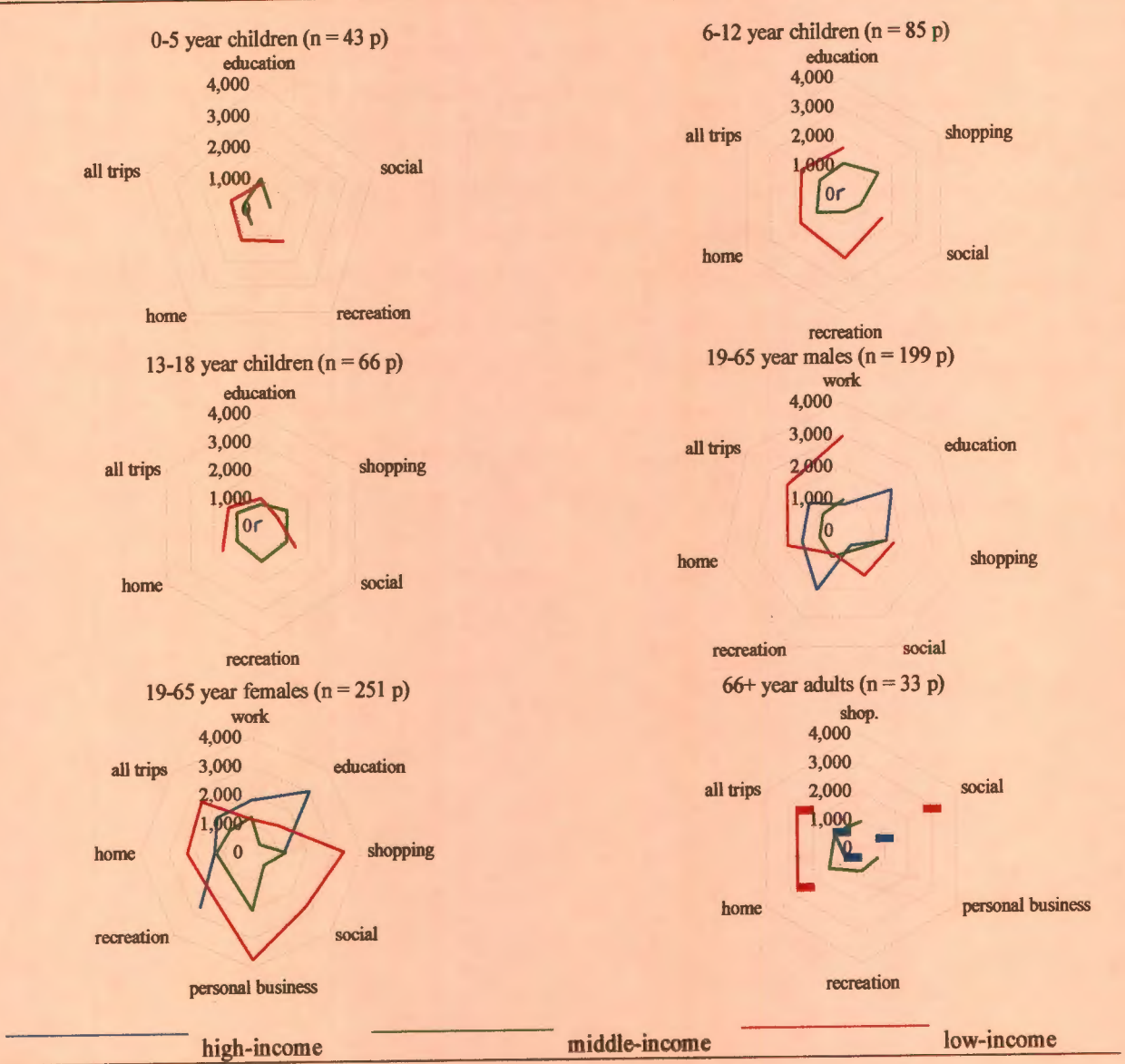


Figure 3.80 Mean imputed (main mode) walking trip distance (metres) by person type, household income and destination activity purpose (n = 678)



3.10 SUMMARY AND CONCLUSION

The general objective of the primary research reported upon in this chapter was to demonstrate the nature of travel need and behaviour in its fuller diversity and complexity – and the importance of local travel need in particular – through empirical observation in metropolitan Cape Town as a case study of a South African city; and in doing this to begin to fill some of the gaps in understanding identified in chapter 2.⁶⁷ Empirical observation took the form of a previous day recall household interview using an activity diary survey instrument. An activity-based method was selected on the grounds that this

⁶⁷ Not all the information gaps identified in chapter 2 could be explored however. In particular, it proved difficult to obtain data on informal work-related travel in a study of this nature, and the sample contained too few disabled passengers to draw findings. It also proved difficult, due to cognitive problems in collection and coding, to collect quality data on trip chaining and mode transfer (particularly amongst lower income households). The experience of this research suggests that to explore these dimensions of travel behaviour in detail, more targeted surveys would be required.

analytical framework has been shown to lead to more accurate recall of local and non-motorised travel, and is best able to understand travel behaviour within the constraints of households' daily lives – within what Torsten Hägerstrand (1970) called the 'twilight zone between biography and aggregate statistics'.

On the basis of the gaps in current knowledge identified in the review of secondary data sources in chapter 2, a number of research questions were identified relating to the extent of all travel, and the influence of income, neighbourhood form and location, life-cycle stage and personal circumstances on travel behaviour. An additional objective was to test activity-based methods of data collection and analysis in the South African context. Bearing in mind the relatively low confidence interval of the sample, these research questions and testing objective are addressed summarily in turn.

With regard to the nature and extent of all travel, the primary research found, amongst other things, that:

- travel patterns can vary quite considerably across the days of the week;
- home-based work trips account for around just 20% of all weekday trips;
- together the conventional 06h00-09h00 and 16h00-19h00 peak periods account for about 46% of weekday travel;
- the motor car is used as the main travel mode for about 48% of all trip purposes, and given a very similar proportion of households have access to motor cars (49%), car dependency amongst these households is therefore considerable; and
- walking accounts for around 36% of all trip purpose main mode use, and therefore despite considerable car dependence, remains an important mode of transportation.

With regard to the influence of household income on travel patterns, the primary research found, amongst other things, that:

- household and personal trip generation decline with income;
- trip purpose distributions vary, with poorer households undertaking fewer shopping trips but more social and personal business trips;
- wealthier households drive significantly more and walk significantly less than poorer households, with in the region of 61% of trips amongst low-income households undertaken on foot as the main travel mode; and
- while travelling for longer periods of time, poorer households have narrower discretionary trip ranges, but given their tendency to walk more and for longer, have considerably wider walking trip ranges (and therefore 'local areas' as defined in this dissertation).

With regard to the influence of neighbourhood location and form on travel patterns, the primary research found, amongst other things, that:

- peripherally located households compensate for poorer accessibility by generating fewer multi-purpose trips and linking trips into chains;
- as a result of longer trip lengths, peripherally located commuters leave home earlier and return home later than centrally located commuters;
- a lack of adequate public or non-motorised mode alternatives would appear to lead to higher car ownership and use amongst peripherally located households within the same income bands;
- centrally located households living in pedestrian-friendly neighbourhoods walk considerably more; and
- greater walking opportunities in more central and pedestrian-friendly locations enable lower income households or persons to effectively compensate to some extent for low private mobility.

With regard to the influence of household life-cycle stage on travel patterns, the primary research found, amongst other things, that:

- households with children, and particularly younger children, generate more trips than those without;
- the presence of children increases the number of education, recreation and serve passenger trips undertaken by the household, and significantly intensifies and constrains the daily activity schedules of adults with childcare responsibilities; and
- older adult households without children generate the fewest trips.

With regard to the influence of personal circumstances on travel patterns, the primary research found, amongst other things, that:

- amongst higher income households, domestic logistics and childcare responsibilities amongst adult females lead to highest rates of personal trip generation and widest discretionary trip ranges;
- income generation responsibilities and job-seeking amongst adults lead to highest rates of personal trip generation amongst lower income households;
- mode use varies considerably across person types;
- access to household cars is skewed towards adult males;
- adult females without access to household cars display similar trip generation rates to adult females in households without car access;
- independent child mobility varies across age groups and household incomes, and is lowest amongst younger children in wealthier households; and
- walking trip ranges are highest amongst adults from lower income households, and the width of ranges decline as individuals get older and younger.

With regard to the methodological lessons learned from the application of an activity-based method in the South African context, in the process of data collection and analysis it was found, amongst other things, that:⁶⁸

- the skills, professionalism and racial category of interviewers are probably the most important factors in determining the successful administration of surveys (with the complexity of activity diary methods) in South Africa, and the best laid survey plans can be undone if not executed properly;
- leave-behind self-completion activity diary tables are too elaborate for respondents generally – amongst respondents with lower education levels because tables are difficult to read and complete, and amongst respondents with higher education levels because completion instructions are seldom read;
- the use of CAPI technology can avoid problems associated with diary table completion, and can lead to lower refusal and substitution rates;
- most respondents are reluctant or unwilling to keep a diary for more than a 24 hour period (but as the previous 24 hour day is probably the longest possible period for accurate recall, the use of recall interviews necessitates this diary period anyway);
- activity diary survey instruments can result in considerably greater trip recall than trip diary instruments – by between 18% and 35% in the South African context; and
- activity-based methods provide valuable and detailed insights into travel needs and behaviour not possible in other survey methods, but their data intensity and attendant difficulties in application increase survey costs significantly – even though economies of scale in larger samples would probably bring the sampling unit costs quoted in this chapter down.

Regarding the last point, solutions to the problem of increased survey cost, in my view, lie in data sharing. Because the analysis of human behaviour invariably involves questions of who did what, when, where and for how long, activity participation and time-use data are relevant across numerous arenas of policy research. These include measuring formal and informal economic activity, paid and unpaid labour, social change, quality of life, service consumption and many other policy concerns (Harvey and Pentland 1999), as well as passenger transportation (van der Reis 1985). Thus possibilities exist for the cost of collecting activity participation and time-use data to be shared by numerous commissioning agencies.

The general conclusion of the chapter is therefore that travel needs indeed diverge widely on the basis of a variety of financial, geographical, societal and demographic factors, and understanding the relative impact of these is indeed a complex task. Income is undoubtedly though the primary determinant of private mobility, and as such, is probably the most significant variable in determining patterns of travel behaviour in South African cities. The presence of children in the household also has

⁶⁸ See Behrens (2001) for a detailed account of the methodological lessons learned from the research experience.

a significant impact on travel activities. It is erroneous however to assume that personal travel constraints and choices are constant within income bands or other household classifications, as age, gender and household responsibilities effect travel behaviour as well. Neighbourhood form and location also have a significant impact on travel behaviour, and it is also erroneous therefore to assume that households located in different parts of the city with similar demographic and income characteristics necessarily have similar travel patterns.

The information gaps preventing a full understanding of this diversity and complexity are large. Non-work and off-peak travel would appear to account for the majority of household travel activity (80% and 54% respectively), and the focus on commutes and peaks in past surveys has therefore in all likelihood distorted widely held perceptions of travel needs and patterns. In particular, as a result of being routinely excluded or underestimated in past travel surveys, the importance of walking trips – in terms of their roles in satisfying travel needs and in analysing road safety problems – has not been fully understood. Main mode walking trips would appear to be particularly important in satisfying the travel needs of middle- and low-income households (accounting for 43% and 61% of all trip main mode use respectively). At best this exclusion or underestimation has introduced a routine bias in the way in which the urban transportation problem has been framed and has skewed transport planning resources away from local network issues, and at worst has led to neglect in the planning and design of infrastructure improvement for the poor and vulnerable road users. In the absence of data, the tendency has been to assume that South African cities are similar to those in the developed world around which published data are more readily available, and from which many analytical and planning practices were imported. The findings of this study, regarding for instance the asymmetry of morning and afternoon peak periods and forward and return trips, suggest this is problematic. Of particular relevance to the focus of the dissertation, the data presented in this chapter indicate that the earlier (and later) mentioned assumptions regarding the inevitability of universal car access and use, walking distances, and the introverted or localised nature of walking trips that underlie imported local network configuration ideas, are refutable.

Chapter 4

The configuration and management of local networks

4.1 INTRODUCTION

This chapter now shifts the focus of the dissertation away from travel need, to the second arena of practice investigated in this study: local network configuration and management. While the findings of chapter 3 with regard to travel need in its fuller diversity and complexity have implications for numerous transport planning matters, the focus of the dissertation necessitates that chapters 4 and 5 concentrate on local network configuration and management matters in particular. The overriding implication for local networks is that, given their hitherto poorly understood importance in satisfying travel need, greater resources need to be allocated to transport planning in local areas and for non-motorised modes.⁶⁹ This chapter addresses the question of how local networks have been configured and managed, and the extent to which practices have been developed to match actual local travel needs in South African cities (as best they have been understood). The following chapter reviews evidence of relationships between particular network planning practices and improved conditions of travel in local networks, as well as precedent for co-ordinated and proactive local network management.

The chapter starts out by reviewing how approaches to local network configuration and management have evolved internationally. It then goes on to describe South African practices, and to discuss how these have been influenced by international approaches. Local network *configuration* is defined fairly narrowly in the chapter, as the arrangement of footways, roadways, pathways and cycleways in 'greenfield' development to delimit street blocks and open spaces, and to facilitate local travel by various modes between the different land use activities they accommodate. Local network

⁶⁹ While it is difficult to accurately identify public expenditure on local network items like traffic calming, footways, roadway crossing facilities and cycleways, relative to metropolitan network items like freeways, arterials and bridges, it is fairly safe to say that far greater amounts have been spent on the latter. In Cape Town for instance combined expenditure on 'minor works projects', 'bicycle and pedestrian facilities' and 'TSM (and safety) projects' out of the *Cape Town Consolidated Metropolitan Transport Fund* averaged just 8% of total expenditure between 1986/87 and 1994/95 (Behrens and Wilkinson 2001). This excludes expenditure by local municipalities on their own projects however, and does not therefore provide an accurate reflection of total relative public expenditure. While some local area transport plans have been produced, statutory requirements – stemming from the *Urban Transport Act* (78 of 1977) and the *National Land Transport Transition Act* (22 of 2000) – have been for metropolitan-wide transport plans, which have therefore received greater attention. However, relative financial and human resource allocations are both difficult to quantify.

management is then defined as the addition or extension of footway, pathway and cycleway systems, the provision of additional driveway or roadway accesses, the provision of roadway crossing facilities, and the control of vehicular traffic through roadway retrofitting, subsequent to greenfield construction. In terms of the restricted focus of this dissertation, pavement construction, geometric design, urban traffic control and traffic regulation, fall outside the scope of these definitions.

The chapter is divided into five sections, including this introduction and a concluding summation. Section 4.2 (the next section) reviews the evolution of approaches to local network configuration and management internationally, in terms of a number of broad periods, from the emergence of the town planning profession at the beginning of the 20th century to the present day. The contexts within which different network configuration and management ideas emerged are discussed, as well as the factors that initiated changes in practice. While this is a task that has been undertaken in detail elsewhere, although with different emphases and for different purposes (see for instance Hall and Ward 1998, Hass-Klau 1990 and Southworth and Ben-Joseph 1997), this progression of ideas is presented here at some length to provide a foundation from which the origins of South African practices can be identified and the contextual differences between South Africa and the countries of origin can be understood. Section 4.3 then identifies South African network configuration practices and their origins, and section 4.4 identifies South African network management practices and their origins. Both network configuration and network management practices in South Africa are discussed through a review of evolving design codes.

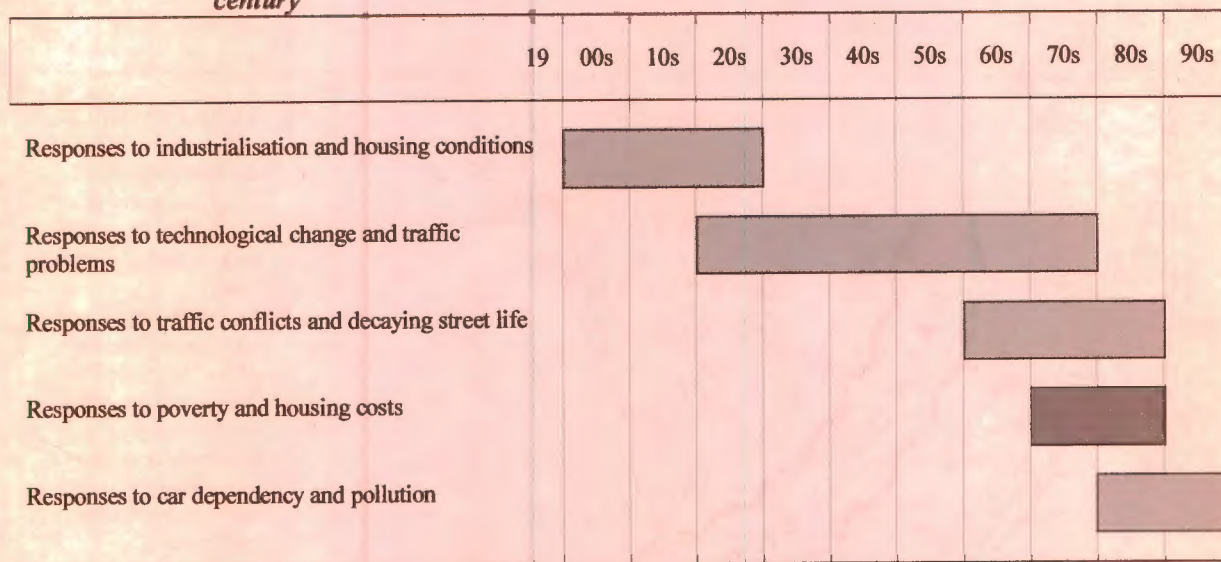
4.2 EVOLUTION OF APPROACHES TO LOCAL NETWORK CONFIGURATION AND MANAGEMENT

A review of the international literature suggests that, on the basis of the contexts to which they responded, the emergence of local movement network configuration and management ideas can be broken into five overlapping periods (see figure 4.1). In the interests of summarising the fairly complex emergence and evolution of ideas, fairly crude generalisations have had to be made around the way the planning and design 'problem' was interpreted in each period, and the nature of the planning and design 'solution' offered. The policy environment, academic critiques, generic problem definition, generic solution, ideas and underlying assumptions of each of the following periods are discussed in turn.⁷⁰

⁷⁰ It should be noted that while the definition of a local movement network provided in this dissertation recognises the multi-modal nature of local movement systems and therefore makes an explicit distinction between pathway, footway, roadway and cycleway systems, many of the configuration and management ideas mentioned in this chapter were developed primarily around a network or layout of roads. It should also be noted that many of the ideas discussed in the chapter are embedded in broader town planning concepts, and are therefore related to residential densities, land economics, land use distribution patterns, and public facility and amenity locations, etc. as well as to local network configuration and management.

- ideas that emerged during the 1900s to 1920s in response to rapid industrialisation and urbanisation in the United Kingdom and United States, and associated poor housing conditions;
- ideas that emerged during the 1920s to 1970s in response to changes in transportation technology and motor car use in the developed world, and associated traffic problems;
- ideas that emerged during the 1960s to 1980s in response to growing traffic conflicts in western Europe, and associated barriers to the use of streets for pedestrian-based activities;
- ideas that emerged during the 1970s and 1980s in response to poverty and housing costs in the developing world; and
- ideas that emerged during the 1980s and 1990s in response to increasing motor car dependency and ownership internationally, and associated global environmental pollution.

Figure 4.1 *Periodisation of the emergence of movement network design ideas during the 20th century*



4.2.1 1900s-1920s: Responses to industrialisation and housing conditions

The first period of local movement network planning emerged in response to two fundamental changes in the nature of urban settlements at the turn of the previous century. The first was the increasing industrialisation and urbanisation of British and American economies and cities, and the location of worker housing close to polluting industrial activities. The second was the appearance of the first motor vehicles as an additional mode of urban transport, and the manufacture of motor vehicles for popular ownership.⁷¹

The planning and design ‘problem’ was therefore essentially seen to be:

- the need to address the overcrowded and unsanitary inner city housing conditions of the newly industrialised and urbanised labour force,

⁷¹ The production of the first Model T Fords for instance, began in 1907. (Southworth and Ben-Joseph 1997)

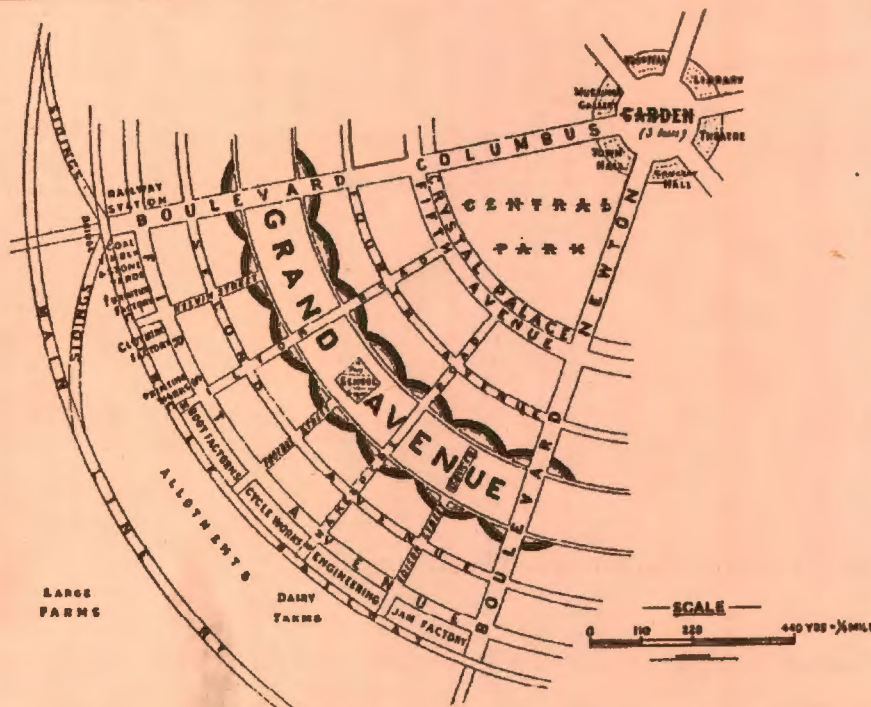
- the need to prevent traditional community lifestyles and values from being eroded by the perceived socially alienating nature of large cities, and
- the need to accommodate the motor car as a means of popular travel.

The 'solution' that emerged at this time thus centred on:

- the creation on spatially identifiable 'communities' or 'neighbourhoods',
- the physical separation of residential from industrial and commercial land uses, and
- the creation of 'sub-urban' housing conditions in which the convenience of urban living was combined with the tranquillity of rural living.

Two key ideas emerged during this period – the 'garden city', and the 'neighbourhood unit'.

Figure 4.2 *The 'garden city' idea*



NETWORK FEATURES:

- the configuration of roads in a radial pattern, converging on a central park, to create a town 'centre'
- the use of curved roads, open courts, and *culs-de-sac* to create interest and discourage fast cars
- the provision of numerous possible through connections to facilitate pedestrian movement
- the reduction of the width of 'internal' roads to discourage through-traffic

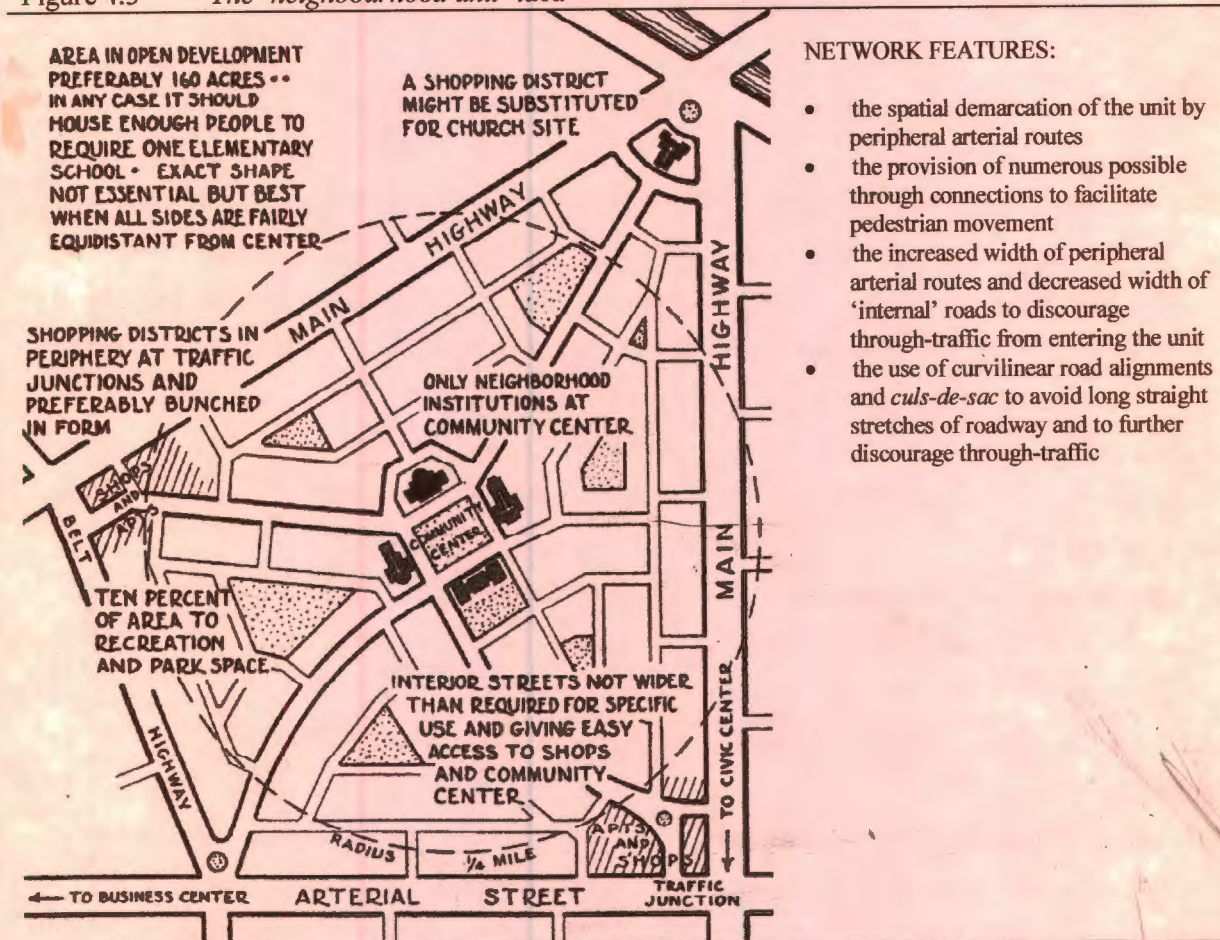
Source: Howard 1902:53

4.2.1.1 Garden city

The garden city movement emerged in the United Kingdom at the turn of the previous century, motivated largely by the seminal writings of the social reformer Ebenezer Howard (1898, 1902). Howard's initial publication *Tomorrow! A peaceful path to real reform* was republished a few years later as the more widely distributed *Garden cities of tomorrow*, with its underlying socialist message toned down. Raymond Unwin and Barry Parker were the first architect-planners to apply Howard's 'garden city' idea in practice (in Letchworth and Welwyn north of London). Howard's garden city idea involved a system of self-contained 'slumless and smokeless' satellite towns, of approximately 32 000

people and covering about 3 650 hectares, surrounded by green open spaces. The satellite towns were characterised by detached dwellings, large erven, and a separation of land uses. The road networks of the early garden city developments tended to be configured in a radial pattern – converging on a central park (and in some instances a railway station as well) surrounded by public buildings. While curved roads, open courts, and *culs-de-sac* were incorporated within the networks in order to create interest and prevent cars from moving too fast, the prevention of through-traffic was not a priority, and the networks offered vehicles and pedestrians numerous possible through connections. Through-traffic was discouraged by reducing the width of ‘internal’ roads. (Hall and Ward 1998, Ward 1992)

Figure 4.3 The ‘neighbourhood unit’ idea



Source: Perry 1939: 75

4.2.1.2 Neighbourhood unit

The ‘neighbourhood unit’ idea was developed by Clarence Perry (1929) in the United States of America in the 1920's, and was fairly heavily influenced by the British Garden City Association. Perry's ‘neighbourhood unit’ idea involved the use of arterial routes to demarcate a neighbourhood periphery, and the location of public facilities and open spaces (typically in the form of the buildings and sportsfields of a primary school) at the geographical centre of the unit within easy walking distance of houses within the unit's boundary. The ideal size of the unit was considered to be approximately 5 000-10 000 people (covering an area of about 65 ha) – based on the population

required to support a primary school. The spatial configuration of the unit sought to recreate the neighbourliness and community cohesiveness of a small rural town, and like the garden city idea, was characterised by low residential densities and large expanses of open space. The road networks of the early neighbourhood units were designed to protect the neighbourhood from heavy traffic (and in particular to minimise conflicts between local school children and vehicular traffic), by discouraging through-traffic from entering the unit. Through-traffic was discouraged by increasing the width of the peripheral arterial routes, decreasing the width of 'internal' roads, and avoiding long straight stretches of roadway through the use of curvilinear road alignments and *culs-de-sac*. The road network still however offered vehicles and pedestrians numerous possible through-connections. (Dahir 1947, Homburger *et al* 1989, Southworth and Ben-Joseph 1997)

4.2.1.3 Assumptions

The ideas that emerged during this period made the following basic assumptions:

- that the 'garden suburb' or 'neighbourhood unit' in question could satisfy at least the daily needs of local residents (e.g. schooling and perishable grocery shopping needs), and in doing so, the need for short non-work trips into surrounding areas would be obviated;
- in relation to the above, that the needs of a local neighbourhood community would remain fairly constant over time – particularly with regard to the demand for, and supply of, schools in the local area; and
- that the sharing of local facilities and amenities, and regular face-to-face contact, would foster common feelings of 'belonging' and 'neighbourliness' amongst local residents.

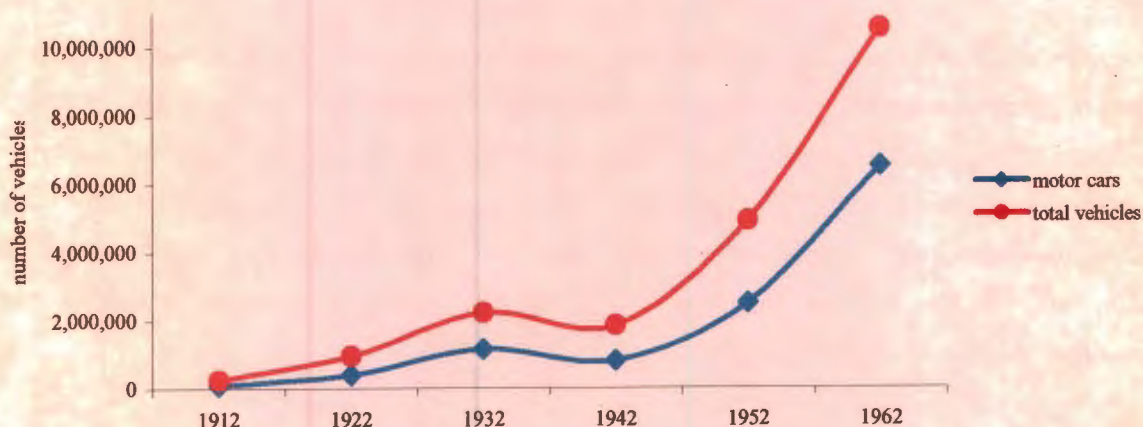
4.2.2 1920s-1970s: Responses to technological change and traffic problems

The second period of local network planning emerged in response to the rapid increases in motor car use that occurred during the 1920s to 1940s in the developed world, and the almost exponential growth in private car ownership that occurred during the post-war economic boom period of the 1950s (see figure 4.4). During this period, research began challenging the above-mentioned assumptions of 'community building' through spatial planning, and it was questioned whether spatial layout principles had a major effect on resident behaviour and social interaction. It was argued that as a result of increased car ownership and personal mobility, the geographical boundaries of 'neighbourhoods' had become blurred – that the 'neighbourhood' was becoming less a physical community than a community of interests (Gans 1967, Homburger *et al* 1989, Webber 1964). The 'open' road networks⁷² of the earlier garden city and neighbourhood units ideas were also criticised on the basis that

⁷² An 'open' road network is conventionally defined as a network of roads that intersect freely with one another, and thus offers a choice of numerous alternative equidistant routes between any two points. 'Closed' road networks (to be discussed later), conversely, adhere to principles of hierarchical access management, and establish clearly defined routes between any two points within the network offering few or no equidistant alternatives.

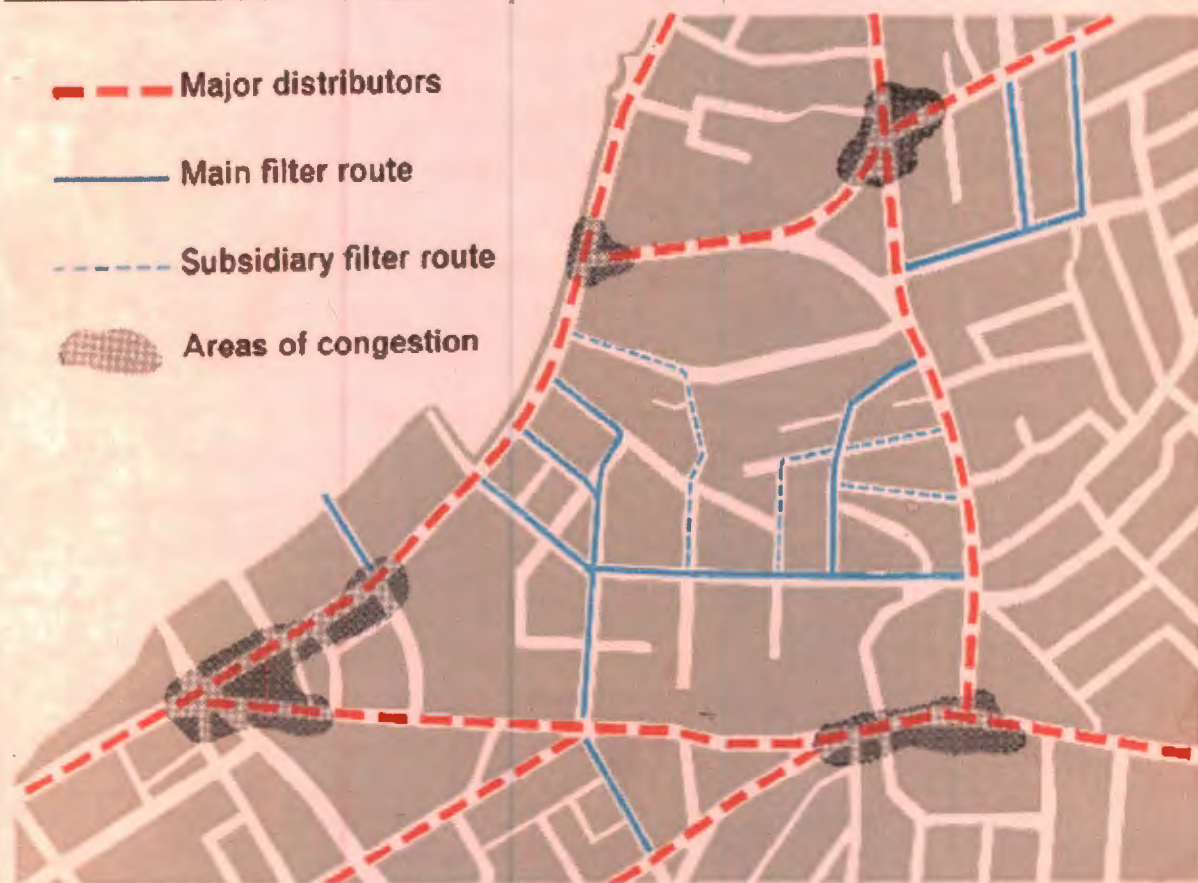
peripheral arterials only discouraged through-traffic until they became congested, and that, once congested, 'internal' roads were used by through-traffic (see figure 4.5). Rapid increases in private motor car usage and the configuration of older 'open' road networks, were seen to be resulting in increased traffic congestion and decreased pedestrian safety.

Figure 4.4 *Growth of vehicles in Great Britain: 1912-1962*



Source: HMSO 1963:11

Figure 4.5 *Example of car drivers seeking alternative routes through residential areas to avoid congested arterials*



Source: HMSO 1963:19

The 'problem' was therefore seen to be less the creation of 'neighbourliness', and more:

- the safe accommodation of increasing levels of private motor car use,
- the efficient accommodation of increasing levels of car use (i.e. the avoidance of traffic congestion), and
- the cost-effective provision of infrastructure to accommodate increasing car use.

As a result of the increasing concern for the accommodation of motorised traffic, transport engineering was established as a specialist discipline in 1930 with the formation of the Institute of Transportation Engineers (ITE) in the United States and the creation of a specialised programme at Yale University (Southworth and Ben-Joseph 1997). The focus of the emerging engineering discipline was "the study and improvement of the traffic performance of road networks and terminals, [and i]ts purpose [was] to achieve efficient, free, and rapid flow of traffic; yet, at the same time, to prevent traffic accidents and casualties" (Matson *et al* 1955:3).

The 1930s onwards saw the establishment (mainly in the United States and the United Kingdom) of numerous other transport engineering agencies, as well as agencies concerned more generally with residential land development, and the publication of numerous so-called 'design standards' (see table 4.1). Due to the established research capacity of some of these agencies, especially the ITE, the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB) and the Transport and Road Research Laboratory (TRRL), their street design guidelines and standards, as well as their design methodologies, tended to be highly influential in other parts of the world. As will be discussed later, South Africa was no exception.

Most early ITE guides were concerned with efficient, high-speed highways, rather than residential streets. The first American residential street design guidelines were produced by the Federal Housing Administration (FHA) – an agency which provided financial assistance and mortgage insurance. The FHA's publications drew heavily from the ideas that emerged over this period, and their guidelines became a basis for qualification for mortgage insurance. Therefore, in much the same way that the four-stage travel forecasting practices became entrenched in the United States through conditions attached to federal road funding, so network configuration practices were institutionalised via mortgage insurance requirements. Later agencies representing the interests of the construction industry (the Urban Land Institute and National Association of Home Builders) produced guidelines that emphasised the need to minimise road construction costs by reducing roadway widths on residential streets. From the 1960s onwards, the first traffic engineering design standards for residential streets were produced – mainly by the ITE, AASHTO and TRB – which have continued to be revised and updated until the 1990s. (RSTF 1990, Southworth and Ben-Joseph 1997)

Table 4.1 *Chronological publication of some key American and British* residential street design standards and guidelines*

YEAR	AGENCY	TITLE
1936	FHA	<i>Planning neighbourhoods for small houses</i>
1940	FHA	<i>Street improvement standards</i>
1947 (1968)	ULI	<i>The community builders handbook</i> [§]
1950	NAHB	<i>Manual for land development</i>
1965	ITE	<i>Recommended practice for subdivision streets</i>
1965	ITE	<i>Traffic engineering handbook</i> [§]
1965	HRB	<i>Highway capacity manual</i> [§]
1966	DOT*	<i>Roads in urban areas</i>
1966	DOHLG*	<i>Cars in housing/1: Some medium density layouts</i>
1971	AASHO	<i>Geometric design guide for local roads and streets</i>
1973	AASHO	<i>A policy on design of urban highways and arterial streets</i> [§]
1974	DOE*	<i>Traffic in general improvement areas</i>
1974 (1990)	ASCE, NAHB, ULI	<i>Residential streets: Objectives, principles and design considerations</i> [§]
1976	DOE*	<i>The design of major/minor priority junctions</i>
1977 (1992)	DOE/DOT*	<i>Residential roads and footpaths: Layout considerations (design bulletin 32)</i> [§]
1984 (1990)	ITE	<i>Recommended guidelines for subdivision streets</i>
1984 (1994)	AASHTO	<i>A policy on geometric design of highways and streets (the 'green book')</i> [§]
1985 (1992)	TRB	<i>Highway capacity manual</i> [§]
1987	IHT*	<i>Roads and Traffic in Urban Areas</i>

Source: HMSO (1977), RSTF (1990), Southworth and Ben-Joseph (1995)

Note: AASHO-American Association of State Highway Officials, AASHTO-American Association of State Highway and Transportation Officials, ASCE-American Society of Civil Engineers, DOE*-Department of the Environment, DOHLG*-Department of Housing and Local Government, DOT*-Department of Transport, FHA-Federal Housing Administration, HRB-Highway Research Board, IHT*-Institution of Highways and Transportation, ITE-Institute of Transportation Engineers, NAHB-National Association of Home Builders, TRB-Transportation Research Board, ULI-Urban Land Institute

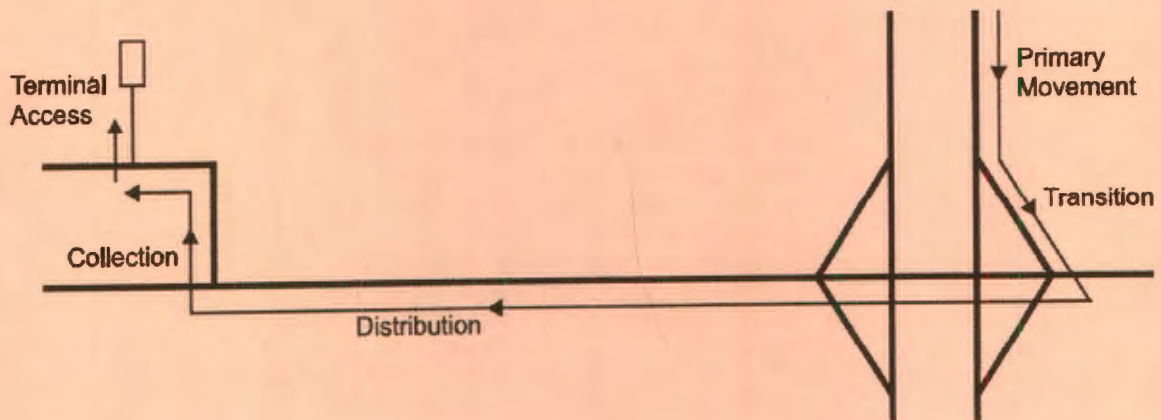
§ Street design standards and guidelines drawn upon in the preparation of movement network design guidelines in South Africa (see section 4.3)

The safety problems associated with through-traffic in residential neighbourhoods were first addressed by traffic engineers in the mid-1950's. One of the first engineering studies on street safety in residential areas – entitled *Subdividing for traffic safety* – was conducted in Los Angeles between 1951 and 1956 by Harold Marks (Southworth and Ben-Joseph 1997). Marks compared accident rates in developments with a 'gridiron' layout, with those in developments with the prevailing FHA discontinuous, curvilinear layout. His study showed that accident rates were substantially higher in 'gridiron' layouts – 77.7 vs. 10.2 accidents/year – and tee-intersections were found to be fourteen times safer than cross-intersections (see figure 5.5). Michael Southworth and Eran Ben-Joseph (1997) contend that these findings provided the basis for an argument that road networks in residential areas should be 'closed' to through-traffic, and that cross-intersections should be avoided.

The 'solution' that emerged during this period thus centred on:

- the creation of traffic distribution (or functional) road hierarchies on the basis of the stages of a motor car trip (see figure 4.6), with 'access standards' (i.e. minimum intersection spacings) associated with each hierarchical tier and frontage access prohibition associated with roads with a 'distributive' function, and
- the configuration of 'local' residential roads (in the form of *culs-de-sac* and looped streets) into networks 'closed' to through-traffic.

Figure 4.6 The stages of a vehicle trip as the basis of a 'functional road hierarchy' (comprised of 'distributors', 'collectors' and 'access roads')



"The six recognisable stages in most trips include main movement, transition, distribution, collection, access, and termination. For example, figure [4] shows a hypothetical highway trip using a freeway, where the main movement of vehicles is uninterrupted, high-speed flow. When approaching destinations from the freeway, vehicles reduce speed on freeway ramps, which act as transition roadways. The vehicles then enter moderate-speed arterials (distributor facilities) that bring them nearer to the vicinity of their destination neighbourhoods. They next enter collector roads that penetrate neighbourhoods. The vehicles finally enter local access roads that provide direct approaches to individual residences or other terminations. At their destinations the vehicles are parked at an appropriate terminal facility." AASHTO1984:1

Source: after AASHTO 1984:3

Five key ideas emerged at various times during this period – the 'Radburn superblock', 'precinct planning', the 'environmental area', 'cluster development', and the 'planned unit development'.

4.2.2.1 Radburn superblock

The 'Radburn superblock' idea was developed by Clarence Stein and Henry Wright in Fairlawn, New Jersey (United States) in 1928, as a highly innovative form of 'neighbourhood unit'. The 'superblock' idea involved the removal of all potential collisions between vehicles and pedestrians within an area of between 14 and 20 ha. This was achieved by the segregation of pedestrians and vehicles onto physically separate roadway and pathway networks. Each dwelling had access to both a roadway (in the form of a *cul-de-sac*) and a footpath, and the pathway network enabled pedestrians to gain access to 'neighbourhood' facilities and services located within the superblock, without encountering vehicular traffic. A system of overpasses and bridges ensured that, where roadways and pathways had to cross, pedestrians never had to cross the roadway at grade. The roadway network of the superblock was characterised by *culs-de-sac*, collector roads, and peripheral limited access arterial routes. The use of access control principles and the subsequent absence of through connections, prevented through-traffic from entering the superblock. (Chang-Moo and Stabin-Nesmith 2001, Hass-Klau 1990, Homburger *et al* 1989)

Figure 4.7 *The 'Radburn superbloc' idea*



NETWORK FEATURES:

- the segregation of pedestrian and vehicles onto physically two separate roadway and pathway networks to remove conflict
- the use of overpasses and bridges to ensure that pedestrians never have to cross roadways at grade
- the provision of each dwelling with access to both a roadway and a footpath
- the use of *culs-de-sac*, collector roads, and limited access arterial routes to prevent through-traffic from entering the superbloc

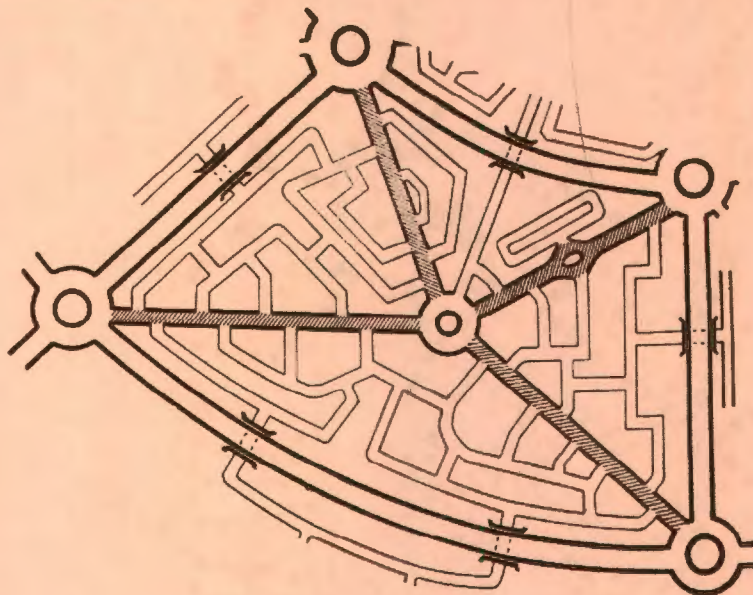
Source: Southworth and Ben-Joseph 1997:63

4.2.2.2 *Precinct planning*

The 'precinct planning' idea was developed by Alker Tripp (1938, 1942) in London, in the late 1930s. Tripp's 'precinct planning' idea involved the control of through-traffic in existing 'open' road

networks, through the introduction of strategic road closures. This was the first movement network configuration and management idea to be concerned solely with the movement of motorised vehicles – from this point on throughout this period, pedestrians were considered in new ideas only from a safety perspective. The road network of the precinct plan was hierarchically classified into ‘arterial’, ‘sub-arterial’ and ‘local’ routes, and shopping, business or residential ‘precincts’, free from through-traffic, were established through the implementation of road closures along ‘sub-arterials’.

Figure 4.8 *The ‘precinct planning’ idea*



NETWORK FEATURES:

- the hierarchical classification of roads into ‘arterial’, ‘sub-arterial’ and ‘local’ routes
- the introduction of road closures along ‘sub-arterials’ routes to create ‘precinct’ free from through-traffic





Source: Tripp 1942:55

4.2.2.3 *Environmental area*

The ‘environmental area’ idea was developed by a working group on traffic chaired by Colin Buchanan in London, in 1963. Buchanan and his colleagues argued in the seminal *Traffic in Towns* report that local areas had an ‘environmental capacity’ which placed limits on the amount of traffic they could absorb. The capacity of a local area to absorb traffic was seen to be a function of a set of measurable environmental qualities that take into account acceptable levels of air pollution, noise, visual disfigurement, luminosity, safety and pedestrian activity. This capacity became the basis for defining ‘environmental areas’, or ‘cells’, from which through-traffic was removed, and diverted around. People were to live, work, and shop in environmental areas free from the hazards of vehicular through-traffic, while a network of interlacing arterials enabled the rapid, uninterrupted distribution of vehicular traffic between areas. The road network of the environmental area was classified into a clear functional hierarchy of ‘primary distributors’, ‘district distributors’, ‘local distributors’ and ‘access roads’. The area had limited access points, which restricted the entry of through-traffic. (HMSO 1963)

Figure 4.9 The 'environmental area' idea



Primary distributors	
District distributors	
Local distributors	
Environmental area boundaries	

Source: HMSO 1963:44

Note: 'Access roads' are not shown in the diagram.

NETWORK FEATURES:

- the definition of areas or 'cells' on the basis of their 'capacity' to absorb traffic without incurring unacceptable levels of air pollution, noise, visual disfigurement, etc.
- the hierarchical classification of roads into 'primary distributors', 'district distributors', 'local distributors' and 'access roads' on the basis of vehicular traffic distribution functions
- the provision of limited access points into environmental areas, to remove and divert through-traffic
- the provision of a network of limited access arterials to enable the rapid, uninterrupted distribution of vehicular traffic between environmental areas

4.2.2.4 Cluster and planned unit developments

The 'cluster development' idea was developed by William Whyte (1964) and others in the United States in the early 1960s, as an alternative to conventional low-density suburban subdivisions. The total number of dwellings in a cluster development was the same as a conventional suburb, only they were situated on smaller erven and grouped more closely together, so that the remaining land could be released and preserved for use as public open space. Gross residential densities therefore remained the same, while net residential densities were higher. The road network of typical cluster developments were characterised by loops and *culs-de-sac* emanating from curvilinear collector streets. The later 'planned unit development' (PUD) idea emerged out of the cluster development idea in the United States in the 1960's and 1970's (Huntoon 1971). PUD's were different from cluster developments in that they had a planned mix of residential, commercial and industrial land uses.

Figure 4.10 The 'cluster/planned unit development' idea



NETWORK FEATURES:

- the use of loops and *culs-de-sac* emanating from curvilinear collector streets
- the provision of limited access points into the cluster development or PUD to remove and divert through-traffic

Source: Whyte 1964:66

4.2.2.5 Assumptions

The ideas that emerged during this period made the following basic assumptions (see Banjo and Dimitriou 1983, Dimitriou 1990 1992, Elkin *et al* 1991, Hillman 1983, Tolley and Turton 1995, Dargay and Goodwin 2000, amongst others):

- that the increased ownership and use of private motor cars was both inevitable and sustainable – as a result, none of the ideas sought to reduce the use of motor cars, just to manage their use more efficiently, safely and cost effectively,
- that future private motor car use was predictable, ultimately reaching a 'saturation level', and that new road construction and increased road capacities were exogenous variables (i.e. they did not influence the amount of traffic) that could satisfy predicted demands for road space,
- that the function of road networks was to distribute motorised traffic (and in some instances that pedestrian and vehicular movements could be totally separated – i.e. the 'superblock' idea), and that hence the urban transport 'problem' was basically one of how to overcome motorised traffic congestion, and
- that pedestrian activities occur within spatially discrete areas or 'cells', and that removing through-traffic from these 'cells' would remove conflicts between pedestrians and vehicles and improve pedestrian safety.

4.2.3 1960s-1980s: Responses to traffic conflicts and decaying street life

The third period of local network planning emerged in western European countries in response to the rapid increases in motor car use and growing traffic conflicts of the 1950s and 1960s, and the associated barriers to the continued use of streets for pedestrian-based activities. During the 1960s and 1970s, countries like The Netherlands and (West) Germany adopted a somewhat different response to growing traffic problems. Whereas local network configuration and management ‘solutions’ in the United States and the United Kingdom were concerned equally with the operational efficiency of traffic flow, safety and cost-effectiveness, the west Europeans were concerned more with safety and the continued use of streets by pedestrians for walking, playing and socialising – the local network configuration and management ideas they developed forced cars to travel considerably slower, and were relatively expensive to implement.

The ‘problem’ was therefore seen to be:

- the need for an improvement in pedestrian safety, and
- the need to address the decay in traditional street use resulting from increased vehicular traffic volumes and speeds.

The ‘solution’ that emerged at this time thus centred on:

- the retrofitting of existing streets (and later entire networks of streets) to accommodate pedestrian uses and reduce traffic speeds, and
- ‘pedestrianisation’ schemes that converted streets for exclusive use by pedestrians.

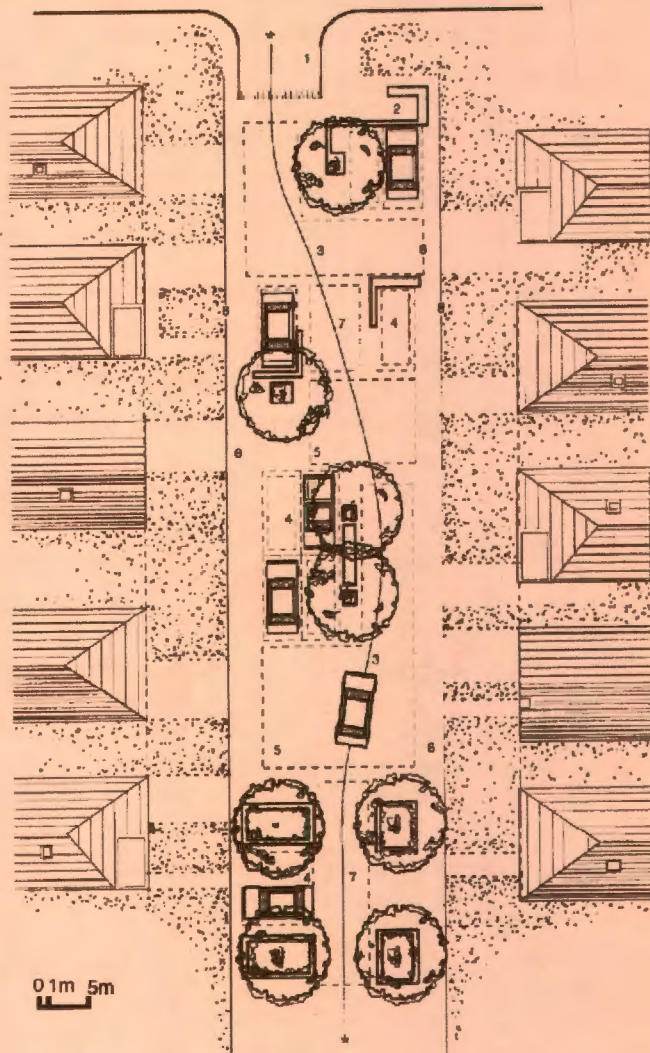
Two key ideas emerged during this period – the ‘*woonerf*’ (meaning living yard) idea, and ‘*verkehrsberuhigung*’ (meaning traffic calming).

4.2.3.1 *Woonerf*

The ‘*woonerf*’ idea was developed by the Municipality of Delft in 1963, and was formally included in the Traffic Code of The Netherlands in 1976. The ‘*woonerf*’ idea essentially involved the (re)design of streets according to the needs of pedestrians (as opposed to vehicles). Whereas the ‘superblock’ idea separated pedestrians from vehicles, the *woonerf* idea integrated pedestrians and vehicles within the same street space, only vehicles were forced to move at almost pedestrian speeds and behave according to a set of pedestrian rules. Typical *woonerven* were characterised by no grade changes between roadways and footways, the narrowing of roadway widths to approximately 2 m in instances where grade separation was provided with widenings at intervals to enable vehicles to pass, the introduction of some form of either vertical or horizontal speed reduction measure every 30–40 m to

physically prevent vehicles from accelerating to speeds greater than about 30 km/h (e.g. speed humps, chicanes), the use of street furniture and tree planting to reduce driver visibility and improve pedestrian amenity, and low legal speed limits (e.g. 15-25 km/h). The Dutch *woonerf* idea prompted the introduction of similar retrofitting practices in other European countries – for instance, the Germans introduced the *wohnbereich*, the Swiss introduced *wohnstrasse* or *rue résidentielle* and the Belgians introduced *rue libre*. (Hass-Klau 1990, Kraay 1986)

Figure 4.11 The 'woonerf' idea



DESIGN FEATURES:

- the integration of roadways and footways
- the narrowing of roadway widths with widenings every 30-40 m to enable vehicles to pass
- the use of speed reduction measures (e.g. tables, surface changes, chicanes) and shifted horizontal roadway alignments every 30-40 m
- the use of street furniture and tree planting to reduce driver visibility

- 1= clearly marked entry
- 2= sitting area/bench
- 3= bend in driving lane
- 4= parking space
- 5= varied paving materials
- 6= no continuous curb
- 7= chockers/planting beds
- 8= typical right-of-way

Source: Southworth and Ben-Joseph 1997:110

4.2.3.2 Verkehrsberuhigung

The '*verkehrsberuhigung*' idea was developed by Rolf Monheim (1975) amongst others in (West) Germany in the 1970s. The idea essentially involved applying the *woonerf* principles of vehicle restraint, on an area-wide basis. While clearly influenced by the ideas contained in the *Traffic in Towns* report, *verkehrsberuhigung* differed from the 'environmental area' idea in that greater emphasis tended to be placed on cross-section design than on network configuration, and traffic was 'calmed' on 'major' as well as 'minor' roads (Keller 1986, Pharaoh and Russell 1991). *Verkehrsberuhigung*

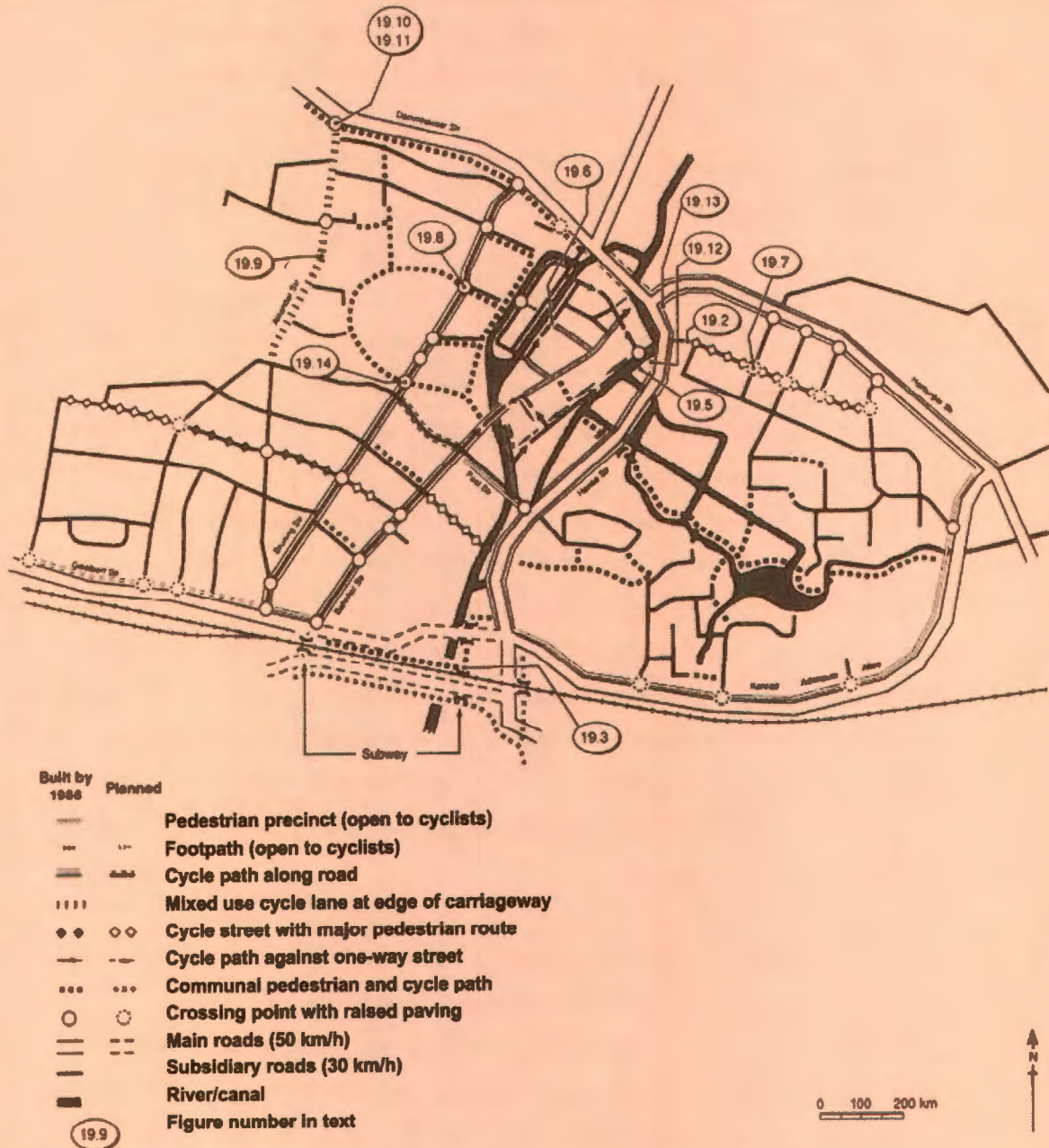
measures typically included the reconstruction of certain streets for use by pedestrians only, the narrowing of street entrances to discourage through-traffic from moving off major roads, the use of raised crosswalks to favour pedestrians at intersections, the introduction of *woonerf*-type design features on roads to 'calm' (both through and local) vehicular traffic, and area-wide speed limits of 30 km/h. The idea was initially applied to residential neighbourhoods and city centres (in the form of 'pedestrianisation' schemes), and later (in the 1980s) to major urban roads with abutting concentrations of commercial activity. In the case of the latter, the operational efficiency of traffic flow was (at least partially) maintained by retaining auxiliary lanes at main intersections. (Hass-Klau 1990, Monheim H 1986, Monheim R 1986)

The German *verkehrsberuhigung* idea prompted the introduction of similar area-wide traffic restraint practices in other countries – initially in other European countries like The Netherlands and Denmark, and later in the United States and the United Kingdom. The introduction of street retrofitting measures in the United States and the United Kingdom indicated a shift in emphasis in local network planning practice from facilitating new traffic, to managing existing traffic. Concerns for operational efficiency and cost began to be perceived as less important than concerns for safety and for what became known as 'liveability'. There was a growing argument that while the residential street design standards developed in the 1960s and 1970s had clearly prevented through-traffic from entering residential areas, they had also encouraged local traffic on 'collector' roads inside residential areas to travel at high speeds. Wide roadways, long sight distances and large-radius intersection curves had facilitated driving speeds on 'collectors' well above the 40 km/h generally considered to be safe in residential areas (Bosselmann and O'Hare 1983, Homburger *et al* 1989). There was however some debate around how area-wide traffic restraint ideas should be applied, and two often fairly indistinct schools of thought emerged (Pharaoh and Russell 1991).

The first school of thought, which became known as 'environmental (or neighbourhood) traffic management', emphasised the reduction of traffic *volumes* in residential neighbourhoods (Bosselmann 1987, Hass-Klau 1986, Homburger *et al* 1989). 'Environmental traffic management' was directly influenced by the 'environmental area' idea (Bosselmann and O'Hare 1983). In the United States the task of measuring 'environmental capacities' was taken up by a team of researchers in San Francisco in the late 1970s and early 1980s led by Donald Appleyard. Their research showed a strong relationship between traffic volumes and street residents' concerns for safety, identity, comfort and privacy. The study of three similar streets (in terms of housing form and residents) within the same neighbourhood with 'light' (2 000 vehicles/day), 'medium' (8 200 vehicles/day) and 'heavy' (17 750 vehicles/day) traffic volumes indicated that there was an inverse correlation between traffic volumes, and levels of social interaction and 'liveability'. Appleyard *et al*'s (1981) findings led to the emergence of the American 'liveable streets movement', and prompted many public authorities to adopt policies and practices aimed at 'managing' the volume (and speed) of traffic on residential streets by restricting network continuity and retrofitting. The planning and design 'problem' however

continued to be understood mainly as the protection of residential streets from increasing volumes of speeding through-traffic.

Figure 4.12 The 'verkehrsberuhigung' idea



NETWORK FEATURES:

- the reconstruction of certain streets for use by pedestrians only
- the narrowing of street entrances to discourage through-traffic from moving off major roads
- the use of raised crosswalks to favour pedestrians at intersections
- the use of *woonerf*-type design features to 'calm' vehicular traffic
- the use of area-wide 30 km/h speed limits

Source: Döldissen and Draeger 1990:273

The second school of thought, which became known simply as 'traffic calming', emphasised the reduction of traffic *speed* in urban areas (Pharaoh and Russell 1991). While many 'traffic calming' schemes constituted elements within wider traffic volume restraint policies, there were many others

where no reduction of traffic volume was intended. It was argued that the removal of unwanted through-traffic did not necessarily address the problems caused by the remaining traffic, and that the means of diverting through-traffic (e.g. road closures and one-way street systems) often made access to properties highly inconvenient, and eroded the viability of mixed land uses along 'closed' routes. Reducing speed was seen to directly address the main source of the traffic problem, while at the same time retaining convenient local access as well as the traditional character and functions of roads. 'Traffic calming' was therefore different from 'environment traffic management' in that it identified traffic speed (as opposed to volume) as the main problem.

4.2.3.3 Assumptions

The ideas that emerged during this period made the following basic assumptions:

- that in the case of isolated *woonerf* street conversions, vehicular traffic would continue to use the street, instead of simply using adjacent streets, and
- that the extensive installations and utility relocations associated with street (and network) retrofitting would be affordable across the entire settlement.

4.2.4 1970s-1980s: Responses to poverty and housing costs

The fourth period of local network planning emerged in the developing world (mainly Latin America, India and Africa) during the 1970s and 1980s, in response to poverty, rapid urbanisation, and low housing and serviced land affordability. At the time developed countries were formulating design responses to traffic problems, the planning and design issues in the developing world were somewhat different – mainly around making the capital and operating costs of housing and serviced land more affordable. In the 1960s and 1970s, due to significantly lower per capita incomes, the developing world did not experience the same absolute increases in private car ownership (even though growth rates may have been similar or greater in some countries due to low base levels), and hence speeding through-traffic was not regarded as the major planning and design problem (Hilling 1996, Tolley and Turton 1995).

The 'problem' in the developing world was seen to be:

- the high capital and operating costs associated with the reticulation of utility services in greenfield and *in-situ* upgrade residential developments, and
- the scarcity and cost of suitable land for residential development.

An increasing concern for housing costs led to the introduction of 'site-and-service' developments, in which 'standards' for new housing and infrastructure provision were essentially lowered. Developers

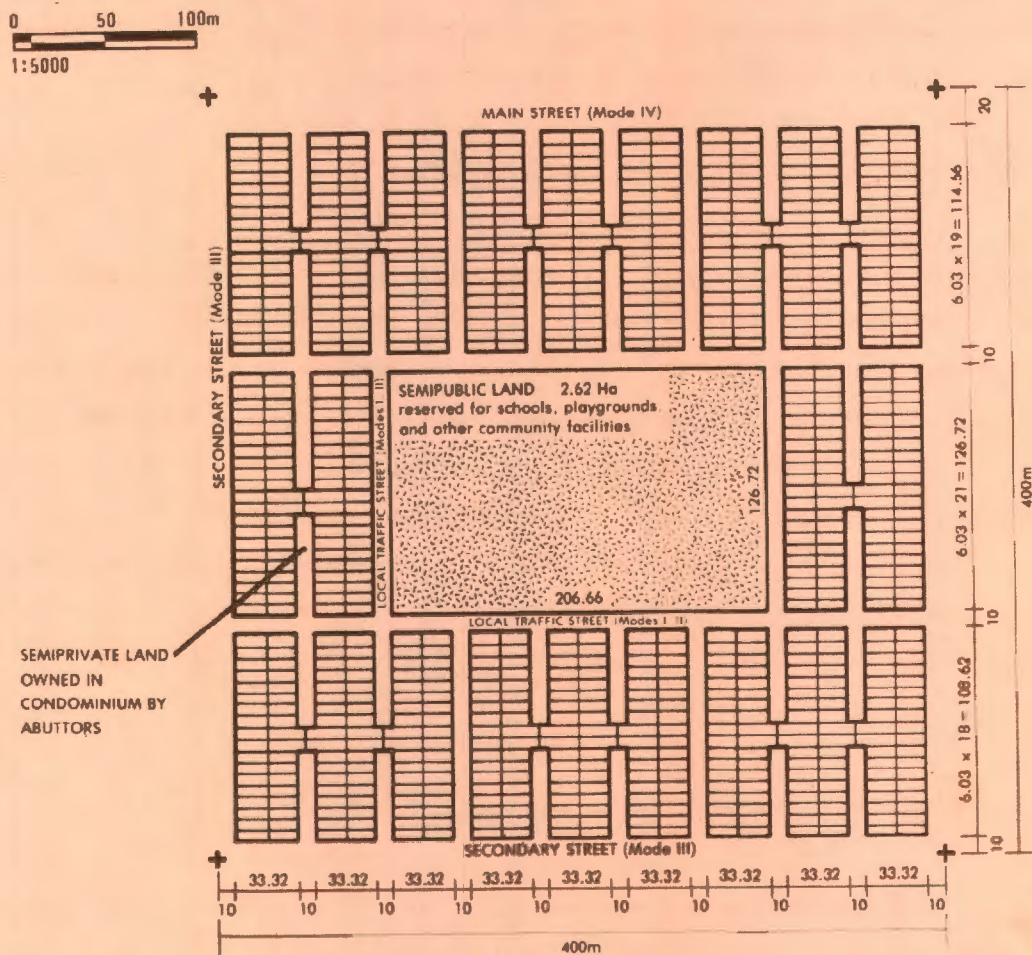
continued to install utility services and subdivide land, but low-income households were expected to construct their own houses (or 'top structures'). In 1972 the World Bank adopted 'sites-and-services' as its official housing programme, and subsequently become the primary advocate of this system throughout the developing world.

The 'solution' that emerged at this time thus centred on:

- reducing utility service reticulation lengths (and therefore costs) per unit area and per dwelling unit, and
- increasing gross residential densities in ground-related 'incremental' housing developments, by decreasing residential erf sizes and increasing residential land take-up.

Two key ideas emerged during this period – the 'cluster layout' idea, and the 'planning module' idea.

Figure 4.13 The 'cluster layout' idea



NETWORK FEATURES:

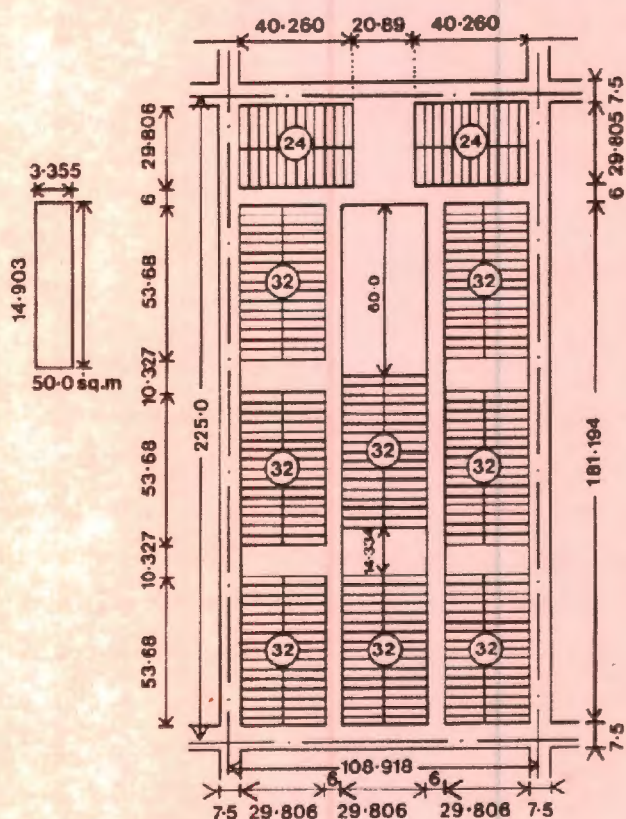
- the provision of numerous possible neighbourhood through connections to facilitate multi-directional pedestrian movement
- the provision of relatively short 'blocks' (approximately 100 m x 150 m) to enable direct pedestrian movement
- the provision of narrow pedestrian *culs-de-sac* or through-paths within 'blocks'

Source: Caminos and Goethert 1978:21

4.2.4.1 Cluster layout

The 'cluster layout' idea was developed for application in greenfield site-and-service developments by Horacio Caminos and Reinhard Goethert in the 1970s, and was later applied to *in-situ* upgrade developments (Davidson and Payne 1983, Turner 1980). The 'cluster layout' idea involved the assembly of several 'blocks' (i.e. a form of 'superblock') within an 'urban segment' (i.e. a form of 'neighbourhood unit'). Caminos and Goethert (1978) argued that, paradoxically, the smaller the serviced site within a conventional two-erf deep block subdivision, the greater the infrastructure networks (and cost) per unit area. They argued that by clustering small serviced sites around *culs-de-sac* within 'blocks', infrastructure networks per unit area similar to those in large erf subdivisions could be achieved. In addition, in the event of services being provided on a communal basis (e.g. public standpipes in *in-situ* upgrades), the clustering of erven within 'blocks' was seen to create clearly identifiable groups of users. The movement network of the cluster layout was characterised by 'urban segments' (approximately 400 m x 400 m) open to through-traffic and multi-directional pedestrian movement (or 'intercommunication'), 'block' dimensions of approximately 115 m x 120 m to enable direct pedestrian movement, and the provision of relatively narrow (often semi-privately owned) pedestrian *culs-de-sac* or through-paths within 'blocks'.

Figure 4.14 The 'planning module' idea



NETWORK FEATURES:

- the provision of a 'superblock' of approximately 100 m x 180 m to enable direct pedestrian movement
- the provision of narrow (6 m) paths leading across the 'superblock' to facilitate pedestrian access and through-movements

4.2.4.2 *Planning module*

The 'planning module' idea was developed for application in greenfield sites-and-services developments by B K Chakrabarty in the 1980s. Chakrabarty (1987, 1991) argued that in conventional residential layout design practice the planner relied mainly on intuition when preparing plans that attempted to minimise service reticulation costs and to optimise the utilisation of land – with the reduction of erf sizes to the smallest possible level generally being the typical means of effecting cost savings. As an alternative to this, the 'planning module' idea involved modelling the optimal configurations for modules, or units, of design (in terms of savings in serviced land costs per erf), using a non-linear programming technique. The 'module' of design in the case of a residential layout was either an erf, a block, or a grouping of blocks. The movement network of the planning module was characterised by a form of 'superblock' (approximately 100 m × 180 m) to enable direct pedestrian movement, and the provision of narrow (6 m wide) multi-directional pedestrian through-paths within the 'superblock'.

4.2.4.3 *Assumptions*

The ideas that emerged during this period made the following basic assumptions:

- that households occupying erven fronting pedestrian pathways within 'superblocks' (i.e. without private vehicular access), would not own cars, and
- that private motor car use would continue to be low, and through-traffic volumes would not increase significantly.

4.2.5 **1980s-1990s: Responses to car dependency and pollution**

The fifth period of local network planning emerged in response to increasing motor car dependency throughout both the developed and developing world in the 1980s and 1990s, and the associated emergence of air pollution problems at a global scale. Between the 1950s and the mid-1990s, the global car fleet increased by 800% (from approximately 53 to 430 million vehicles), and it has been estimated that if these trends continue unabated this figure will reach 900 million by 2010 – with much of the increase occurring in the developing world (Minter 1997, Newman 1996). The energy crisis of the 1970s, and the prospect of significant 'global warming' due to the 'greenhouse effect', forced a fairly widespread realisation that this trend in urban transportation and its tendency to enable cities to 'sprawl' outward at low densities was highly problematic. As a result, the assumptions underlying the by now entrenched local network design practices and processes developed in the 1920s-1970s period, as well as the appropriateness of these practices in the developing world (Appleyard 1983, Banjo and Dimitriou 1983), began to be questioned.

Firstly, the assumption that increased car use was inevitable and sustainable was argued to be incorrect (Cervero 1996, Dimitriou 1990, Hillman 1983, Newman 1996, Newman and Kenworthy 1989, Tolley 1990, among others). Car ownership in the developing world, while increasing rapidly, was not comparable with the developed world, and even in the developed world, large portions of the population (i.e. children, the elderly, the disabled, the poor, and very often women in single car households) did not have access to private cars. It was argued that the conventional practice of closing residential 'cells' to through-traffic and slowing access-seeking traffic in order to maximise pedestrian safety within 'cells', did little to promote the access requirements of pedestrians, cyclists and public transport services (sometimes referred to as the 'green modes'), and often simply promoted car dependency and its associated environmental problems. Discontinuous local road networks, often with entry and exit points located along only one side of the site being subdivided, resulted in excessively circuitous pedestrian and vehicle trips – prompting pedestrians to use their cars (if they owned them), and in some cases causing private bus operators to refuse to establish service routes within the new subdivision (Homburger *et al* 1989). Secondly, the assumption that predicted private motor car use could be satisfied through new road construction was argued to be incorrect (Goodwin 1996, Mogridge 1997, among others). As discussed in chapter 2, it was argued that far from being an exogenous variable, the construction of new and wider roads in already congested conditions did little to relieve traffic congestion, as it released latent traffic demand as well as contributed to a decline in public transport service and usage. A cycle was identified in which congestion gave rise to greater road capacity, greater road capacity resulted in additional 'induced' car use and less public transport use, and greater car use resulted in more congestion. Thirdly, the assumption that the function of road networks is to distribute motorised traffic was argued to be incorrect (Cervero 1996, Hillier 1996, Pietrucha and Opiela 1993, among others). Local network configuration and management practice was seen to have become car-oriented – on the basis that, *inter alia*, the conventional measure of performance was the 'level-of-service' for vehicles (based on volume:capacity ratios, average intersection delays and operating speeds), and conventional functional road classifications considered only the movement of motorised traffic (see figure 4.6). It was argued that roads and road networks perform a variety of social, economic and non-motorised movement functions, as well as traffic distribution functions.

The 'problem' during this period was therefore seen to be:

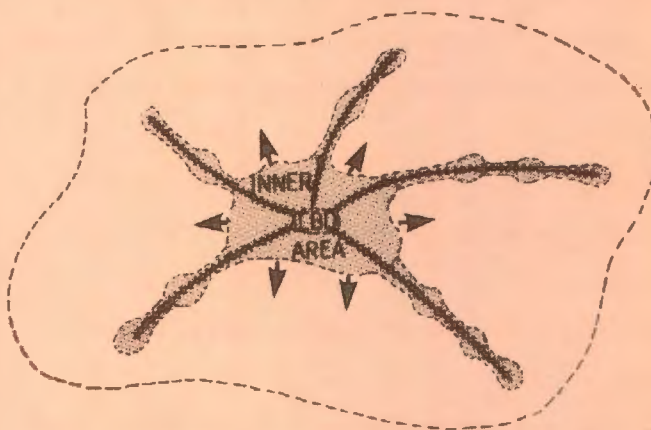
- the need to reduce the environmental impacts of urban transportation systems (particularly vehicular 'greenhouse gas' emissions), and
- the need to make urban transportation systems more equitable for those who do not have access to private motor cars, as well as for non-movement road users.

Two sets of, often complementary, policy responses emerged in relation to this problem. The first was to address the problem without attempting to change existing travel patterns – by introducing

transportation technologies that consume less fuel and produce less pollution, developing 'intelligent transport systems' that enable vehicles to use road systems more efficiently, and implementing low-cost, remedial 'transport system management' (TSM) projects that improve operational efficiency (as well as safety). The second policy response was to attempt to fundamentally change travel behaviour and modal split – by implementing 'travel demand management' strategies that get people out of their cars and into more sustainable modes like public transport vehicles, bicycles and their feet, and, in the longer term, changing urban structure and form. In other words, an adoption of the earlier discussed watershed shift from what were essentially 'supply-side' or 'predict-and-provide' solutions in the 1920s-1970s period, to 'demand management' solutions.

In the context of global vehicle fleet increases, it was argued that even if the introduction of the former 'cleaner' and 'smarter' technologies was accelerated, they would not improve pollution or efficiency levels as more vehicles would simply be driven more kilometres, and that 'urban restructuring' and TDM would therefore be essential if the above environmental and social problems were to be addressed successfully (Cervero 1996, Tolley 1990, Newman 1996, among others). A number of fairly similar ideas on how cities might be 'restructured', and on the role local network design might play in TDM efforts, emerged in various parts of the developed and developing world – largely out of empirical observations of the operations of traditional 'main streets' supportive of public transport services and their adjacent passenger catchments (Cervero 1995, Newman and Kenworthy 1989, Tanghe *et al* 1984, van der Ryn and Calthorpe 1986, among others).⁷³ These ideas all essentially argued that areas adjacent to major public transport routes (usually radiating out of city centres) should be developed, or gradually redeveloped, into higher density, mixed land use and pedestrian-friendly 'corridors' and 'nodes' (see figure 4.15).

Figure 4.15 *The 'reurbanisation' idea as a way of 'restructuring' low-density, car-dependant cities*



"Huge potential exists for infill developments, intense mixed use developments of vacant or under-utilised land, redevelopments of existing poorly used industrial and warehousing sites, etc. In particular, development on or near rail reserves would appear to be crucial as a part of an integrated approach to lowering automobile dependence and providing a viable alternative to the car" (Newman and Kenworthy 1989:114)

Source: Newman and Kenworthy 1989:115

⁷³ These ideas also emerged in South Africa, with the additional function of addressing the spatial imbalances that had resulted from apartheid policies, in the form of 'activity spines' or 'corridors' (Derek Chittenden and Associates 1990, Dewar *et al* 1977, Dewar 1984, Dewar and Watson 1981, Green 1990, Naudé 1988 1991).

The 'solution' that emerged at this time, in relation to the configuration of these redevelopments or 'infills', thus centred on:

- the configuration of movement networks that are primarily oriented to both the movement, and safety, needs of pedestrians, cyclists and public transport users,
- the configuration of public rights-of-way into networks that are more 'open' to shorter distance through-movements, so that pedestrians are provided with convenient and direct routes to all local destinations (the most important of which being public transport stops), and
- the design of streets as complex multi-functional public spaces.

Three key ideas emerged during this period – the 'traditional neighbourhood development', the 'pedestrian pocket', and the 'transit-oriented development'.⁷⁴

4.2.5.1 *Traditional neighbourhood development*

The 'traditional neighbourhood development' (TND) idea was developed by Andres Duany and Elizabeth Plater-Zyberk (1991) amongst others in the United States, in the early 1990s. TNDs have also been called 'neo-traditional developments' and 'urban villages'⁷⁵ – all falling under the banner of 'new urbanism' or 'neo-traditional planning' (Bookout 1992, Katz 1994, Leccese and McCormick 2000). The TND idea involved the development of compact, mixed land use, 'walkable' neighbourhoods, similar to the traditional American town of the 19th and early 20th centuries, and to Clarence Perry's 'neighbourhood unit' idea in particular.⁷⁶ Its proponents argued that by bringing higher density homes, jobs, shops and recreational amenities closer together, neighbourliness would be created, walking and cycling would become easier, public transport services would become more viable, and dependence on the motor car would be reduced. The road network of the TND was characterised by a rectilinear configuration of highly interconnected streets with some variations to accommodate changes in topography, natural features, and scenic 'place-making' vistas. Mid-block alleys were often provided to eliminate the need for, and risks associated with, numerous kerb cuts for driveways in streets. Roadways ('defined' by buildings and trees) were narrow (approximately 3 m) and kerb radii were small (3 m or less) to reduce traffic speeds and make pedestrian crossing easier. Footways on both sides of the roadway were wide, and blocks were relatively short, to facilitate convenient pedestrian movement. On-street parking was permitted to 'buffer' pedestrians from cars. It was argued that a road network with more through connections would relieve 'suburban congestion'⁷⁷

⁷⁴ Some authors do not differentiate between 'pedestrian pockets' and 'transit-oriented developments' (see for instance Atash 1994 and Boarnet and Crane 2001). While these ideas are similar in most respects, the perhaps somewhat artificial distinction made here is on the basis of detailed network configuration.

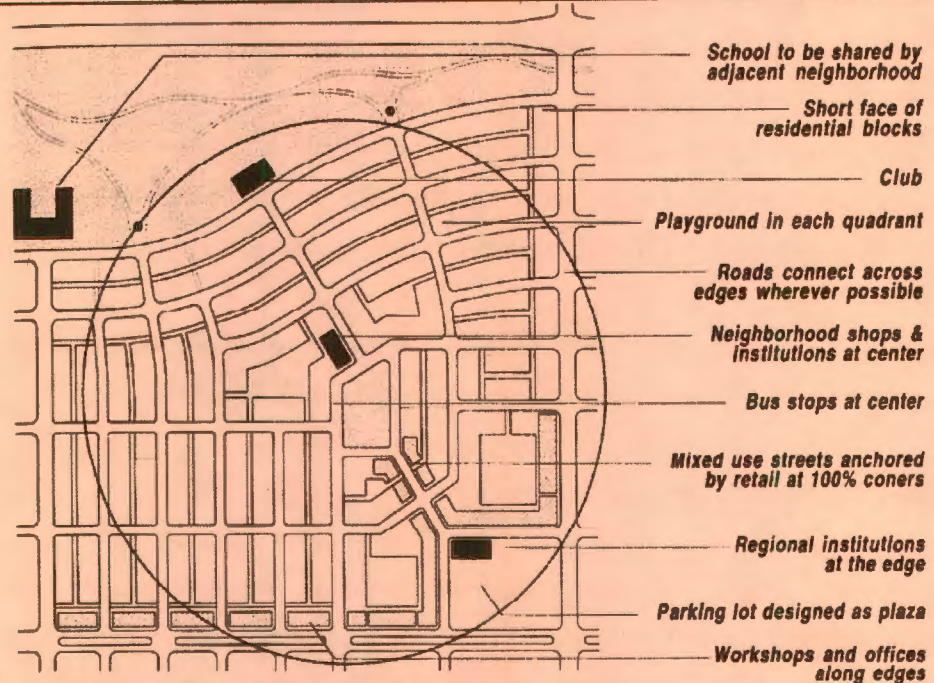
⁷⁵ The 'urban village' is the approximate equivalent of the 'traditional neighbourhood development' idea in the United Kingdom (Aldous 1992).

⁷⁶ Some diagrammatic illustrations of the TND idea have in fact been derived directly from Perry's neighbourhood unit diagram (see for instance Leccese and McCormick 2000)

⁷⁷ 'Suburban congestion' (or 'suburban gridlock') had occurred within curvilinear, 'closed' suburban developments. It was a more recent form of congestion associated with circumferential suburb-to-suburb travel, and the need for even relatively short vehicular trips to be undertaken on limited access arterials and freeways. (Cervero 1986)

by offering alternative routes to nearby destinations and dispersing traffic more evenly, and thus reducing the load on limited access arterials.

Figure 4.16 The 'traditional neighbourhood development' idea



NETWORK FEATURES:

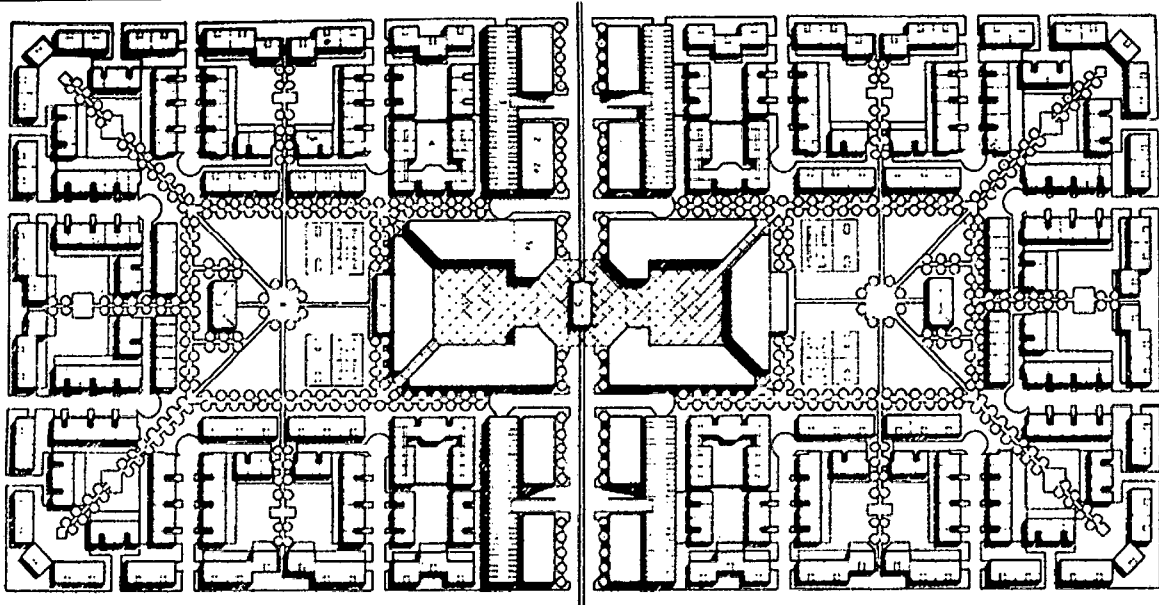
- the provision of a network of highly interconnected, rectilinear streets, with some variations to accommodate changes in topography, and vistas
- the provision of mid-block allies to eliminate the need for, and risks associated with, numerous kerb cuts for driveways in streets
- the narrowing of roadways (approximately 3 m), and the reduction of kerb radii (3 m or less), to reduce traffic speeds and make pedestrian crossing easier
- the 'definition' of roadways with fronting buildings and trees
- the provision of wide footways on both sides of the roadway, and the use of relatively short blocks, to facilitate easy pedestrian movement

Source: Dutton 2000:23

4.2.5.2 Pedestrian pocket

The 'pedestrian pocket' idea was developed by Peter Calthorpe and Doug Kelbaugh (1989) amongst others in the United States, in the late 1980s. The 'pedestrian pocket' idea involved the development of small, high density neighbourhoods around public transport stops. The boundaries and size of the pocket were set by a maximum walking distance of approximately 400 m (i.e. a 5 minute walking radius around a public transport stop). The pocket contained a fine mix of land uses, and higher density housing forms. The movement network of the pedestrian pocket was characterised by a rectilinear and radial network of pedestrian pathways originating from the central public transport stop, and rectilinear roadway loops and *culs-de-sac* that led off the roads that defined the pocket. As in the 'superblock' idea (see figure 4.7), pedestrians and vehicles were therefore separated (albeit only partially) onto separate movement systems.

Figure 4.17 The 'pedestrian pocket' idea

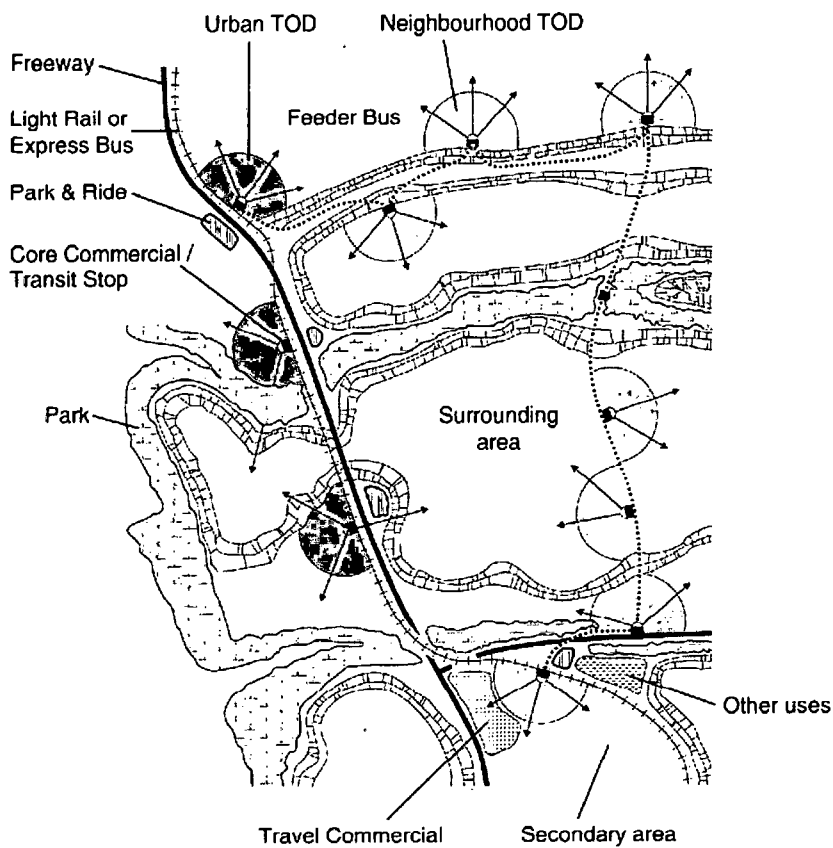


NETWORK FEATURES:

- the partial segregation of pedestrians and vehicles onto separate movement systems to remove conflict
- the provision of a rectilinear and radial network of pedestrian pathways originating from the central public transport stop to ensure a maximum walking distance of 400 m
- the provision of rectilinear loops and *culs-de-sac* that lead off the roads which define the pocket

Source: Kelbaugh 1989:7

Figure 4.18 'Transit-oriented developments' in metropolitan context

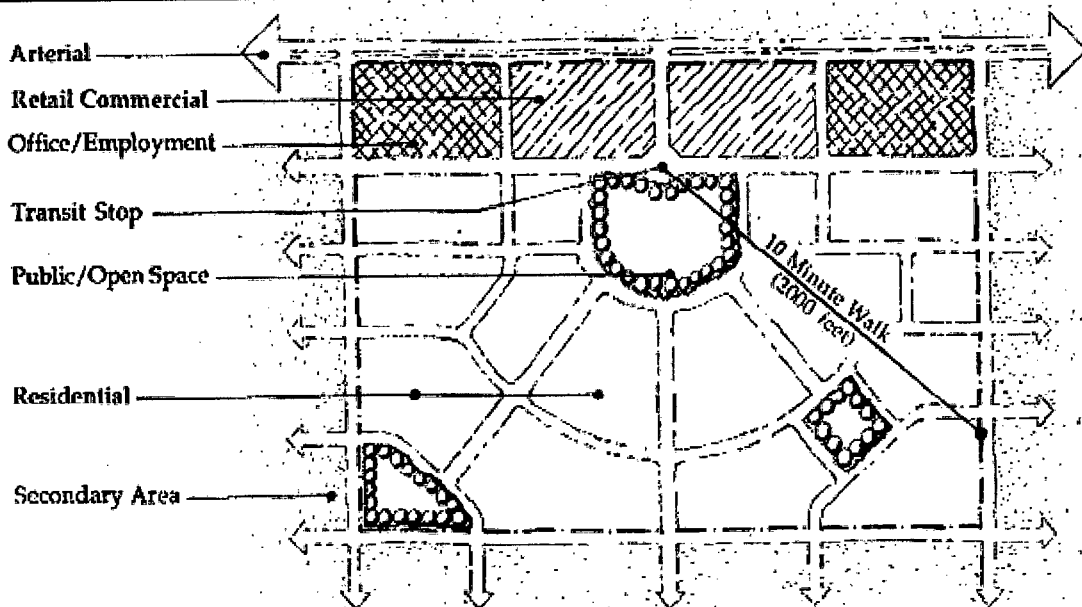


Source: Hall and Ward 1998:148

4.2.5.3 Transit-oriented development

The 'transit-oriented development' (TOD) idea was developed by Peter Calthorpe (1993) amongst others in the United States, in the early 1990s. TODs have also been called 'transit villages' (Bernick and Cervero 1997). The principle difference between TODs and the earlier discussed TNDs and pedestrians pockets, is their geographical focus on public transport stops and interchanges in the case of the former, and their greater size and more open roadway systems in the case of the latter. The TOD idea involved the (re)development of compact, mixed use and pedestrian-friendly neighbourhoods within a 10 minute (or 800 m) walking radius of a public transport stop or interchange (see figure 4.18). Importantly, the TOD was not intended to function as a self-sufficient neighbourhood – all residents were not expected to work or shop in the TOD. The road network of the TOD was characterised by a network of interconnected streets, with typically direct radial connections to public transport stops and interchanges. It was argued that a road network with more through connections would provide more direct pedestrian access to local destinations and public transport stops, and encourage mode switching from private motor cars to public transport.

Figure 4.19 The 'transit-oriented development' idea



NETWORK FEATURES:

- the provision pedestrian-friendly and interconnected street networks within a 10 minute (or 800 m) walking radius of public transport stops
- the configuration of roadway and footways in a radial pattern converging on the public transport stop or interchange

Source: Katz 1994:xxxi

The TND and TOD ideas forced some transport engineering agencies to reconsider the street design standards developed in the 1960s and 1970s. With the growth in TND and TOD projects in the 1990s, traffic engineers in the United States increasingly found themselves in a position of not having to respond to whether the roadway widths, on-street parking, kerb radii, road layout and intersection spacings of a TND or TOD project should be built, but rather to how traffic engineering principles

should be applied in implementing the project. The TND and TOD ideas therefore forced numerous changes in the application of conventional street design standards. In particular, dense, interconnected road networks resulted in the redefinition or elimination of conventional functional road hierarchies as a 'design control' (i.e. the attachment of geometric design, access control and pavement standards to prescribed 'local', 'collector', etc. road classifications), and mixed land uses abutting some roads performing 'collector' and 'arterial' traffic distribution functions resulted in sacrifices in operational efficiency in order to maintain safety and multi-functional street use. In addition, 'traffic calming' was used as a proactive design measure to maintain safety standards within interconnected road networks – as opposed to being used simply as a reactive retrofitting measure to correct 'design failure'.

(Atash 1994, Bochner 1998, Ewing 1999, Forbes 2000, ITE 1994, Lerner-Lam *et al* 1992, West and Lowe 1997)

Table 4.2 *Chronological publication of some new or supplementary American, British and Australian residential street design standards and guidelines*

YEAR	AGENCY	TITLE
1992	RTC	<i>Planning for transit: A guide to community and site design</i>
1992	SRT	<i>Transit and land use coordination guidelines</i>
1993	SDMTD	<i>Designing for transit</i>
1993	SCCTA	<i>Transit oriented development design concepts</i>
1993	TRI-MET	<i>Planning and design for transit</i>
1994	ITE	<i>Traffic engineering for neo-traditional neighbourhood design</i>
1994	FTA	<i>Planning for transit-friendly land use: A handbook for New Jersey communities</i>
1994	DOE/DOT	<i>Planning policy guidance: Transport (PPG 13)</i>
1996	TRI-MET	<i>Planning and design for transit handbook: Guidelines for implementing transit supportive dev.</i>
1996	FPTO	<i>Pedestrian- and transit-friendly design</i>
1997	WAPC	<i>Liveable neighbourhoods: community design code**</i>
1997	ECC	<i>The Essex Design Guide for residential and mixed use areas*</i>
1997	1997	<i>Transport in the urban environment</i>
1998	ITE	<i>Traditional neighbourhood development street design guidelines</i>
1998	DETR	<i>Places, streets and movement</i>
1998	TRL	<i>Towards good urban design</i>
1999	IHT	<i>Planning for public transport in developments*</i>
1999	ITE	<i>Traffic calming: State of the practice</i>
2000	DETR	<i>By design: Urban design in the planning system*</i>
2000	EP/THC	<i>Urban design compendium*</i>
2000	WAPC	<i>Liveable neighbourhoods**</i>
2000	WAPC	<i>Liveable neighbourhoods: Street layout, design and traffic management guidelines**</i>

Note: DETR-Department of Environment, Transport and the Regions, DOE/DOT-Departments of the Environment and Transport, ECC-Essex County Council, EP-English Partnerships, FPTO-Florida Public Transit Office, FTA-Federal Transit Administration, IHT-Institution of Highways and Transportation, ITE-Institute of Transportation Engineers, RTC-Regional Transport Commission, SCCTA-Santa Clara County Transportation Authority, SDMTD-San Diego Metropolitan Transport Development, SRT-Sacramento Regional Transit, THC-The Housing Corporation, TRI-MET-Tri-County Metropolitan District of Oregon, TRL-Transport Research Laboratory, WAPC-Western Australia Planning Commission

It began to be recognised that conventional street design standards had evolved within a market framework which favoured private car use and paid little attention to the movement requirements of other modes, and that although most traffic engineering design manuals included design specifications for 'residential streets', very few (if any) contained any design specifications for 'mixed land use streets'. As a result of these criticisms, official bodies in the United States, United Kingdom and Australia (amongst other countries) began revising, or at least supplementing, their street design guidelines and codes (see table 4.2). By June 1993, Cervero (1994) had identified some thirty-eight

agencies which had developed, or were in the process of developing, 'transit-supportive' design guidelines in North America⁷⁸. These revisions typically promoted public transport and non-motorised travel in local network configuration, by encouraging design practices that create, amongst other things, direct pedestrian access to local destinations and public transport stops, slower vehicle travel speeds, and multi-functional street space.

4.2.5.4 Assumptions

The ideas that emerged during the 1980s to 1990s period made the following basic assumptions (see Audirac and Shermeyen 1994, Boarnet and Crane 2001, Box 2000, Falconer Al-Hindi and Staddon 1997, Gordon and Richardson 1997, Hall 1998, Talen 1999, Winburn 1992, amongst others):

- that pedestrian-oriented spatial configurations (together with TDM strategies) would impel drivers to abandon their cars in favour of walking, cycling and public transport in sufficient quantities to significantly reduce global 'greenhouse gas' emissions,
- that proactive 'traffic calming' design measures within 'open' road networks, in the case of TNDs and TODs, would prevent the safety problems associated with speeding motorised traffic from (re)emerging,
- that there is a market demand for higher density, mixed use, pedestrian-oriented residential developments amongst higher income households and commercial investors, and
- that (as in the case of earlier 'neighbourhood units') the inclusion of front porches and centrally located public facilities and squares in TND neighbourhood designs would re-introduce 'traditional neighbourliness'.

4.3 LOCAL NETWORK CONFIGURATION PRACTICES IN SOUTH AFRICA

Which then of the approaches to local network configuration described above have been applied in South Africa? As mentioned in the introduction to this chapter, South African practices are identified and discussed in this and the following section through a review of evolving codes. A review of the South African codes of practice that deal in whole or in part with the configuration of local movement networks (excluding road construction and urban traffic control) reveals numerous past, current and incomplete codes (see table 4.3). In order to trace and simplify dominant local network configuration practices in South Africa, this section excludes codes of practice dealing only with loading, parking and road-based public transport facilities, and focuses on the sequence of codes produced by the Council for Scientific and Industrial Research (CSIR) on residential service and amenity provision. Table 4.3 illustrates that the production of official codes of practice has been undertaken primarily by

⁷⁸ This fairly rapid production of guides in the United States, was fuelled in part by the requirements of the two earlier mentioned pieces of legislation dealing with air quality and intermodal transportation efficiency – the Clean Air Amendments Act of 1990, and the Intermodal Surface Transportation Efficiency Act of 1991.

two agencies: the CSIR on behalf of a variety of government departments, and the Committee of Urban Transport Authorities (CUTA)⁷⁹ on behalf of the NDoT. It is suggested that the evolution of the CSIR's guidelines provide a better reflection of the evolution and origins of network configuration ideas in South Africa during the 1980s and 1990s. The first CSIR guideline (the 'blue book') was produced prior to the first CUTA guidelines, and while the CSIR and CUTA guidelines at times use different terminology (particularly in relation to road classification), the general approach to local network configuration is essentially the same.

Table 4.3 *Chronological publication of South African local network configuration codes of practice (excluding road construction and urban traffic control)*

YEAR	AGENCY	TITLE
1951*	Thomas Floyd	<i>Township Layout</i>
1976*	SAICE	<i>Guidelines on the Planning and Design of Township Roads and Stormwater Drainage</i>
1983	NDoT (Metroplan)	<i>Guidelines for off-street loading facilities</i>
1983	DCD (CSIR)	<i>Guidelines for the provision of engineering services in residential townships ('blue book')</i>
1985	NDoT (Metroplan)	<i>Parking standards</i>
1986	NDoT (Metroplan)	<i>Bus terminals and bus stations planning and design guidelines</i>
1986	DDA (CSIR)	<i>Guidelines for services and amenities in developing communities ('brown book')</i>
1986	NDoT (CUTA)	<i>Guidelines for the geometric design of urban arterial roads (UTG 1)</i>
1987	NDoT (CUTA)	<i>Guidelines for the geometric design of urban collector roads (UTG 5)</i>
1987	NDoT (CSIR)	<i>Guidelines for the provision of public transport facilities for developing communities</i>
1988	DDA (CSIR)	<i>Toward guidelines for services and amenities in developing communities ('green book')</i>
1989	NDoT (CUTA)	<i>Geometric design of urban local residential streets (UTG 7)</i>
1989	NDoT	<i>Guidelines for the design of combi taxi facilities</i>
1990	NDoT (CUTA)	<i>Guidelines for the geometric design of commercial and industrial local streets (UTG 10)</i>
1991	NDoT (CSIR)	<i>Principles for the planning of activity streets</i>
1992	NDoT	<i>Location of termini and stopping facilities for minibus-taxis</i>
1994	NDoH (CSIR)	<i>Guidelines for the provision of engineering services and amenities in residential township development ('red book')</i>
2000	NDoH (CSIR)	<i>Guidelines for human settlement planning and design ('new red book')</i>
§	NDoT (COLTO)	<i>Guidelines on spatial planning (TPG 5)</i>

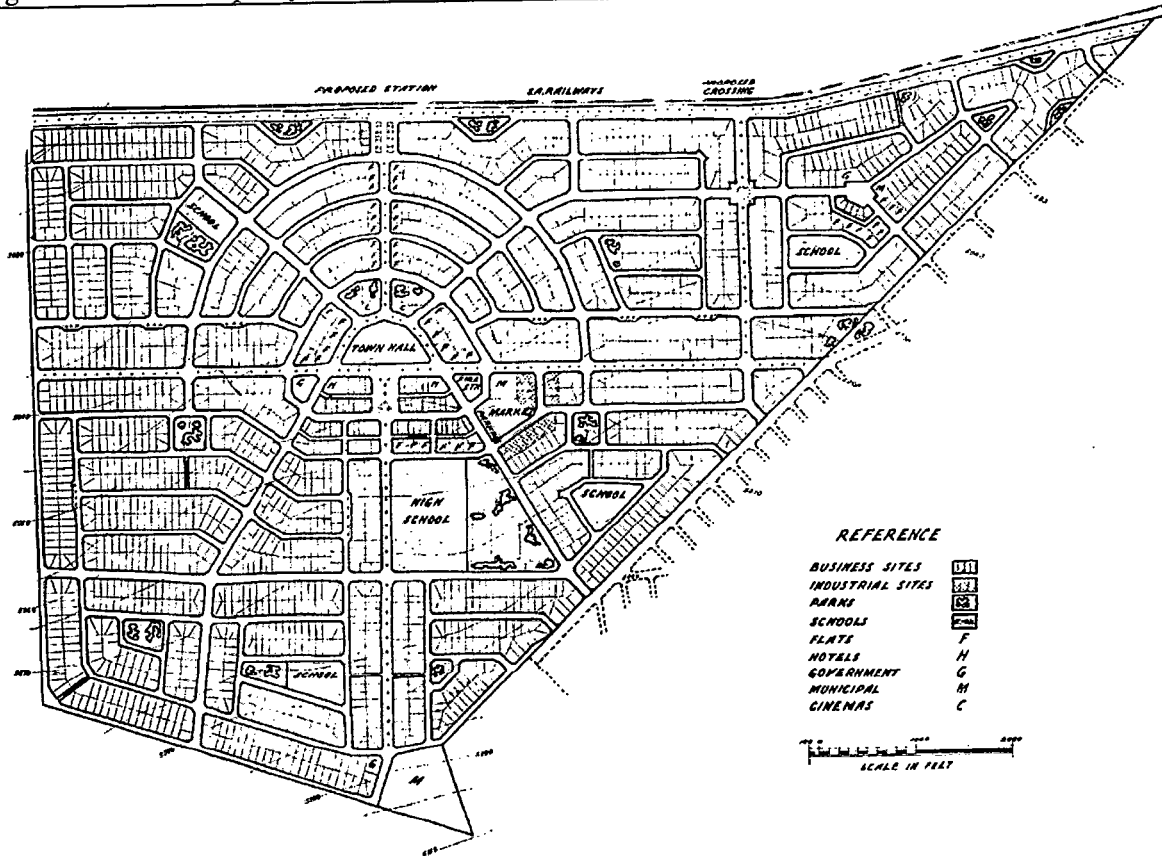
Note: *-unofficial, §-abandoned, SAICE-South African Institution of Civil Engineers, NDoT-National Department of Transport, CSIR-Council for Scientific and Industrial Research, DCD-Department of Community Development, DDA-Department of Development Aid, CUTA-Committee of Urban Transport Authorities, NDoH-National Department of Housing, COLTO = Committee of Land Transport Officials

4.3.1 1951: Township layout

Perhaps the earliest (unofficial) local network design guidelines in South Africa were prepared by Thomas Floyd in 1951. The document, entitled *Township Layout*, was explicitly prepared in the absence, at the time, of guidelines which dealt with layout planning peculiar to South African conditions. Floyd (1951) identified examples of these peculiar conditions as being the frequent construction of 'servants quarters' in the backyards of single-storey houses, the 'variety of races', climatic conditions, and the 'rural or semi-rural character' of the majority of South African people.

⁷⁹ The Committee of Urban Transport Authorities (CUTA), responsible for the production of the *Urban Transport Guidelines* (UTGs), was later replaced by the Committee of Land Transport Officials (COLTO) in the early 1990s. The Land Transport Co-ordinating Committee (LTCC) within COLTO was responsible for producing a further set of guidelines known as *Transport Planning Guidelines* (TPGs). Work on incomplete or draft TPGs came to a halt in 1998 however, as a result of both a review of the functions of COLTO and its sub-committees and a lack of funding (Krynauw *et al* 1999). Following the disbanding of the LTCC at the end of the 1990s, work on the completion of incomplete TPGs was abandoned.

Figure 4.20 Example of the local network configuration idea promoted in 'Township layout'



NETWORK FEATURES:

- the configuration of 'main roads' in a semi-radial pattern, converging on a central town centre
- the use of curved roads and distorted rectilinear configurations to discourage fast cars
- the alignment of blocks parallel to 'major roads' to reduce the number of intersections between 'major' and 'minor' roads
- the provision of numerous possible through connections
- the use of right angle (tee- or cross-) intersections between 'major' and 'minor' roads to maximise driver visibility

Source: Floyd 1951:20



The guidelines (see chapter 2.7 of Floyd 1951) recommended a road network configuration in which 'main roads' radiated out from a town centre, and 'residential townships' were situated in between these radial routes. The recommended configuration of 'minor roads' was characterised by distorted rectilinear networks, relatively open to through-traffic. 'Main road' intersections typically took the form of traffic circles, while 'minor road' intersections were either controlled by stop-streets or 'robots' (the South African term for traffic signalisation). Intersections between 'major' and 'minor' roads occurred at right angles to maximise driver visibility. The guidelines stressed however that no particular road layout configuration should be consistently or rigidly adhered to in practice, as the site's topography and surroundings needed to be the dominant determining factors. Guidelines for road network configuration in 'native locations' (see chapter 3.5 of Floyd 1951) were essentially the same as for (white) 'residential townships' – the main differences related to the gradients necessary for cheaper gravel roads⁸⁰.

⁸⁰ It should perhaps be noted however that in his contemporaneous 1953 doctoral thesis on 'native housing', Douglas Calderwood argued for closed road systems in 'native housing estates': "[i]t is essential ... that no road except the planned roads will tend to become through roads. Once the road pattern is such that residential roads lead only to a particular block of

While the *Township Layout* document does not contain a reference list, the guidance provided in relation to public facilities and road layout suggests its influences. The location of public facilities within the geographical centre of a radial road network, and the relatively open nature of the road network, indicates that the local network configuration ideas promoted in the document were influenced by the British 'garden city' and American 'neighbourhood unit' ideas that emerged during the 1900s-1920s period (see section 4.2.1).

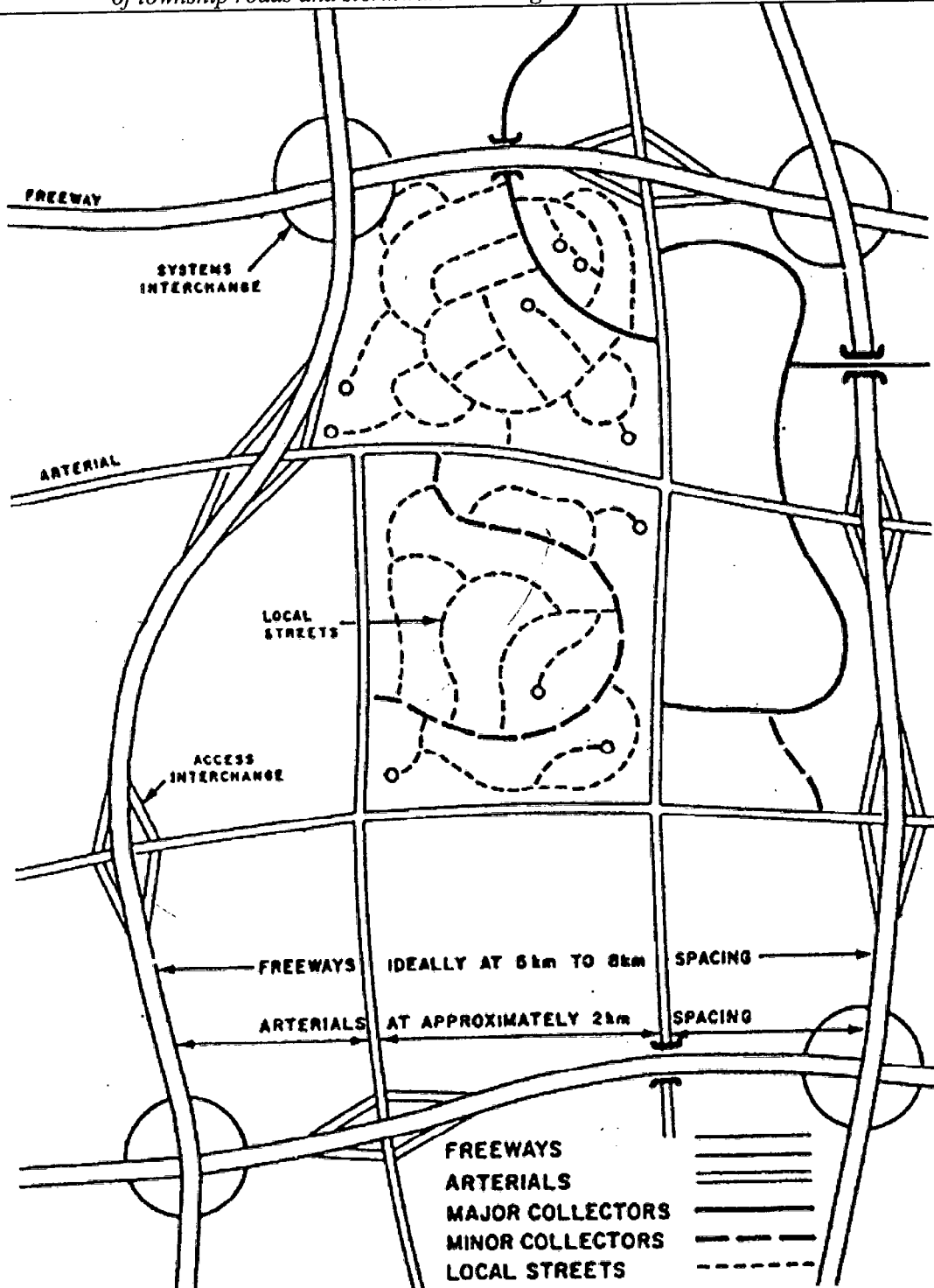
4.3.2 1976: Guidelines on the planning and design of township roads and stormwater drainage

The next (unofficial) local network configuration guidelines in South Africa were prepared in 1976 for the South African Institution of Civil Engineers (SAICE). The document, entitled *Guidelines on the planning and design of township roads and stormwater drainage*, was compiled by a sub-committee chaired by D Giddy, representing both the SAICE and the South African Institute of Town and Regional Planners (SAITRP)⁸¹. The guidelines were prepared in order to provide a basis for co-operation between the various disciplines involved in the planning, design and construction of new 'townships', and to assist local authorities in the preparation of by-laws and town planning schemes for the control of urban development. The aim of the guidelines was to achieve uniform township road and stormwater drainage 'standards'. These standards were the first South African equivalent of the residential street design standards prepared in the United States and the United Kingdom (see table 4.1). It was argued that the standardisation of procedures and designs would result in greater efficiency and lower development costs (e.g. narrower road reserves, simultaneous service installation, etc.). It was recognised however that these standards should be flexible with regard to unique site conditions, and that 'sub-economic' housing, as a 'special circumstance', would require modifications or relaxations of the standards provided. (SAICE 1976)

The document argued that a 'safe', 'efficient' and 'economical' access and circulation system was necessary in order to achieve the maximum amenity in residential townships, and the greatest potential in commercial and industrial townships. The following 'principles' (amongst others) were provided as a guide for the planning and design of a safe, efficient and economical road network (see chapter 1.2 of SAICE 1976):

dwelling, then, considering the traffic movement within low income housing, the road widths can be determined accordingly" (Calderwood 1953:100). See diagram 3 on page 123 for an illustration of kind of movement network envisaged.
⁸¹ It is perhaps worth noting however that the title page of the document explicitly states that the document did not necessarily reflect the opinion of the South African Institute of Town and Regional Planners – suggesting that consensus could not be reached with regard to some aspect(s) of the guidelines.

Figure 4.21 Local network configuration idea promoted in 'Guidelines on the planning and design of township roads and stormwater drainage'



NETWORK FEATURES:

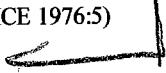
- the hierarchical classification of roads into 'freeways', 'arterials', 'collectors' and 'local streets'
- the provision of limited access points onto bordering 'arterials' to minimise through-traffic within 'townships'
- the use of crescents, non-continuous connecting roads and *culs-de-sac* within 'townships' to reduce 'minor road' traffic speeds
- the frequent use of tee-intersections in the configuration of the 'minor road' networks

Source: SAICE 1976:27 (redrawn in CUTA UTG 7, on page 10)



- design the minor road system for minimum through-traffic movements, whilst maintaining adequate internal circulation,
- create least interference and detrimental effect on bordering arterial routes,

- correctly classify streets within the system and see that the design and appearance of the road is in conformity with the classification,
- design local streets to encourage low speeds without the introduction of hazardous elements, giving preference to crescents, non-continuous connecting roads and *culs-de-sac*,
- design for minimum practical total length of internal streets and minimum number of intersections which, in the case of the internal layout of the minor roads, should be mainly of the T type,
- relate the layout to topography,
- design ... for the efficient and safe movement of traffic with the minimum of regulation, relating the geometric standards to the function and traffic classification of the particular road, and
- minimise pedestrian-vehicular conflicts, pedestrian movement within the township should involve a minimum number of street crossings – in general while vehicular flow should be directed outwards to the peripheral arterials, pedestrian travel should be inward oriented. (SAICE 1976:5)



As indicated in the above principles, roads were classified according to their traffic distribution function. The following road classification was recommended (see chapter 4 of SAICE 1976):

- | | |
|---|---|
| <ul style="list-style-type: none"> • Major Roads: Freeway Major Arterial Minor Arterial Major Collector | <ul style="list-style-type: none"> • Minor Roads: Minor Collector Local Street <i>Cul-de-sac</i> |
|---|---|

The approach to movement network planning promoted in the document was clearly influenced by the ideas that emerged during the 1920s-1970s period (see section 4.2.2). The explicit concern for safety, efficiency and cost echoed the interpretation of the planning and design ‘problem’ during this period, and the classification of roads according to traffic distribution functions and the configuration of ‘minor roads’ into ‘closed’ networks, were consistent with the planning and design ‘solution’ that emerged in response to this interpretation of the problem. The document’s reference list clearly indicates that the residential street design standards that were produced by agencies like the Institute of Transportation Engineers, the Highway Research Board, the Urban Land Institute and the American Association of State Highway Officials in the 1960s and 1970s (see table 4.1), in the United States, influenced the recommended approach to movement network planning practice in South Africa.

4.3.3 1983: Guidelines for the provision of engineering services in residential townships (the ‘blue book’)⁸²

The first official local network design guidelines in South Africa were prepared in 1983 for the Department of Community Development. The document, entitled *Guidelines for the provision of engineering services in residential townships*, was compiled by the National Building Research Institute (NBRI) of the CSIR. The need for official national guidelines and standards was identified by the Fouché Commission of Enquiry (of 1977) into what the then Minister of Community Development (S F Kotzé) referred to as “the exorbitant prices of erven and dwelling houses as well as the delay in the establishment of residential townships” (DCD 1983:i). Delays experienced in the approval and development of residential townships were often perceived to be due to disagreements surrounding the standard of engineering services required in different parts of the country. The purpose of the ‘blue

⁸² The colour of the ring binder within which this document, and its subsequent versions, were bound, resulted in the guideline documents becoming known as the ‘blue book’, the ‘brown book’, the ‘green book’, and the ‘red book’.

book' guidelines was therefore to provide a set of national norms for the provision of engineering services for residential township development. While non-mandatory, provincial administrations, local authorities and developers were all urged to adhere to the guidelines as far as possible.

Initially four 'working sub-committees' were established to prepare guidelines on different engineering services, but as it became apparent that road layouts played a major role in the cost of services, a fifth working sub-committee on 'Township Traffic and Transportation' was established. The chapters of the document were thus concerned with the planning of road layouts and their geometric design standards, the structural design of roads, urban stormwater management, sewerage, water supply, and electricity distribution.

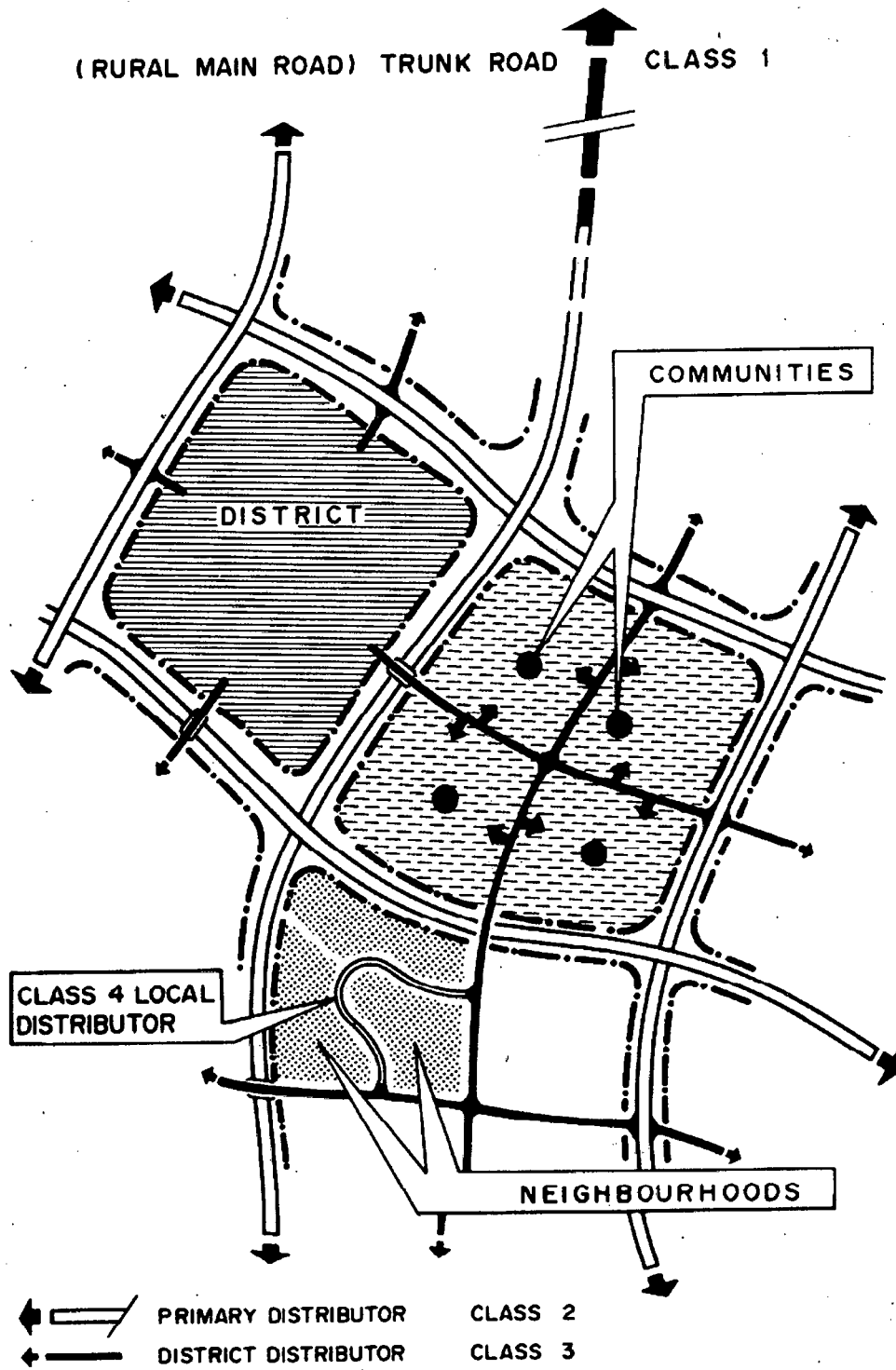
The document argued that in order to achieve 'acceptable living environments', the following 'goals' should be pursued in residential township development: 'economy', 'functional efficiency', 'safety', 'convenience', 'environmental quality', 'privacy', and 'security of person and property' (see part A.4.2 of DCD 1983). In order for these goals to be achieved through local network configuration, the following 'principles' (amongst others) were provided (see part A.5.1.1 of DCD 1983, and part B.3.2 for illustrations of most of these principles):

- the overriding principle relating to road layout is that the road system should be developed in a functional hierarchy which segregates distributive traffic movements by destination and journey length,
- the layout should seek to minimise the number of intersections, especially on higher order roads,
- there should be a continuous gradation in function from one level of the hierarchy to the next, avoiding the possibility of intersection between high and low order roads – roads should generally intersect only with roads one level above or below them in the hierarchy,
- four-way intersections should be avoided in higher order roads unless traffic volumes and turning movements warrant the installation of traffic signals or traffic circles – the preferred intersection is a tee-junction, with the lower order road joining the higher order road at right angles,
- zoning and density policies ... should seek to minimise internal vehicular flow – traffic from the more intensive vehicular traffic generators should not have to pass less intensive generators on the way to higher order roads,
- land uses which attract vehicular traffic should be placed on local distributors and at or near the periphery of the area, so as to concentrate traffic on the local distributors – the neighbourhood should predominately be served by local access roads,
- residential access roads should be designed with as much consideration for pedestrians and cyclists as for motor vehicles,
- bus routes and land uses attracting pedestrians should be placed so as to minimise walking distance and to avoid at-grade pedestrian crossing of class 1, 2 and 3 roads, and
- separate pedestrian and/or cycle facilities should be provided within the road reserve at places where pedestrian/cycle movement are concentrated and where there are large speed differentials between vehicles and other road users – segregation is not necessary where the operating speed of traffic is of the order of 15 to 30 km/h. (DCD 1983:A.16)

As indicated in the above principles, roads were classified according to their traffic distribution function. The following road classification was recommended (see part B.2.2 of DCD 1983):

- | | |
|--|--|
| <ul style="list-style-type: none"> • Distributor Roads: <ul style="list-style-type: none"> Class 1 Trunk Road Class 2 Primary Distributor Class 3 District Distributor Class 4 Local Distributor | <ul style="list-style-type: none"> • Access Roads: <ul style="list-style-type: none"> Class 5a Access Collector Class 5b Access Loop Class 5c Access <i>Cul-de-sac</i> Class 5d Access Way Class 5e Access Court Class 5f Access Strip |
|--|--|

Figure 4.22 *Functional road hierarchy promoted in 'Guidelines for the provision of engineering services in residential townships' (the 'blue book')*



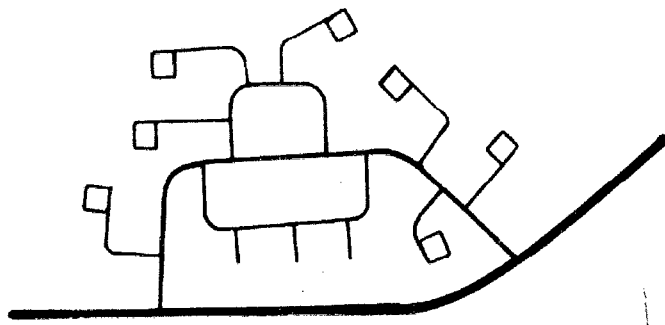
NETWORK FEATURES:

- the design of the road system on the basis of a 'functional hierarchy' which segregates distributive traffic movements by destination and journey length,
- the control of road intersection so that roads only intersect with other roads one level above or below them in the hierarchy,
- the provision of limited access points onto bordering class 4 'local distributors' to exclude through-traffic from 'neighbourhood cells'
- the provision of predominately 'local access roads' to serve 'neighbourhood cells'

Source: DCD 1983:B3

Note: 'Class 5 access roads' are not shown in the diagram.

Figure 4.23 *Local network configuration idea promoted in 'Guidelines for the provision of engineering services in residential townships' (the 'blue book')*



NETWORK FEATURES:

- the minimisation of the number of intersections - especially on higher order roads to maintain operational efficiency
- the use of tee-intersections to reduce potential vehicular conflict points, with the lower order road joining the higher order road at right angles
- the use of (class 5) 'loops', 'culs-de-sac', 'ways', 'courts' and 'strips' within 'neighbourhood cells' to reduce local traffic speeds

Source: DCD 1983:B18

The 'blue book' essentially expanded upon the (unofficial) guidelines published by the SAICE in 1976, and drew from literature reviews and studies on road safety, residential traffic and intersection accidents, conducted by the National Institute for Transport and Road Research (NITRR) of the CSIR (Cameron 1977 1980, Cameron and Del Mistro 1981, Cameron and Price 1980, Del Mistro 1979a 1979b 1980, among others). The approach to movement network configuration promoted was therefore primarily influenced by the ideas that emerged during the 1920s-1970s period, and to a lesser extent by the Dutch *woonerf* idea of the 1960s – in relation to the design of 'residential access roads' (see sections 4.2.2 and 4.2.3.1). The explicit concern for economy, functional efficiency, safety and environmental quality⁸³, etc. echoed the interpretation of the planning and design 'problem' during the 1920s-1970s period, and the classification of roads according to traffic distribution functions and the configuration of 'residential access roads' into 'closed' networks, were consistent with the 'solution' that emerged in response to this 'problem'. The document's reference list indicates that the residential street design standards that were produced by agencies like the American Association of State Highway Officials and British Department of Transport in the 1970s (see table 4.1), influenced the recommended approach to local network planning in South Africa. In fact effort was taken to illustrate compatibility between the proposed functional road hierarchy, and the earlier SAICE road classifications as well as various American, British and Australian classifications (see appendix B.1 of DCD 1983).

4.3.4 1986: Guidelines for services and amenities in developing communities (the 'brown book')

The next official local network design guidelines in South Africa were prepared in 1986 for the Department of Development Aid (DDA), which was responsible for housing in the 'self-governing territories'. The draft document, entitled *Guidelines for services and amenities in developing communities* (the 'brown book'), was compiled by the NITRR, the NBRI and the National Institute for

⁸³ The term 'environmental quality' was used in the same sense as, and drew from, the *Traffic in Towns* report's reference to 'environmental areas' in which the capacity of local areas to absorb traffic became the basis for delimiting areas from which through-traffic was excluded (see section 4.2.2.3).

Water Research (NIWR) of the CSIR. The need for new official guidelines was identified by the DDA when the application of the 'blue book' guidelines in low-income residential developments had resulted in levels of service that were unaffordable. While the 'blue book' guidelines were explicitly intended to be applicable to 'higher', 'middle' and 'lower' income township developments, it became accepted that they were inappropriate in 'developing communities'. It was acknowledged that the 'blue book' had been intended for use in 'municipal townships' (presumably meaning white municipal areas) and 'economic housing' developments, not 'developing communities'. The DDA instructed the CSIR to adapt the 'blue book' norms and standards to suit the requirements of low-income residential developments, but to ensure that there was no needless repetition of material. Like the 'blue book', the 'brown book' guidelines were non-mandatory. However, whereas public authorities and developers were urged to adhere to the 'blue book' guidelines as far as possible, professionals were requested to acknowledge contextual differences and use the 'brown book' guidelines with discretion. The chapters of the 'brown book' were concerned with stormwater management, layout planning, transportation, residential planning, the geometric and structural design of roads, water supply and sanitation.

The document argued that the process of township planning and design should be guided by the following 'goals': 'economy', 'functional efficiency', 'safety of person and property', 'convenience', and 'environmental quality, health, amenity and general welfare' (see part B.5 of DDA 1986). In order for these goals to be achieved through 'circulation and road layout', the following 'principles' (amongst others) were provided (see part B.6.2 of DDA 1986):

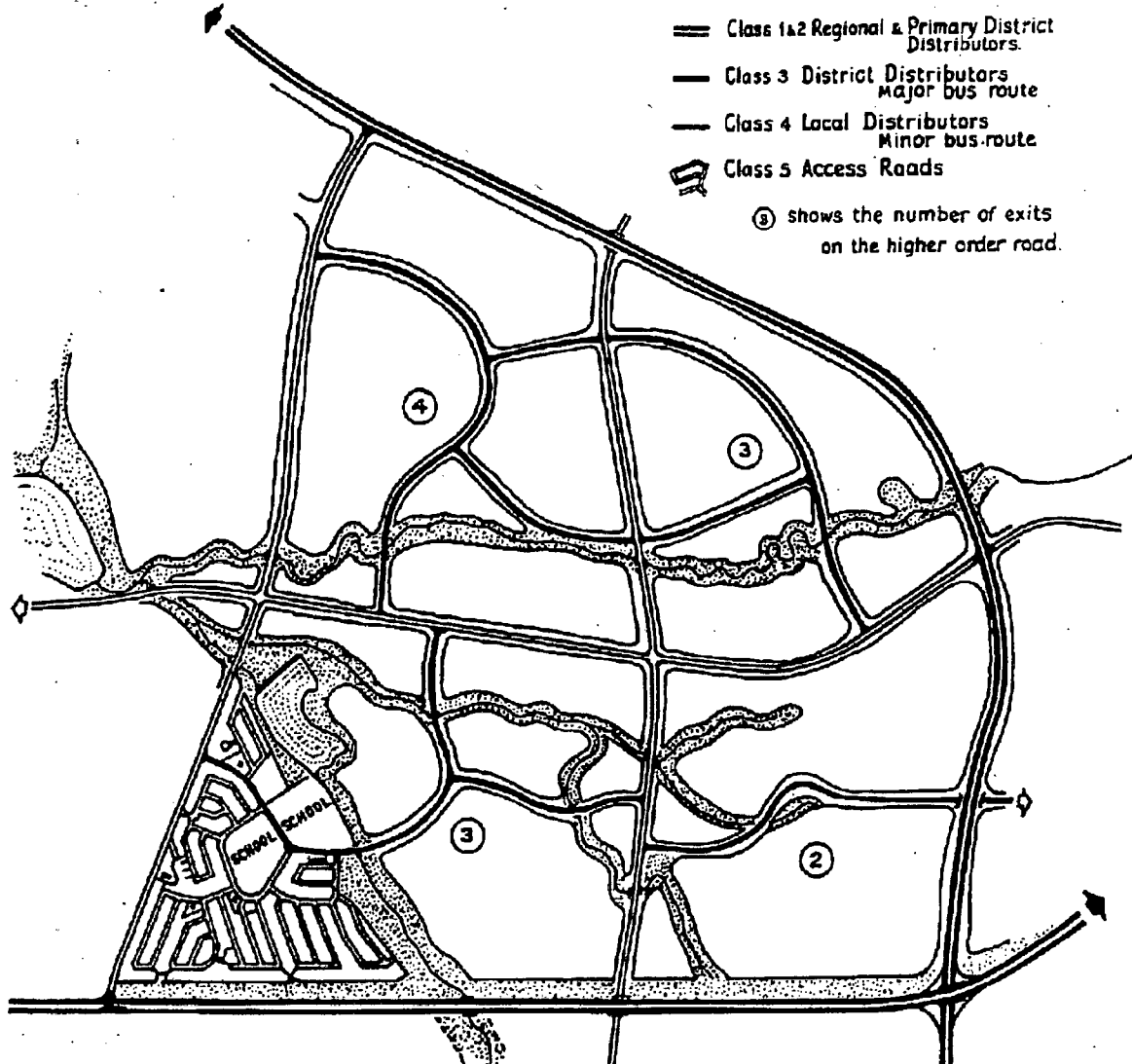
- the road hierarchy [should] differentiate road classes by their function and destination, with higher order roads carrying the heaviest traffic over the longest distances,
- the layout should exclude from residential areas any extraneous traffic, particularly heavy vehicles, which should be attracted by higher order roads,
- residential roads should be designed with as much consideration for pedestrians and cyclists as for motor vehicles,
- the pedestrian circulation network should be considered as part of the total circulation system – when the road layout does not offer the most direct route between generators of pedestrian traffic, it should be supplemented by exclusive pedestrian rights-of-way,
- where pedestrian or cycle movements are concentrated, particularly during peak traffic periods, and where there are large differentials in speed between vehicles and other road users, footways or cycle facilities should be provided within the road reserve – this segregation is not necessary where the speed of motor vehicles is less than about 30 km/h,
- land uses which attract vehicular traffic should be located on class 4 or class 3 roads, so as to concentrate traffic (and thus, heavy axle loads) on higher order roads, and
- the layout should minimise the number of intersections, particularly along higher order roads. (DDA 1986:B.51)

In order for these goals to be achieved through 'bus route planning', the following 'principles' (amongst others) were provided (see part B.6.3 of DDA 1986):

- use the most direct route,
- minimise the route length,
- frequency of service is more important than penetration into the residential area,
- link major attractors and generators,
- do not over-emphasise the bus network attributes - rather think of a system of lines,
- avoid circular or loop routes, and
- use roads which enable buses to travel quickly safely and comfortably - avoid: narrow winding roads, those obstructed by parked vehicles, crossing main traffic flows, stop streets.

As indicated in the above principles, roads were classified and configured according to the earlier 'blue book' classes and principles. The new emphasis on pedestrian circulation and bus route planning in 'developing communities' was intended to be accommodated within the same basic local network configuration idea.

Figure 4.24 *Local network configuration idea promoted in 'Guidelines for services and amenities in developing communities' (the 'brown book')*



NETWORK FEATURES:

- the design of the road system on the basis of a 'functional road hierarchy',
- the control of road intersection so that roads only intersect with other roads one level above or below them in the hierarchy,
- the provision of limited access points onto bordering class 4 'local distributors' to exclude through-traffic from 'neighbourhood cells'
- the provision of predominately 'residential access roads' to serve 'neighbourhood cells'

Source: DDA 1986:G11

The 'brown book' essentially adapted the 'blue book' guidelines for use in lower income residential developments. The approach to local network planning was therefore also primarily influenced by the ideas that emerged during the 1920s-1970s period (see section 4.2.2). The 'cluster layout' idea from the 1970s-1980s period (see section 4.2.4) only influenced the guidelines with regard to block and erf

subdivision, not network configuration. The document's reference list indicates that the residential street design standards that were produced by agencies like the American Association of State Highway Officials, the British Department of Transport and the Transportation Research Board in the 1970s and 1980s (see table 4.1), similarly influenced the recommended approach to local network configuration.

4.3.5 1988: Toward guidelines for services and amenities in developing communities (the 'green book')

The final version of the guidelines for 'developing communities' was published in 1988 by the DDA. The document, entitled *Toward guidelines for services and amenities in developing communities*⁸⁴ (the 'green book'), was compiled by the CSIR's Divisions of Roads and Transport Technology, Building Technology and Water Technology (formerly the NITRR, NBRI and NIWR) and a CUTA Technical Sub-Committee on Stormwater Management. It was reiterated that the 'blue book' had focused on 'developed communities', and guidelines were therefore required for 'developing communities'. The chapter headings of the 'green book' were the same as the 'brown book'. The chapter on 'transportation' however was fairly extensively revised to focus almost exclusively on public transport.

The 'goals' and 'principles' of the 'green book' were the same as the 'brown book' (see part B.5/6 of DDA 1988). The new chapter on public transport however added the following guidelines (with regard to movement networks) for the provision of public transport facilities for 'developing communities' (see part E of DDA 1988):

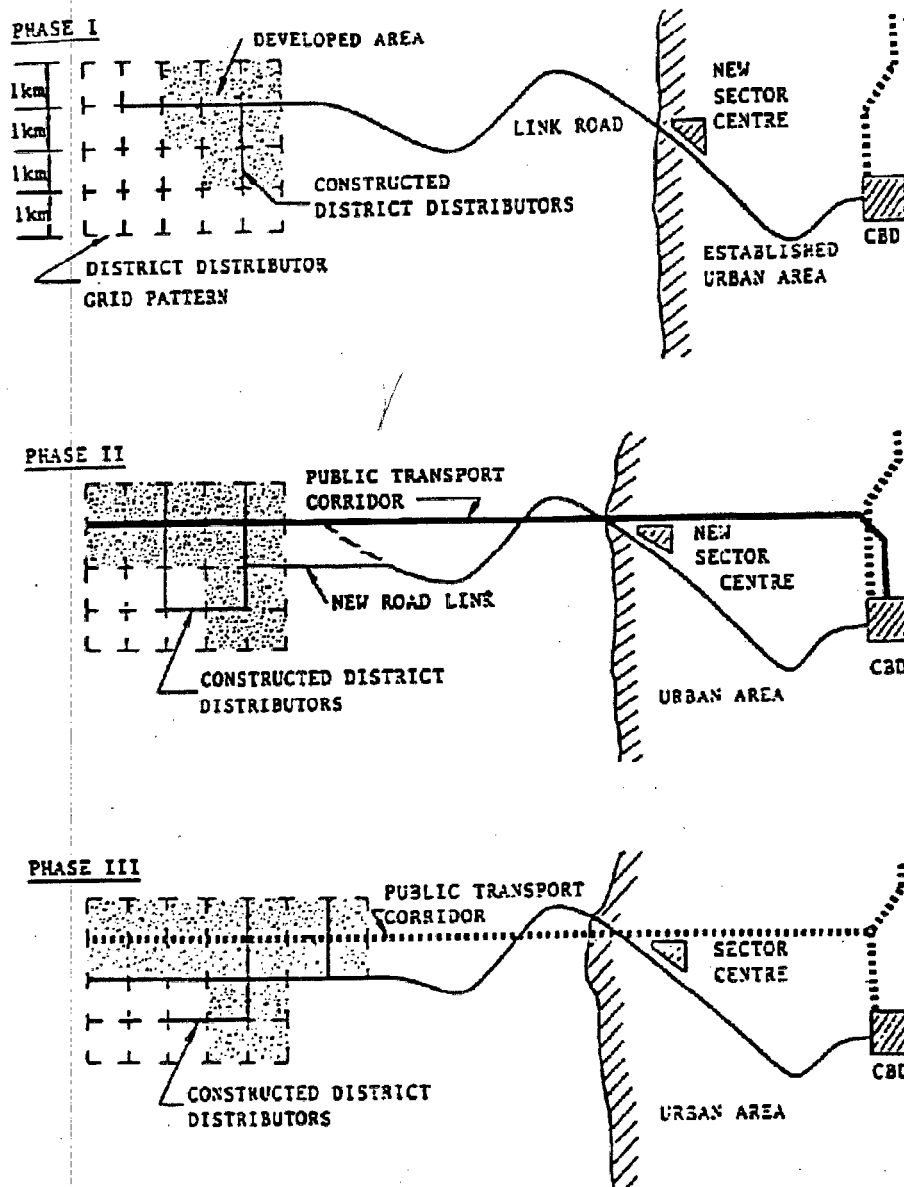
- public transportation routes should be spaced at less than 2 km intervals and stops located along these routes at 1 km intervals,
- public transport routes for developing communities should be accommodated on the proposed district distributor [class 3] road system⁸⁵ which also acts as the boundary system of 'superblocks'⁸⁶ of urban development - as demand increases it could become necessary to dedicate these corridors for public transport vehicle only - the established public transport corridors, which would initially be used by road vehicles could be upgraded to become rail corridors, and
- the corridor should be seen as a public transport corridor and not only as a bus or rail corridor - as such, its use can be changed over time or it could have a multi-modal use. (DDA 1988:E.2)

⁸⁴ The title started with 'toward' because at the time of publication not all the chapters on engineering services had been completed.

⁸⁵ It should perhaps be noted that other proposals on how public transport services might be accommodated within the 'blue book' functional road hierarchy and network configuration (by the same author), indicated that bus routes should be accommodated on (class 4) local distributors in order to maintain a minimum walking distance to the service route of 400 m (Del Mistro 1988) - as opposed to (class 3) district distributors.

⁸⁶ The term 'superblock' is presumably used here to refer to 'community' or 'neighbourhood' cells with diameters of approximately 1-2 km - as opposed the Radburn-type 'superblock' (see section 4.2.2.1).

Figure 4.25 *Public transport system evolution promoted in 'Towards guidelines for services and amenities in developing communities' (the 'green book')*



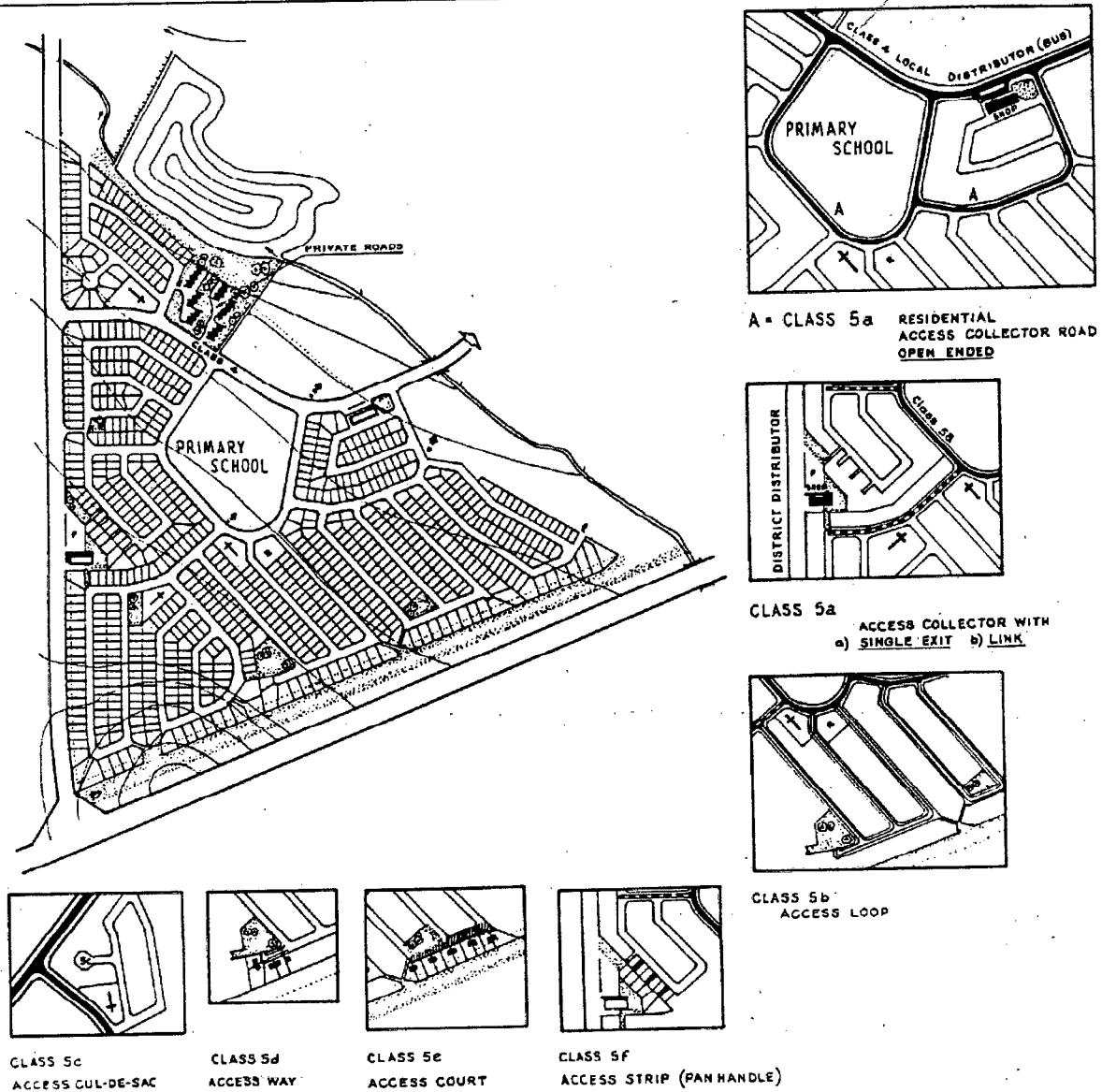
Source: DDA 1988:E.27

4.3.6 1994: Guidelines for the provision of engineering services and amenities in residential township development (the 'red book')

The next official local network design guidelines in South Africa were released in 1994 by the Department of National Housing in collaboration with the National Housing Board. The document, entitled *Guidelines for the provision of engineering services and amenities in residential township development* (the 'red book'), was compiled by the CSIR's Division of Building Technology. The need for new official guidelines arose when, in different contexts, site conditions had required a combination of both higher 'blue book' and lower 'green book' standards. In these cases there had been confusion as which standards and guidelines to apply. The 'red book' therefore consolidated the guidelines of the 'blue book' and 'green book' into a single document, to provide a range of standards – referred to as a 'level-of-service matrix'. The guidelines therefore dealt with every level of

engineering service, from the most basic to the most sophisticated. The guidelines of the 'red book' were concerned with layout planning, stormwater management, geometric design standards, the structural design of urban roads, water supply, sanitation and solid waste management.

Figure 4.26 Local network configuration idea promoted in 'Guidelines for the provision of engineering services and amenities in residential township development' (the 'red book')



NETWORK FEATURES:

- the configuration of the road layout on the basis of a 'functional road hierarchy' which segregates distributive traffic movements by destination and journey length,
- the control of road intersection so that roads only intersect with other roads one level above, equal to, or below them in the hierarchy,
- the provision of limited access points onto bordering class 4 'local distributors' to exclude through-traffic from 'neighbourhood cells'
- the minimisation of the number of intersections - especially on higher order roads to maintain operational efficiency
- the use of tee-intersections to reduce potential vehicular conflict points, with the lower order road joining the higher order road at right angles
- the use of (class 5) residential access 'loops', 'culs-de-sac', 'ways', 'courts' and 'strips' within 'neighbourhood cells' to reduce local-traffic speeds

The document argued that layout planning and related services should pursue the following 'goals': 'economy', 'functional efficiency', 'safety', 'convenience', and 'environmental quality' (see chapter 2 of NDoH 1994). 'Key factors' (amongst others) in achieving these goals in 'circulation and road layout' were identified as (see table 2.1 of NDoH 1994):

- minimise the number of road intersections, [and] provide automatic right-of-way for traffic on higher order roads (the road hierarchy requirement),
- inhibit through-traffic in neighbourhoods and internal streets / keep extraneous traffic out of residential areas,
- provide short-distance links between adjacent neighbourhoods,
- relate the spacing and layout of intersections to traffic requirements,
- relate commuter access from the home to the work place with the road hierarchy,
- locate traffic-generating facilities near entrances to residential areas or adjacent to higher order roads,
- supply convenient parking facilities, segregate pedestrian, cyclist and vehicular traffic, and
- consider the topography, site size and housing requirements when deciding on the orientation and alignment of streets.

The 'red book' simply consolidated and summarised the previous 'blue book' and 'green book' guidelines, and its guidelines relating to local network configuration were therefore also primarily influenced by the ideas that emerged during the 1920s-1970s period (see section 4.2.2). As in the case of the earlier official guidelines, the document's reference list (a consolidation of previous reference lists), indicates that the residential street design standards that were produced by agencies like the American Association of State Highway Officials, the British Department of Transport and the Transportation Research Board in the 1970s and 1980s (see table 4.1), influenced the recommended approach to local network configuration.

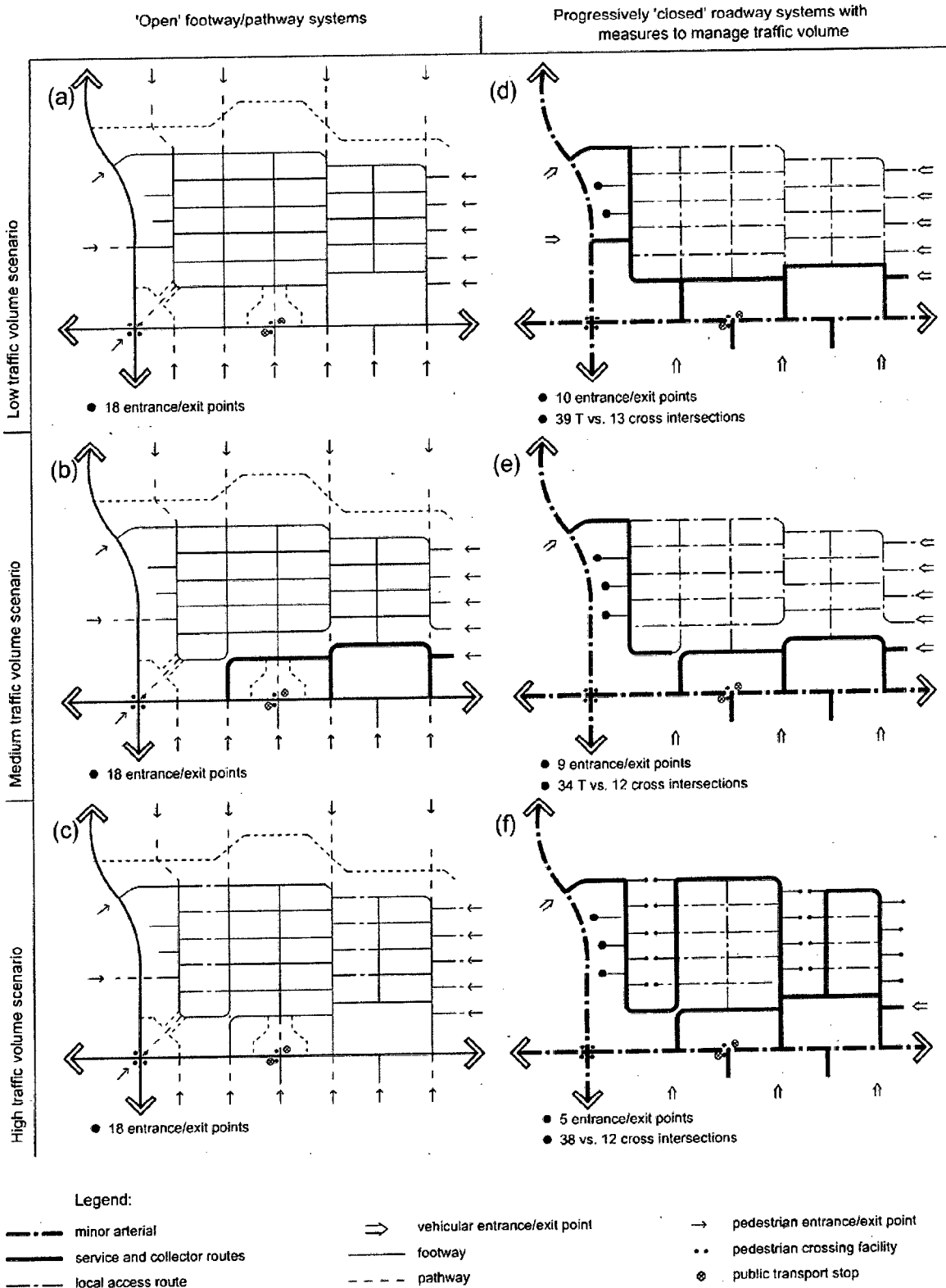
4.3.7 2000: Guidelines for human settlement planning and design (the 'new red book')

The final version in the CSIR's sequence of codes of practice was released in 2000 by the Department of National Housing (NDoH). The document, entitled *Guidelines for human settlement planning and design*, was compiled by the CSIR's Division of Building Technology. The need for a revision of the earlier 1994 code was identified by practitioners in a series of national workshops conducted in 1995 in which the planning chapters (chapters 1-3) were sufficiently criticised to motivate their complete redrafting (CSIR 1995). In particular, these chapters were criticised for 'favouring car-based communities'. The revision that followed represented the first substantive reconsideration of the local network configuration ideas presented in this sequence of codes. The chapters of the 'new red book' were concerned with settlement-making, planning method and participation, planning guidelines,⁸⁷ stormwater management, road geometric design and layout planning, road materials and construction, water supply, sanitation, solid waste management, and energy. The document argued that in order to achieve 'human- and nature-centred development', the following 'performance qualities' should be pursued in settlement-making: 'efficiency of resource use', 'opportunity generation', 'convenience',

⁸⁷ Chapter 5 on 'planning guidelines' was concerned with movement networks, public transport, hard open spaces, soft open spaces, public facilities, land subdivision, public utilities, and a variety of 'cross-cutting issues' including crime prevention, ecological sustainability and fire safety. As mentioned earlier, together with Vanessa Watson and Paul Mann, I assisted the CSIR in the preparation of the section on 'movement networks'.

'choice', 'equality of access', 'quality of place', 'sensory qualities', and 'sustainability' (see chapter 2 of NDoH 2000).

Figure 4.27 Local network configuration idea promoted in 'Guidelines for human settlement planning and design' (the 'new red book')



The essence of the guidance provided in relation to movement networks was that public rights-of-way, or road reserves, should be configured into networks that are multi-directional (see chapters 5.1 and 5.2 of NDoH 2000). This was argued to enable flexibility in the configuration of different movement systems for different modes, and address the criticisms of the car-oriented nature of local network configuration practices associated with earlier codes. It was argued to be possible for a multi-directional public right-of-way network to maintain easy and direct pedestrian and bicycle circulation in all directions, and in particular to public transport stops (through the design of the footway, pathway and cycleway component of the network as an open system); while at the same time preventing or limiting the safety and intrusion problems associated with extraneous vehicular traffic (through the design of the roadway component of the network as a 'closed' system). The exact configuration of a local network was however argued to be dependent on context specific factors like topography, the distribution of traffic generating activities in surrounding areas, and patterns of mode use.

A multi-directional public right-of-way network was further argued to enable the different movement systems for different modes to be adapted to become more 'open' or 'closed' as modal split and dynamic land use development processes alter the nature and pattern of movement demand and the functions of particular links. Network configurations were argued to determine, to a large extent, the pattern of land sub-division, which in turn forms the basis for title registration and the allocation of development rights. Given that large scale expropriation and compensation is required in order to significantly alter patterns of land ownership and development rights, discontinuous or 'dendritic' public right-of-way networks were argued conversely to be extremely difficult to adapt.

The approach to movement network planning promoted in the document was clearly influenced by the ideas that emerged during the 1980s and 1990s period around the relationship between network configuration on public transport use (see section 4.2.5), as well as those that emerged during the 1960s-1980s period in The Netherlands and Germany (see section 4.2.3). The explicit concern for the movement needs of pedestrians and public transport users echoed the interpretation of the planning and design 'problem' during these periods, and the focus on public transport stops in network configuration and pro-active traffic calming was consistent with the planning and design 'solution' that emerged in response to this interpretation of the problem. The document's reference list clearly indicates that many of the revised or supplementary residential street design standards listed in table 4.2 influenced the recommended approach to movement network planning practice in South Africa.

4.4 LOCAL NETWORK MANAGEMENT PRACTICES IN SOUTH AFRICA

Having now discussed codes of practice dealing with network configuration, which then of the approaches to local network *management* described earlier have been applied in South Africa, and what codes of practice have been prepared? A review of design codes that deal in whole or in part with the management of local movement networks (excluding road maintenance and urban traffic control) reveals numerous past, current and incomplete codes (see table 4.4). Management practices are discussed in terms of the addition or extension of movement infrastructure for pedestrians (incorporating footways, pathways and roadway crossing facilities), the addition or extension of movement infrastructure for cyclists (incorporating cycle lanes, cycleways and roadway crossing facilities), the control of vehicular traffic through roadway retrofitting (incorporating traffic calming and transport system management), and the provision of additional driveway or roadway accesses (incorporating access management).

Table 4.4 *Chronological publication of South African local network management codes of practice (excluding road maintenance and urban traffic control)*

YEAR	AGENCY	TITLE
1982	NDoT (Metroplan)	<i>Manual for the planning and design of bicycle facilities in urban areas</i>
1984	NDoT	<i>Guidelines for the planning and design of bicycle facilities in urban areas</i>
1987	NDoT (Metroplan)	<i>Guidelines for the planning and design of pedestrian facilities</i>
1988	NDoT	<i>Draft guidelines for the transportation system management process</i>
1991	NDoT (CUTA)	<i>Guidelines for the transportation system management process (UTG 9)</i>
1991	NDoT	<i>Guidelines for the choice of appropriate bus priority measures</i>
1992	NDoT	<i>Proposed guidelines to improve pedestrian safety at freeway interchanges</i>
1992	NDoT	<i>The determination of optimum sidewalk capacity in city centres and warrants for the provision of pedestrian footways in urban areas</i>
1992	NDoT	<i>HOV priority treatment in the South African context</i>
1992	NDoT	<i>South African road traffic signs manual</i>
1993	NDoT	<i>Pedestrian facility guidelines: Manual to plan, design and maintain safe ped. facilities</i>
1993	NDoT	<i>Spacing of accesses on major arterials</i>
1994	AA	<i>Traffic calming: guidelines and warrants</i>
1995	NDoT	<i>Spacing of accesses on arterials streets</i>
1995	NDoT	<i>General guidelines for transportation demand management</i>
1996	NDoT (CSIR)	<i>National guidelines for traffic calming</i>
1996	PAWC	<i>Road access policy</i>
1997	NDoT (COLTO)	<i>Guidelines for travel demand management (TPG 9)</i>
1997	NDoT (COLTO)	<i>Guidelines on traffic calming (TPG 14) draft</i>
1999	NDoT (COLTO)	<i>South African Road Safety Manual</i>
2001	PAWC	<i>Road access guidelines</i>
2001	PAWC	<i>Guidelines for evaluating and monitoring critical road traffic safety issues in the W. Cape</i>
2001	NDoT	<i>South African road traffic signs manual</i>
2001	NDoT (COTO)	<i>National guidelines for road access management in South Africa (draft)</i>
§	NDoT (COLTO)	<i>Guidelines on the transport system management (TSM) process (TPG 12)</i>

Note: §-abandoned, NDoT-National Department of Transport, CSIR-Council for Scientific and Industrial Research, CUTA-Committee of Urban Transport Authorities, PAWC = Provincial Administration of the Western Cape, COLTO-Committee of Land Transport Officials, COTO-Committee of Transportation Officials AA-Automobile Association of South Africa Road Traffic Safety Foundation

4.4.1 Pedestrian facilities

The management of local networks through the addition or extension of movement infrastructure for pedestrians has occurred within the frameworks of transport system management (TSM) programmes,

and road traffic (safety) management strategies (and more specifically within these, pedestrian plans). As will be discussed later (in section 4.4.3), TSM processes involved identifying transport system problems within a delimited study area, and generating and selecting appropriate solutions. While wide-ranging, some of these solutions potentially involved the improvement of infrastructure for pedestrians.⁸⁸ The infrastructure component of the current overarching national *Road Traffic Management Strategy* (RTMS) of 1997 proposes conducting road safety audits to identify high incident locations on the road network, and implementing a programme of short-term, cost-effective remedial engineering measures at these locations (Botha 1997, NDoT 2000). Provincial authorities have prepared road traffic safety management plans (e.g. PAWC 1998), which are intended to be implemented by metropolitan and local authorities (PAWC 2000). A *South African road safety manual* was released in 1999 specifically to assist in the process of preparing and implementing these plans (van Schalkwyk *et al* 1999) (see section 4.4.3). Of particular relevance to this section, a component of the provincial road traffic safety management plans are pedestrian (management) plans (e.g. Makhanya *et al* 1998, de Beer and Davidson 2000, de Beer and Johnson 2000). In line with the national RTMS, these plans involve conducting safety audits to identify hazardous pedestrian locations, and developing education, enforcement and remedial infrastructure measures to improve pedestrian safety at these locations. Important amongst remedial infrastructure measures are the provision of roadway crossing facilities and pathways.⁸⁹ In the case of the Provincial Administration of the Western Cape's *Pedestrian Plan* of 2000, 50 such hazardous locations were identified, 42 of which fell within the Cape Metropolitan Area.

Official codes of practice concerned with the addition or extension of movement infrastructure for pedestrians – and drawn upon in the implementation of the above pedestrian plans – have taken the form of a sequence of manuals for road traffic signage and signalling, and a sequence of guidelines for pedestrian facility planning and design.

The *South African road traffic signs manual* provides warrants for the provision of mid-block (or non-intersection) pedestrian crossing facilities, as well as for the provision of signals for pedestrian crossing at signalised traffic intersections. The manual has been revised on three occasions since its first release in the 1970s. The original edition, and its first revision in 1982, provided very basic warrants for pedestrian signal control based on pedestrian crossing volumes for any hour of a normal day. The later editions of the manual in 1993 and 2001 revised and extended these warrants considerably. In the 1993 edition, warrants were based on vehicle and pedestrian flows for any four consecutive hours (including a peak period) of any normal weekday (NDoT 1993:section 6.8.1).

⁸⁸ The schedule of possible 'pedestrian mode strategy actions' listed in the CUTA code on TSM, includes: widened sidewalks, new crossings, street closures, new walkways, car-restricted zones, overpasses, and islands (CUTA 1991:92).

⁸⁹ While national and provincial road traffic safety management plans identify traffic calming as one of the possible remedial measures that could be implemented to address hazardous locations, in practice, in the case of Cape Town at least, there is little or no relationship between these plans and the actual implementation of traffic calming measures (Sandra Hinrichsen *pers comm* 2001). As will be discussed later, this is largely to do with a disparity between the classification of roads subject to traffic calming in terms of current traffic calming policy, and the types of high incident road accident locations that have been identified in safety audits.

Various charts were provided onto which the flow of pedestrians and vehicles per hour could be plotted, with the placement of the plot on the chart indicating whether or not a crossing facility was warranted, and if so, whether or not it should be signalised. In the 2001 edition, queue lengths replaced volumes as the basis for warranting traffic signals (NDoT 2001:section 2.4.2).

The first official guidelines specifically for pedestrian facility planning and design were published in 1987 by the NDoT (Vorster and Greef 1987). The chapters of the code – entitled *Guidelines for the planning and design of pedestrian facilities* – covered pedestrian characteristics, pedestrian planning and design, pedestrian malls, and relevant South African legislation. The chapter on the characteristics of pedestrians described walking speeds, pedestrian space, walking trip generation rates and distances. The chapters on pedestrian planning and design provided guidance on the design process to be followed in the preparation of a pedestrian plan, pedestrian ‘levels of service’, and design standards for pathways, footways, stairs, queuing areas, street crossings, and pedestrian malls (with St Georges Mall in Cape Town and Voortrekker Mall in Alberton provided as case studies). In the absence of much South African data on pedestrian characteristics at the time, the guidelines drew quite heavily from studies in the United States (e.g. Fruin 1971, Pushkarev and Zupan 1975, TRB 1985, Untermann 1984).

A major revision and extension of the national guidelines for pedestrian facility planning and design occurred in 1993, in the form of *Pedestrian facility guidelines: Manual to plan, design and maintain safe pedestrian facilities* (Ribbens and de Beer 1993). The revised code was divided into four sections. The first section reiterated the *South African road traffic signs manual*'s warrants for, and provided guidance on the layout and siting of, mid-block crossings, refuge islands, grade-separated crossings, road intersection crossings, scholar patrol crossings, and footways. The second section identified planning and design considerations for particularly problematic pedestrian areas, including modal interchanges, pedestrian malls and road construction sites. The third section identified planning and design considerations for freeways and freeway interchanges. The fourth section provided guidance on the identification of hazardous locations and the compilation and use of pedestrian facility inventories. The 1993 code was the culmination of a research programme, conducted by the CSIR between the early 1980s and early 1990s, to develop warrants for the provision, and guidelines for the siting and layout, of various types of pedestrian facilities.⁹⁰ Warrants and design guidelines for mid-block crossing facilities were proposed by Lockwood (1987), Ribbens and Bohar (1981) and Ribbens (1983 1985a 1987). Design guidelines for pedestrian refuge islands and grade-separated pedestrian crossings were proposed by Ribbens (1985b 1989). Countermeasures for unsafe road intersection crossings were proposed by Ribbens (1985c). Warrants for the provision of paved footways were proposed by the NDoT (1992), and design guidelines for improving pedestrian safety at freeway interchanges were proposed by de Beer and Ribbens (1992).

⁹⁰

For a more detailed overview, see Hubrecht Ribbens' (1996) retrospection on this research programme.

4.4.2 Bicycle facilities

The management of local networks through the addition or extension of movement infrastructure for cyclists has typically occurred within the frameworks of bicycle demonstration projects (e.g. in Cape Town, Pretoria and Randburg in the late 1970s and early 1980s), and potentially TSM programmes (see section 4.4.3). Bicycle travel, while accounting for a minimal share of mode split in South African cities as demonstrated in chapters 2 and 3, has recently been given a significant boost by a national bicycle transport initiative – *Shova Kalula* (meaning ‘pedal easy’) – launched in 2001. *Shova Kalula* is aimed at overcoming current impediments to the supply of low cost (i.e. <R150) bicycles. It is a joint initiative between the national, provincial and local spheres of government and a non-government organisation Afribike, and is supported by partners in the United States, United Kingdom and The Netherlands. New and used low-cost bicycles are procured from overseas, and a delivery chain has been developed for their distribution that includes cycle repair training courses, occasional modifications to produce load carrying work-cycles, and container-based shops. The initiative is targeted at an estimated 350 000 secondary school and 445 000 primary school scholars who currently walk more than 3 km to school, as well as to an estimated 573 000 urban and 472 000 rural workers who currently walk for more than 20 minutes daily to get to work. (NDoT website 2001)

Official codes of practice concerned with the addition or extension of movement infrastructure for cyclists have, as in the case of pedestrian facilities, taken the form of the *South African road traffic signs manual* which provides warrants for mid-block and traffic intersection crossing in much the same way as it does for pedestrians, and a sequence of national guidelines for bicycle facility planning and design.

The first official guidelines for bicycle facility planning and design were published in 1982 by the NDoT. The chapters of the code – entitled *Manual for the planning and design of bicycle facilities in urban areas* – covered bicycle problems and needs, bicycle promotion, the classification of cycle paths, the planning process that should be followed on preparing a bicycle plan, interim warrants for the provision of cycle paths, the design of the various classes of cycle path, cycle path construction, traffic control, and related facilities like bicycle parking, lighting and rest areas. The chapter on classification proposed four classes of cycle paths: class 1 ‘cycle roads’ occupying a completely separate reserve for use by both cyclists and pedestrians; class 2 ‘cycle ways’ within road reserves but separated from the roadway by a kerb or barrier; class 3 ‘cycle lanes’ demarcated on carriageways by road markings; and class 4 ‘on-street cycle routes’ indicating unmodified roadways upon which bicycle use is permitted. Interim warrants to determine the provision of each of these classes were based upon peak hour bicycle and motor vehicle volumes. Because little South African research had been undertaken on bicycle facilities at the time, the code was explicitly based on codes mainly from the United States and United Kingdom.

A revision of the guidelines for bicycle facility provision occurred in 1984, in the form of *Guidelines for the planning and design of bicycle facilities in urban areas* (Vorster 1984). The broad content of the revised edition remained essentially the same as its earlier edition. The main change was a refinement of guidelines and warrants on the basis of South African experiences derived from the implementation of the national bicycle demonstration projects in Cape Town, Pretoria and Randburg (de Waal and Garrod 2001). Additions and changes included a greater number of illustrations, and three annexures dealing with the three demonstration projects, the administration of bicycle surveys, and an example of demand estimation of school-based bicycle trips. Warrants for the provision of cycle paths continued to be based upon bicycle and motor vehicle volumes, but were simplified.

4.4.3 Roadway retrofitting

The management of vehicular traffic in local networks through roadway retrofitting has occurred within the frameworks of TSM programmes, road traffic safety management plans and traffic calming policies, as well as, potentially, the mitigating measures associated with traffic impact assessments (TIAs) of new land use developments. In much the same way as hazardous pedestrian locations are identified and considered for remedial pedestrian facilities as discussed earlier, within these frameworks locations experiencing high vehicle accidents, capacity bottlenecks or traffic intrusion problems are identified and subjected to an assessment of possible remedial roadway retrofitting measures.

Official codes of practice concerned with the control of vehicular traffic through roadway retrofitting have taken the form of an UTG guideline on the TSM process, the earlier mentioned road safety manual, and various traffic calming policies.⁹¹

The UTG guideline on TSM – entitled *Guidelines for the transportation system management process (UTG 9)* – was released by CUTA in 1991, three years after an initial draft version. The code defined TSM as a short term management process aimed at achieving maximum efficiency from the transport system, through a range of (preferably low cost) measures covering transport infrastructure, modes, land use and human behaviour (CUTA 1991). A later revision of this code, as part of COLTO's TPG series, was abandoned. The code sets out a 7-stage TSM process which involves: communication by the public of their transport system improvement needs; the definition of the TSM problem including the delimitation of the study area, the identification of goals and objectives, and the identification of specific problems and 'problem locations'; the generation of three or more alternative solutions for each problem identified; the analysis of alternative solutions in terms of their maintenance costs, and compatibility with goals and objectives and longer term transport plans; the evaluation and selection of

⁹¹ In order to focus this section on *local* roadway retrofitting practices, the section excludes codes of practice dealing with measures that afford priority to buses and other higher occupancy vehicles, and with travel demand management strategies more generally. While these measures clearly involve roadway retrofitting, they are primarily metropolitan, as opposed to local, interventions.

the most appropriate alternative through a procedure that incorporates the public's views, accident statistics and a cost-benefit estimation; the implementation of selected alternative solutions within twelve months of the initial public communication; and finally the monitoring of the effectiveness of implemented solutions principally through before and after survey comparison. The schedule of possible TSM actions listed in the code, that involve roadway retrofitting, includes: intersection reconfiguration, median turn restrictions, road closures, on-street parking removal or expansion, park-and-ride lots, bus priority measures, new lanes, one-way streets, turn lanes, and road widening (CUTA 1991:appendix G).

The *South African road safety manual* was produced by COLTO's Road Traffic Management Co-ordinating Committee in 1999. The code provides guidance on the preparation of road traffic safety management plans. As in the case of pedestrian plans and TSM programmes, the recommended process involves a method through which a transport planning authority can identify, prioritise and analyse hazardous locations, evaluate alternative remedial measures, as well as monitor the performance of measures after implementation. The code draws from previous studies and manuals in Australia, the United Kingdom and United States, but represents, according to the authors, one of the first examples of a comprehensive best-practice road safety manual. (van Schalkwyk *et al* 1999)

The first official national guidelines on traffic calming were released in 1996 by the NDoT (Schermers 1996). The chapters of the code – entitled *National guidelines for traffic calming* – covered a national traffic calming policy framework, a range of implementational issues, traffic calming need studies (including warrants), and the selection of appropriate measures. The guidelines recommended that traffic calming projects be identified within the framework of TSM, in preference to *ad hoc* public requests. Traffic calming policies have however been drafted and implemented by local authorities, not higher spheres of government. In the case of metropolitan Cape Town, prior to the amalgamation of the six local metropolitan councils into a single 'unicity' authority in 2000, each of the local councils implemented their own policy. These independent policies were replaced by a single draft policy in 2001, entitled *Traffic calming policy for the City of Cape Town* (CCT 2001). The chapters of the new policy document cover the management and co-ordination of traffic calming operations by 'traffic calming teams' responsible for specified areas, the traffic calming process, and funding. The prescribed traffic calming process involves a written application from members of the public (and in some instances by officials or consultants) for traffic calming measures to be applied to a specified street(s). An initial assessment leads to a decision on whether the application should be dealt with in terms of a 'traffic calming policy', or a more flexible 'public amenities traffic safety policy'.

If adjudged to be a traffic calming policy issue, the application is then subjected to a screening process whereby a score is derived from a set of weighted criteria (e.g. number of accidents, through-traffic volume, pedestrian volume, vehicle speeds, etc.). If the score, or warrant, exceeds a specified number

(currently set at 30) the application is subjected to a further detailed investigation, the weighted scoring of which is then used for the prioritisation of traffic calming project implementation in the context of constrained budgets. The detailed investigation criteria are based in the national code of 1996. If the score derived from the screening process is less than the specified number, the application is refused. The data collected in the detailed investigation is then used to inform the selection of appropriate traffic calming measures. The proposed measures are submitted to affected residents for comment, and implemented if 80% affected resident approval is achieved. In terms of the policy, only class 5 residential roads, and under special circumstances, class 4 local distributors, are considered for the implementation of traffic calming measures. In the absence of an inventory of classified streets, the traffic calming team applies its judgment to determine the classification of the road subject to application. Drawing from the earlier discussed 'blue book' of 1983, local distributors are defined in the policy as 'residential through roads which primarily distribute traffic within communities and link district distributors and residential access roads' (see figure 4.22).

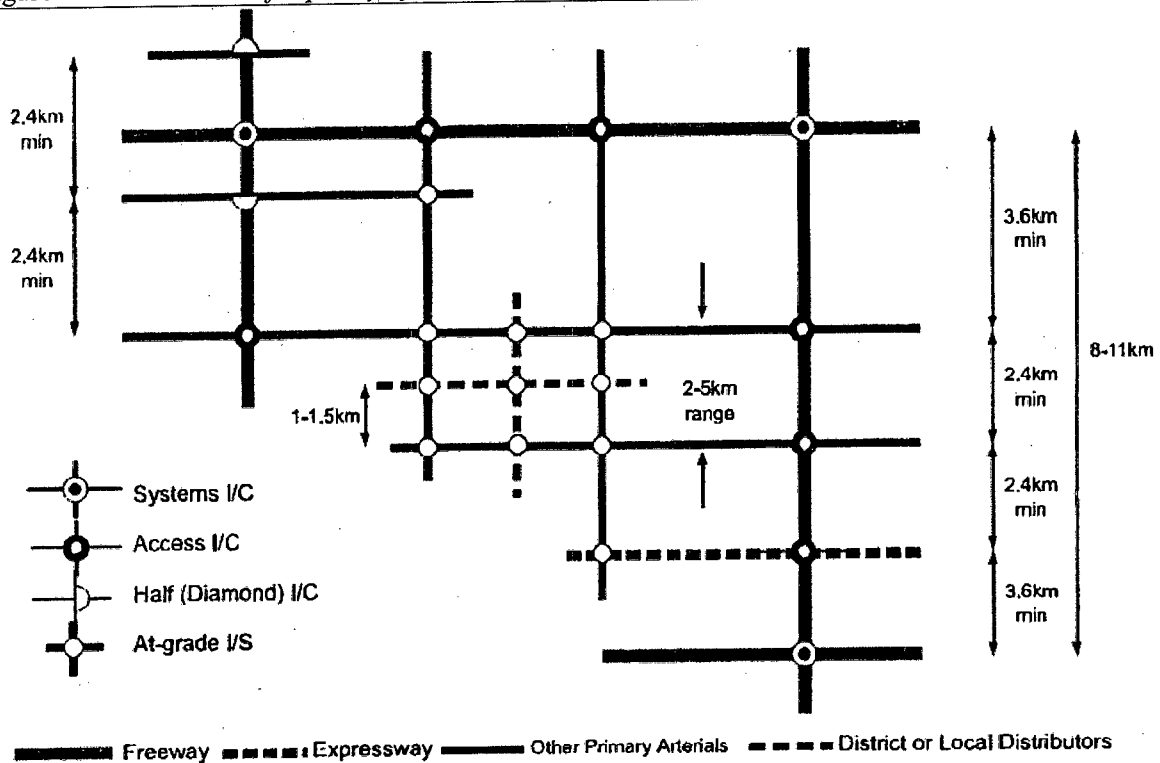
If the application is adjudged to be a public amenities traffic safety policy issue – in other words a traffic calming issue at a localised area immediately surrounding public facilities like schools, libraries and clinics – a weighted scoring is determined for the purposes of prioritising pedestrian accesses for treatment. No cut-off score is applied to warrant the implementation of traffic calming measures, and the public amenities traffic safety policy takes precedence over the traffic calming policy. The policy is not restricted to just class 4 and 5 roads as in the case of the traffic calming policy, and the public participation process is restricted to the governing body of the public facility in question.

The approach to roadway retrofitting adopted in the above codes of practices has clearly been influenced by the policy responses aimed at using existing road networks more efficiently discussed in the 1980s-1990s period (see section 4.2.5), as well as, to a lesser extent the '*woonerf*' and '*verkehrsberuhigung*' ideas that emerged in the earlier discussed 1960s-1980s period (see section 4.2.3).

4.4.4 Access management

The management of driveway or roadway access provision has occurred within the frameworks of road access standards and access management plans. While access management is clearly a metropolitan or at least corridor planning issue, arterial access spacing policies effectively delimit local areas and impact on how local networks are connected to larger scale movement networks, and are therefore included in this section. Historically, access standards applied in South Africa have been influenced by road development philosophies formulated in the United States (PAWC 2001), with their origins in the 'precinct planning' and 'environmental area' ideas discussed in 1920s-1970s period (see section 4.2.2).

Figure 4.28 *Parallel frequency of arterials recommended in 'Road access guidelines'*



Source: PAWC 2001:19

Provincial transport authorities have been the agencies responsible for the assessment of much roadway or driveway access applications arising from new land use development adjacent to arterial routes, and have therefore produced their own codes of practice dealing with access standards and arterial management. In the case of the Provincial Administration of the Western Cape (PAWC), a draft *Road access policy* was released in 1996, and later revised as the *Road access guidelines* in 2001. The chapters of the revised code cover the interaction between transport systems and land use development, the functions and hierarchical classification of roads, intersection and access categorisation, access spacings, arterial access management planning, and a range of associated issues including service roads, pedestrian access and emergency services. Guidelines are provided on the spatial location, or parallel frequency, of different classes of arterials. The recommended parallel frequency of 'freeways', 'expressways and other primary arterials', 'district distributors' and 'local distributors' is 8-11 km, 2-4 km, 1-1.5 km and 0.5-1 km respectively (see figure 4.28). Beyond this basic spacing of arterial interchanges and intersections, minimum access spacings for 'expressways', 'primary distributors', 'district distributors' and 'local distributors' are provided for different interchange or intersection conditions (e.g. full vs. left turn only access, signalised vs. unsignalised, driveway vs. normal side street, and driveway volumes). In addition, the code adds an innovative extra dimension to minimum access spacings by developing a further variation according to the 'roadside development environment' (including 'urban', 'intermediate', 'suburban', 'semi-rural' and 'rural' environments), with spacing standards relaxed in more intensive urban settings. So for instance, the minimum recommended spacings of full access unsignalised normal side streets and signalised intersections along a 'local distributor' are 60 m and 225 m respectively in an 'urban' development

environment, whereas in a 'suburban' development environment these spacings increase to 120 m and 375 m respectively (see PAWC 2001:66, figures 6.5.1 and 6.5.2).

A process to produce nationally uniform access management guidelines – entitled *National guidelines for road access management in South Africa* – was initiated under the auspices of the Committee of Transportation Officials (COTO). Earlier national guidelines on arterial access spacing were released by the NDoT in 1993 and 1995. Initial indications are that the proposed draft national guidelines prepared in 2001 differ fairly significantly from the PAWC code, and how this will be resolved was, at the time of writing, unclear.

4.5 SUMMARY AND CONCLUSION

Since the first appearance of town planning as a specialist discipline at the turn of the previous century, a number of approaches to local network configuration and management can be identified, from those concerned with creating geographically-defined social units that emerged in the early 1900s; to those aimed at accommodating increased car use and at restricting through-traffic of the 1930s to 1960s; to those aimed at reducing vehicle speeds and at minimising of serviced land costs of the 1970s; to those aimed at encouraging walking, cycling and public transport use of the 1980s and 1990s. Changes in configuration and management practices have typically occurred in response to shifts in mode share, and the problems associated with increased motor car traffic in particular, as well as changes in the broader transport policy environment. Most innovation occurred in the United Kingdom, United States and Western Europe.

Network configuration practices in South Africa have taken the form of 'closed' 1.5-2 km square cells of collector and access road networks contained within delimiting grids of limited access arterials and freeways, and introverted in terms of land use distribution and pedestrian movements. These practices have been drawn from British and American ideas concerning road hierarchies and through-traffic elimination developed in the 1920s-70s period (e.g. the 'environmental area'), and concerning introverted pedestrian movement developed in the 1900s-20s period (e.g. the 'neighbourhood unit'). South African practices have thus shared, even if implicitly, the underlying assumptions of these ideas regarding the inevitability of universal car access and the introverted or localised nature of walking trips. Insufficient consideration has been given to how travel needs and behaviours differ between South African contexts, and the contexts within which these imported ideas emerged. In reality, South African car ownership was and is significantly lower, reliance on non-motorised travel significantly greater, walking trip lengths considerably longer, and pedestrian road accident fatalities considerably higher. The evolution of South African codes of practice outlined in this chapter illustrates how the accommodation of the travel needs of low-income groups (or 'developing communities') was essentially considered within the basic framework of a local network configuration idea developed out

of a consideration of the travel needs of middle and high-income groups (or ‘developed communities’). Later versions of the CSIR’s design codes (in the form of the ‘brown’ and ‘green book’) acknowledged that the earlier ‘blue book’ had in fact been developed for use in ‘developed communities’ (or ‘municipal townships’). In preparing these later versions, the CSIR was instructed to consider how the site planning and network configuration guidelines presented in the ‘blue book’ might be applied in a ‘developing community’ context, not to fundamentally reconsider them. Concerns raised about the applicability of the ‘blue book’ guidelines revolved primarily around affordability, not their appropriateness.⁹² The question raised at the beginning of this chapter related to the extent to which South African local network planning practices have been developed to match actual local travel need. In truth, with regard to majority low-income population of the country at least, on the basis of the review presented in this chapter it is my contention that this has seldom happened, and that local network configuration practices would surely be improved by closer examination of, and response to, actual travel need and behaviour.

The simultaneous emergence, in the late 1980s and 1990s in different parts of the world, of new codes of practice that challenge the assumptions underlying the ideas developed in the 1920s-1970s period (e.g. the ‘pedestrian pocket’ and ‘transit-oriented development’), suggests that what may ultimately, if not already, be regarded as a significant shift in what is dominantly regarded as ‘best practice’ internationally has begun. While in the past there has seldom, if ever, been universal agreement on what constitutes ‘best practice’, it is clear that the local network configuration ideas promoted by the South African codes prepared during the 1980s and early 1990s are not consistent with this international shift in thinking. It is my view that there is a need to fundamentally reconsider the appropriateness of South African local network configuration practices and their underlying assumptions. New ideas need to be developed that take as their starting point the travel needs of the poor majority. A conceptual shift is required in which networks are configured first to meet the needs of non-motorised and public transport modes, and then to accommodate the use of motor cars. The degree to which the recent revisions of some design codes can introduce design practices that do this remains to be seen.

Network management practices in South Africa have taken the form of procedures through which hazardous or inefficient locations within road networks are identified and warrants for pedestrian and bicycle facilities, TSM and traffic calming measures are assessed, as well as access management and TIA mitigation associated with new land use development applications. These practices have also been drawn from British and American ideas originally developed in the 1920s-70s period (e.g. ‘precinct

⁹² The Minister of Education and Development Aid at the time stated in the ‘brown book’s’ preface that “[f]or some time now, it has been the policy of government to relate its standards and controls on housing to the needs of communities, in general, and the ability of individuals to pay, in particular. This means that more emphasis is now placed on the provision of land (serviced and unserviced) than, as in the past, on the provision of housing. Accordingly, it has become necessary for government to review its policies and practices regarding land development, the standards for engineering services and amenity levels and standards. ... In keeping with this need, my Department contracted the [CSIR] to prepare [the ‘brown book’]. The Council was instructed to base the document on the [‘blue book’], which was targeted on municipal townships, but to ensure that there was no needless repetition of ... material.”

planning' and 'environmental traffic management'), as well as more recent ideas associated with improving system efficiency and speed reduction on residential streets. The review presented in this chapter illustrates that, with the exception of those associated with TSM procedures, South African codes of practice have tended to focus on the geometrics of paths and crossings, and on the circumstances under which different types of retrofitting management measures might be warranted at specific locations. Recommended management practices as a result, and as a general rule, do not undertake causal analyses of problems beyond localised traffic engineering assessment of 'road environment' factors like driver visibility, skid resistance, crossing facilities and guardrails. Analytical questions associated with non-motorised trip purposes, timing, origin and destination, and route selection for instance, tend to be omitted, with the consequence that not much is said in the codes about important issues like land use distribution and how this gives rise to particular patterns of non-motorised trip-making, and pedestrian and bicycle network connectivity and the impact of parallel arterial frequency on severance.

Local network management practices have tended to be site-specific (in a spatial or network sense) and reactive (in the sense that management measures are considered on the basis of public request or hazardous location identification) – commonly described as a 'black spot approach'. In terms of the dissertation's aim of investigating whether practices can be improved, it is my contention that local network management practices would surely be improved by a more co-ordinated and proactive approach. Such an approach would enable a more holistic and causal analysis of local area transport problems, and prevent problems from simply being shifted elsewhere. Proactive and area co-ordinated transport planning has only really ever occurred in South Africa at a metropolitan-wide scale.

Chapter 5

Relationships between local network configuration and management practices, and improved local travel conditions

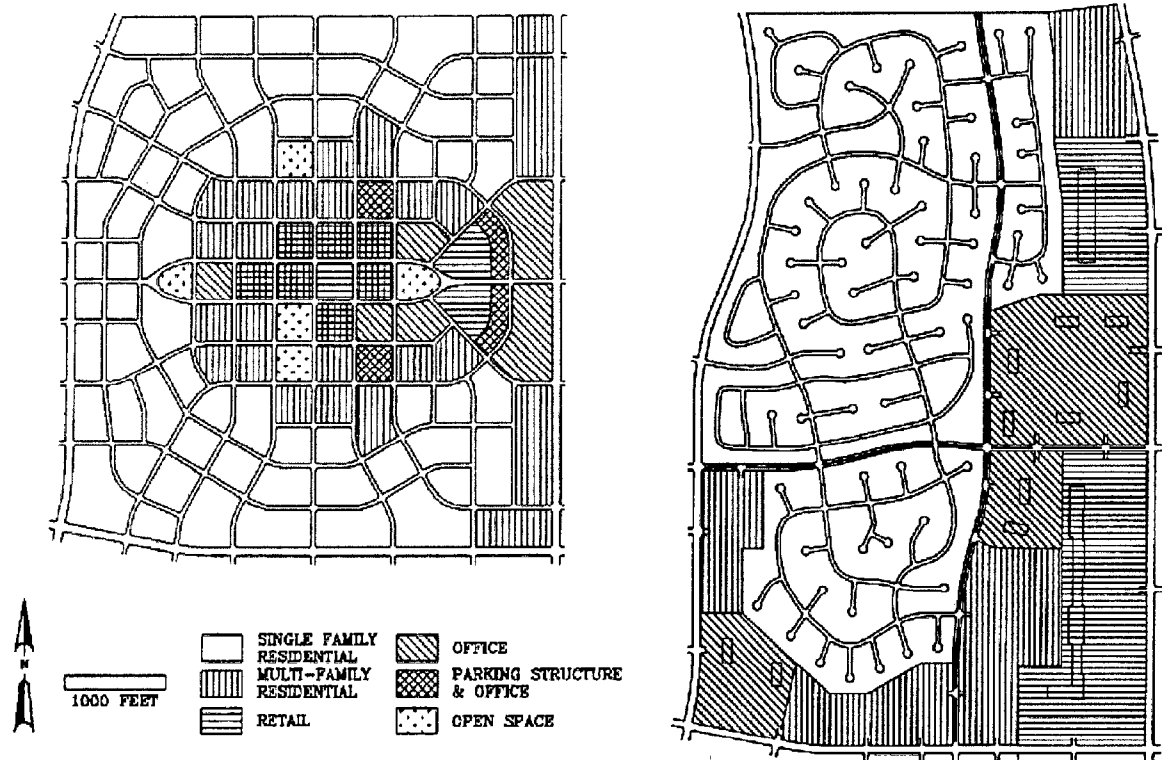
5.1 INTRODUCTION

In chapter 2 it was established that the ambit of travel behaviour in South African cities has not been particularly well understood, and in chapter 3 it was revealed that travel within local networks and on foot is of great importance, particularly for those without access to motor cars. Chapter 4 went on to conclude that local network planning practices in South Africa have been imported without rigorous consideration of contextual difference and, in the case of management more specifically, have typically been site-specific and reactive. This chapter then addresses the question of what evidence there is of different local network planning practices improving the conditions of travel within local networks, and of what precedent there is for more co-ordinated and proactive local network management processes.

A considerable literature has developed which addresses the question of improved local travel conditions articulated above, following the emergence of the earlier mentioned network configuration ideas in the late 1980s and early 1990s explicitly oriented to the needs of non-motorised and public transport modes (see section 4.2.5). The proponents of these ideas – in the form of ‘traditional neighbourhood developments’, ‘pedestrian pockets’ and ‘transit-oriented developments’ – claimed in essence that a combination of mixed land uses, ‘open’ street networks, higher residential densities and narrower ‘calmed’ roadways, would lead to, amongst other things:

- less kilometres travelled – as a result of mixed land uses and more direct network connections;
- a shift from car use to walking and public transport ridership – as a result of closer destinations, ‘pedestrian-scaled’ streets and higher passenger thresholds;
- reduced congestion – as a result of alternative network connections and dispersed travel patterns; and
- safe vehicle speeds – as a result of proactive traffic calming.

Figure 5.1 'Suburban' vs. 'neo-traditional neighbourhood design'



FEATURES:

- open to through-traffic – through the use of grid-like networks
- the land uses fronting streets are mixed
- blocks lengths and street widths are ‘scaled’ to the person on foot
- residential densities are higher

FEATURES:

- closed to through-traffic – through the use of numerous loops and *culs-de-sac*
- the land uses fronting streets are segregated – hence it is possible to identify residential streets, commercial streets, and industrial streets
- blocks are large
- residential densities are low

Source: ITE 1994:2,4 (after Stone and Johnson 1992)

These claimed benefits have been the focus of numerous studies since 1990 which have attempted to test – through either traffic simulation modelling,⁹³ primary empirical observation,⁹⁴ or analysis of secondary datasets⁹⁵ – whether claimed benefits are true, and if so, how significant they are.^{96,97}

Typically, two generic local network forms have been subjected to comparison: one a conventional

⁹³ See for instance Kulash *et al* 1990, Stone and Johnson 1992, and McNally and Ryan 1993.

⁹⁴ See for instance Handy 1992, Cervero 1993, Calthorpe Associates 1995, Cervero and Radisch 1995, Cervero and Gorham 1995, Handy 1996a, Handy 1996b, Kitamura *et al* 1997, Shriver 1997, Moudon *et al* 1997, and Snellen 1999.

⁹⁵ See for instance Cervero 1994, Ewing *et al* 1994, Friedman *et al* 1994, Ewing 1996, Cervero and Kockelman 1996, McNally and Kulkarni 1996, Boarnet and Sarmiento 1996, Helling 1996, Kockelman 1997, and Crane and Crepeau 1998.

⁹⁶ Most, but not all, of this research has occurred in the United States in central and southern Californian cities. This is perhaps because, whereas local network planning research in the United States has been concerned with overcoming the transport and environmental externalities associated with sprawling suburban, car-dependent cities, research in Europe has generally been concerned with managing increasing traffic in older compact urban settlements, built prior to large scale private car ownership. Other possible reasons are that southern Californian cities, like Los Angeles, experience some of the worse levels of vehicle emission-based air pollution in North America, and that these cities contain a variety of generic network configurations (from circuitous suburban to gridiron networks) that facilitate empirical comparison.

⁹⁷ Perhaps because it is a tangible characteristic of these ideas, and the most tangible of claimed benefits, the relative impact of generic network configurations on travel patterns has received the greatest research attention. Other more intangible benefits claimed in the ‘neo-traditional planning’ and ‘new urbanist’ literature, like ‘a sense of place’ and ‘neighbourliness’, have received far less, if any, research attention.

suburban PUD; the other a network with TND and TOD characteristics (see figure 5.1). The conclusions of these studies have been the focus of considerable debate.⁹⁸

The chapter is divided into six sections, including this introduction and a concluding summation. The above mentioned literature is reviewed in terms of two themes. Section 5.2 (the next section) deals with the first theme which relates to the impact that network configuration has on travel behaviour. Section 5.3 deals with the second theme which relates to the impact of network configuration on congestion. A surprising omission in the debate surrounding 'neo-traditional' and 'new urbanist' ideas is consideration of the impact of their grid-like street networks on 'rat running', 'hot rodding' and road accident safety. As discussed earlier, the initial motivation for 'closed' circuitous street networks was after all the increase in road accidents in 'open' networks as a result of increased levels of speeding, extraneous vehicular traffic. This literature review is therefore supplemented by a review of other literature on road accidents in residential neighbourhoods and the effects of traffic calming measures, to introduce a third theme, in section 5.4, relating to the impact of network configuration and management on road safety. Section 5.5 follows with a discussion on precedent for proactive and area-wide local network management processes. The concluding section discusses the implications the reviewed evidence and precedent has for transforming current South African practices in the field of local network configuration and management. The literature reviewed in the chapter represents the third of three literature reviews presented in the dissertation.⁹⁹

5.2 EVIDENCE OF RELATIONSHIPS BETWEEN NETWORK CONFIGURATION AND TRAVEL BEHAVIOUR

What evidence is there then of the impact of network configuration on travel behaviour? This evidence is discussed here in terms of the demand for travel (measured in trip lengths, kilometres travelled, vehicle hours travelled and trip generation rates), and the utilisation of different travel modes (measured in modal split).

5.2.1 Travel demand

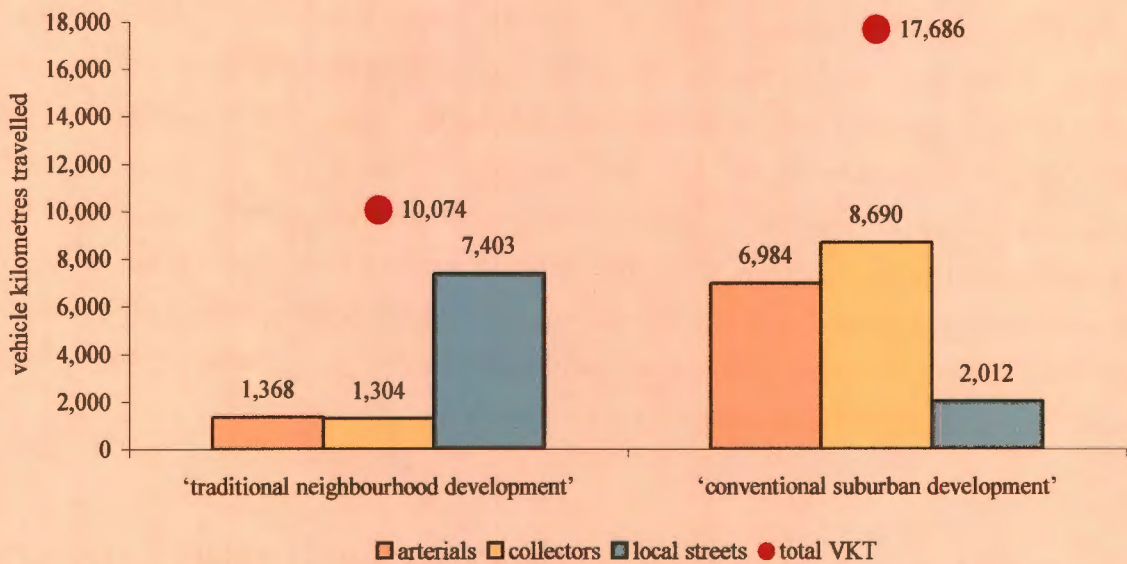
Earlier traffic simulation studies that investigated the impact of network configuration on the demand for travel, concluded that 'neo-traditional' networks necessitate less travel than 'suburban' networks. A simulation study undertaken by Walter Kulash *et al* (1990) argued that, as a result of more direct traffic routing and mixed land uses (i.e. dispersed destinations), 'traditional neighbourhood developments' produce 43% less vehicle kilometres travelled, than conventional 'planned unit

⁹⁸ See for instance Bookout 1992, Woodhull 1992, McNally 1993, TRB 1995, Crane 1996a 1996b, Meyer 1997, Niles and Nelson 1999, Barton 2000a, Litman *et al* 2001, and Boarnet and Crane 2001 – the latter being the most recent and comprehensive of these reviews.

⁹⁹ The earlier two reviews deal with travel analysis (in chapter 2) and local network planning practices (in chapter 4).

developments' (10 074.22 km vs. 17 686.21 km) (see figure 5.2). The study only modelled internal trips however, and assumed a constant trip generation rate for both hypothetical developments. A further simulation study undertaken by Michael McNally and Sherry Ryan (1993) argued that, as a result of drivers being able to choose more direct routes, 'neo-traditional network designs' produce 11% less vehicles kilometres travelled (259 360 km vs. 290 130 km) and 15% shorter average trip lengths (17.60 km vs. 20.69 km), than 'conventional network designs' (see table 5.1). All aspects of the modelled neighbourhoods were held constant, except for the configuration of the road networks.

Figure 5.2 *Simulated comparison of vehicle kilometres travelled: 'conventional suburban' vs. 'traditional neighbourhood' development*



Source: Kulash *et al* 1990

Table 5.1 *Simulated comparison of travel characteristics: 'conventional' vs. 'neo-traditional' network design*

	'NEO-TRADITIONAL NETWORK DESIGN'	'CONVENTIONAL NETWORK DESIGN'
Total trips	14 733	14 019
vehicle km travelled (a.m. peak)	259 360	290 130
total vehicle hours travelled (a.m. peak)	3 940	5 390
mean speed	65.75 kilometres/hour	53.85 kilometres/hour
mean trip length	17.60 kilometres	20.69 kilometres
mean internal trip time	1.50 minutes	1.74 minutes
mean internal-external trip time	9.87 minutes	14.79 minutes
mean through trip time	10.76 minutes	14.64 minutes

Source: McNally and Ryan 1993:75

The assumption of constant trip generation made in these simulation studies was however challenged by subsequent empirical studies, which argued that the greater accessibility created by 'neo-traditional' networks and mixed land uses resulted in varying rates of trip generation across generic network types,¹⁰⁰ and that the travel reduction benefits of 'neo-traditional' networks were therefore

¹⁰⁰ There is an interesting parallel here with the literature on the paradoxical relationship between road capacity increases and induced traffic (Goodwin 1996). The behavioural responses that induce more trips as a result of either road

overstated. An empirical study in the San Francisco Bay area (California), undertaken by Susan Handy (1992), argued that, as a result of greater convenience and accessibility, 'neo-traditional developments' generate 20% more sub-metropolitan and local shopping trips than 'planned unit developments' (18,74 vs. 14,94 person trips/month). She argued that in neighbourhoods with high levels of 'local accessibility', residents have greater opportunities to make numerous short trips to local activities, than in conventional circuitous suburbs, and therefore are more likely to make walking trips to commercial areas. It could not be determined however whether these walking trips replace, or are in addition to, car trips. On the basis of Handy's and other empirical findings, Randall Crane (1996a, Crane and Crepeau 1998) argued that increased trip generation may well offset the shorter mean trip lengths associated with 'neo-traditional' network configurations – resulting in more total vehicle kilometres travelled. He argued that a change in land use and network configuration that improves local accessibility therefore, may or may not reduce car travel – or as Boarnet and Crane (2001) put it, pedestrian- and public transport-friendly plans may 'unintentionally backfire'.

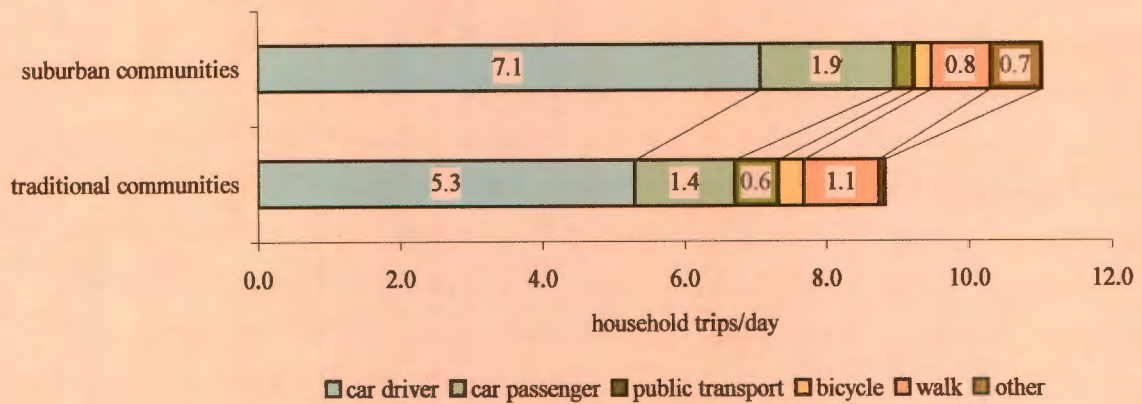
An empirical study in Palm Beach (Florida), undertaken by Reid Ewing *et al* (1994), further de-emphasised the travel reduction benefits of 'neo-traditional' networks and mixed land uses by arguing that despite enjoying ten times less 'accessibility', 'suburban' households generated only two-thirds more vehicle hours of travel per person than comparable households in a 'traditional' area. This, they argued, is because 'suburban' households tend to compensate for poor 'accessibility' by planning multi-purpose trips or carefully linking the individual trips of household members into trip chains.

A later empirical study in the San Francisco Bay area, undertaken by Bruce Friedman *et al* (1994), attempted to clarify the degree to which additional non-work walking trip generation in 'neo-traditional' neighbourhoods, replaces, or is in addition to, non-work car trips. They argued that, when work, non-work, home-based and non-home-based trips are combined, 'suburban community' households, on average, generate 20% more daily trips than 'traditional community' households (11.03 trips/day vs. 8.83 trips/day), and that 'suburban' households take 11% more of these daily trips by car (86% vs. 77%), and 33% less by foot (8% vs. 12%) (see figure 5.3).¹⁰¹ Handy's (1996b) later empirical research in Austin (Texas) indicates that while network design clearly plays a role in encouraging greater pedestrian activity, it is unlikely to lead to significant savings in vehicle kilometres travelled as a result of switching from car to walking modes, and that the opportunity to walk in some cases at least induces trips that would otherwise not have been made.

capacity improvement or greater local accessibility, can both be argued to be consistent with the basic micro-economic theory of supply and demand. In terms of the micro-economics of supply and demand, any increase in supply (i.e. greater road capacity or local accessibility) results in a reduction in price (i.e. the generalised cost of travel). The theory holds that when any good (i.e. travel) is reduced in price, demand for that good increases. Hence increased road capacity or greater local accessibility leads to generalised costs going down, and so demand for travel increases and trips are induced.

¹⁰¹ A similar pattern was found amongst higher income households in Cape Town. The household trip generation rates for the outer and inner location sampling areas of Welgelegen and Rondebosch were 12.34 and 9.88 trips/weekday respectively.

Figure 5.3 *Empirical comparison of daily household trip generation: 'suburban' vs. 'traditional' communities (San Francisco)*



Source: Friedman *et al* 1994:68

These studies illustrate that the research methods applied in understanding the link between neighbourhood design and travel demand, and more particularly some of the assumptions that have been made in these studies, have at times been problematic. More specifically, with regard to the fact that the studies undertaken have largely been conducted at a local area scale, a number of authors have argued that since the transportation impacts of different neighbourhood designs are most likely to accrue at a sub-metropolitan or metropolitan scale, it is at this scale that comparative assessments need to be undertaken. It has been argued that it is only at this scale of simulation or empirical observation, that the impacts of urban form on external trip-making and the effectiveness of metropolitan public transport systems in particular, can be accurately observed. (Cervero 1993, McNally 1993)

These studies also illustrate that the link between neighbourhood design and travel demand is complex, and yet to be properly understood. The travel choices people make can only really be explained if the detailed choices available to them, and their attitudes towards these, are thoroughly understood. More recent studies have concluded that urban form has a relatively marginal impact on travel demand. In an analysis of secondary data, Robert Cervero and Kara Kockelman (1996) for instance, concluded that while residential density, mixed land uses and 'pedestrian-oriented' network design all reduce vehicle kilometres travelled per capita and encourage non-car travel in statistically significant ways, their influences tend to be fairly marginal. Ryuichi Kitamura *et al* (1997) similarly conclude that, while residential density, public transport accessibility, mixed land use, and the presence of footways are significantly associated with trip generation and modal split, attitudinal variables are more strongly associated with travel behaviour than neighbourhood design characteristics.

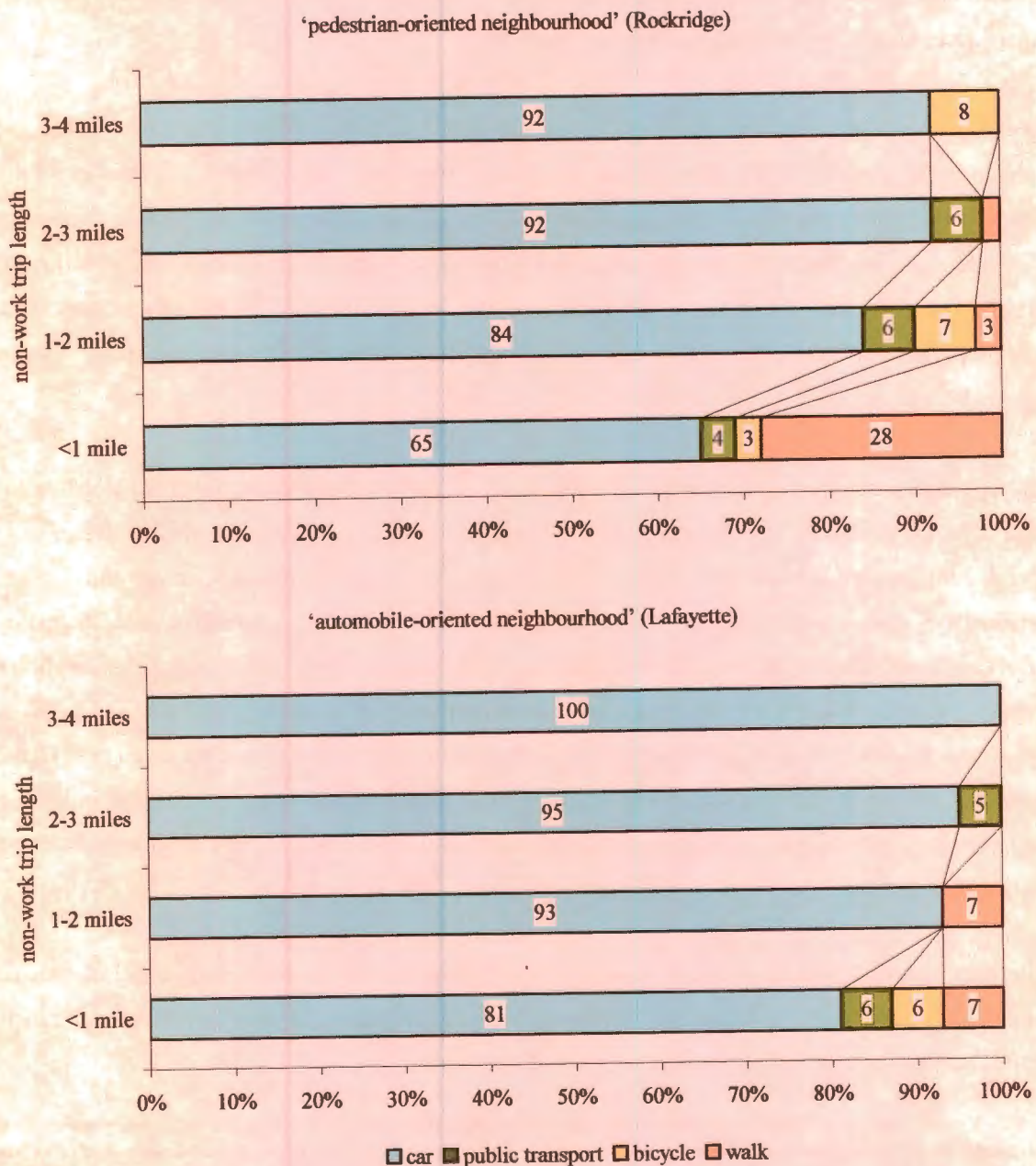
5.2.2 Mode use

Studies investigating the impact of network configuration on the utilisation of different travel modes, have generally concluded that neighbourhood design variables exert their greatest influence on local

shopping trips and other non-work trips. These studies have tended to identify walking, cars and public transport services as the main travel modes.

With regard to walking, empirical studies in San Francisco (California), Portland (Oregon) and The Netherlands have typically concluded that, as a result of more direct connections to more dispersed local destinations, 'neo-traditional' networks and mixed land uses encourage a greater walking share of shorter distance and non-work trip modal split, than conventional suburban neighbourhoods. (Calthorpe Associates 1995, Cervero and Kockelman 1996, Cervero and Radisch 1995, Friedman *et al* 1994, Handy 1992 1996a, Snellen 1999)

Figure 5.4 Empirical comparison of non-work trip mode use by trip distance: 'pedestrian-oriented' vs. 'automobile-oriented' (San Francisco) (n = 620 h)



Source: Cervero and Radisch 1995:19

Perhaps the most detailed of these empirical studies was that of Robert Cervero and Carolyn Radisch (1995), who broke modal split percentages, for non-work trips, down into four different trip distance categories (see figure 5.4). They found that in both 'pedestrian' and 'automobile-oriented' neighbourhoods, residents tend to make fewer car trips as trip distances decrease. In the case of 'pedestrian-oriented' neighbourhoods, cars were used for 92% of trips between 3 to 4 miles long, and this decreased to 65% of trips less than 1 mile (1.61 km). In the case of the 'automobile-oriented' neighbourhoods, cars were used for 100% of trips between 3 to 4 miles long, and this decreased to 81% of trips less than 1 mile. They concluded that households living in 'pedestrian-oriented' neighbourhoods average 10% more non-work trips by non-automobile modes than 'automobile-oriented' households, with the greatest difference relating to shopping trips under 1 mile. They attributed their findings to the greater demand elasticity associated with non-work trips, and the greater 'accessibility' of 'pedestrian-oriented' networks.

There would seem to be general agreement across the empirical studies of modal split, that while neighbourhood design (e.g. distances, barriers created by freeways, traffic safety, etc.) does make a difference in determining whether people perceive walking as an option available to them, there is little evidence to suggest that landscaping features (such as street tree planting, benches, variation in surfacing materials, etc.) are particularly important in the decision to walk¹⁰² – contrary to what some of the proponents of 'neo-traditional' development might have either explicitly or implicitly suggested.

With regard to driving, empirical studies of mode use in California have generally concluded that for longer distance work trips, car share of modal split either remains fairly constant irrespective of network configuration, or is slightly lower in 'neo-traditional' neighbourhoods (Cervero and Gorham 1995, Cervero and Radisch 1995, Friedman *et al* 1994). The most extensive of these studies by Cervero and Gorham (1995) in San Francisco and Los Angeles found that 'transit neighbourhoods' experience slightly lower work trip (single occupancy) car share of modal split (66,9% vs. 73,9%), but more recent studies by Crane (1996b), McNally and Kulkarni (1996) and Kitamura *et al* (1997) have argued that the reasons for this sometimes significant difference relate more to a variety of income, socio-economic, attitudinal and broader public transport availability factors, than local neighbourhood configuration *per se*.

With regard to public transport use, studies in California and Florida have generally concluded that while there is a tendency for higher public transport modal split shares in 'neo-traditional' or 'transit-oriented' developments, the reasons for this are often unclear.

¹⁰² Even though Katherine Shriver (1997) did find in her empirical research in Austin (Texas) that tree planting and an aesthetically pleasing environment were important attributes influencing recreational walking trips. Moudon *et al* (1997) also conclude on the basis of their empirical research of pedestrian volumes in the Puget Sound area of Washington State that, given appropriate land use distribution, pedestrian facility investment programmes can have a significant influence on mode choice.

In a series of empirical studies of public transport ridership in the United States, Robert Cervero (1993, 1994, Cervero and Gorham 1995) draws three main conclusions. The first is that if 'transit-oriented development' is to significantly alter modal split, then both trip origins and destinations must be clustered around stations and stops – public transport-oriented residential development makes little impact on modal split if most job growth occurs in locations far removed from stations and stops (e.g. suburban office parks and shopping centres), and similarly, public transport-served shopping centres will attract relatively few public transport users if most residences and workplaces are not oriented to public transport. The second conclusion is that the form of the city as a whole has a greater role in influencing commuting modal split than local neighbourhood design – islands of 'transit-oriented development' in a sea of freeway-oriented suburbs will do little to change fundamental commuting habits. The nature of local neighbourhood design (including network configuration) in these circumstances, while clearly contributing to levels of convenience, tends only to influence shorter distance non-work trip modal split. Macro-factors, like car ownership levels, settlement densities and cost differentials between public transport and car commuting, are far more powerful determinants of longer distance work trip modal split – a conclusion supported by Ewing's (1996) study in Florida. The third conclusion is that the evaluation of the impacts of TOD on modal split is made difficult by the fact that virtually all these developments in the United States have accompanying non-spatial TDM strategies (e.g. universal parking charges, employer paid public transport allowances, etc.). He argues that it is probable however that modal split differences between TODs and 'comparison sites' are more the result of TDM strategies, than neighbourhood design.

5.3 EVIDENCE OF RELATIONSHIPS BETWEEN NETWORK CONFIGURATION AND TRAFFIC CONGESTION

What evidence is there of the impact of network configuration on traffic congestion? This is discussed in terms of network links and intersections.

5.3.1 Link congestion

With regard to the impact of local network configuration on link congestion, the two earlier mentioned simulation studies concluded that the greater number of possible connections in 'neo-traditional' networks enable relatively more shorter vehicular trips to be dispersed across local networks, thereby reducing the quantity of vehicular trips forced onto arterial networks and reducing their congestion impacts.

The first of these studies undertaken by Kulash *et al* (1990) concluded that one of the most notable differences between the 'neo-traditional' and 'conventional' networks is the former's greater reliance

on local streets for intra-neighbourhood travel (see figure 5.2). They argue that internal travel could be expected to drop substantially on arterial streets within 'neo-traditional' networks (by around 80%) and that local streets would carry significantly more daily vehicle kilometres travelled (by around 368%), but that despite this greater traffic volume on 'neo-traditional' local streets, local links would continue to operate at nearly the same volume-to-capacity (V/C) ratio¹⁰³ as they would in a 'conventional' network (see table 5.2). The explanation they offer for this apparent anomaly is that 'neo-traditional' networks take better advantage of the unused volume capacities inherent in local streets irrespective of network configuration. In other words, local traffic stays local, and this does not create congestion because, in capacity terms, local streets are usually underutilised anyway. Within the connected 'neo-traditional' network, local traffic never enters the arterial system, while the 'conventional' network of *culs-de-sac* and loops forces local traffic onto the arterial system. As a result, arterial V/C ratios in 'conventional' networks are higher than 'neo-traditional' networks (0.92 vs. 0.83), and levels-of-service are lower (D vs. B).

Table 5.2 *Simulated comparison of link volume-to-capacity ratios and levels-of-service: 'conventional suburban' vs. 'traditional neighbourhood' development*

	'NEO-TRADITIONAL NETWORK DESIGN'		'CONVENTIONAL NETWORK DESIGN'	
	V/C RATIO	LOS	V/C RATIO	LOS
arterial streets	0.83	B (stable flow)	0.92	D (high density, stable flow)
collector streets	0.87	D (high density, stable flow)	0.94	D (high density, stable flow)
local streets	0.22	A (free flow)	0.21	A (free flow)

Source: Kulash *et al* 1990

Note: AASHTO recommends levels-of-service of C (restricted flow), D and D on urban and suburban arterials, collectors and local roads respectively. (O'Flaherty 1997:283)

The second study undertaken by McNally and Ryan (1993) reached similar conclusions. They found that the 'conventional' network had around 64% of its links operating at a V/C ratio of 0.0-0.4, whereas the 'neo-traditional' network had 29% of its links operating at this level. About 30% of the 'conventional' network links were found to operate at a V/C ratio of 0.6-1.0, whereas the 'neo-traditional' network had over 70% of its links operating at this level. All these V/C ratios however represent situations in which the links are functioning within capacity, and within what might be regarded as an uncongested state. The 'conventional' network was however found to have 6% of its links operating above a V/C ratio of 1.0 – representing a congested state – whereas the 'neo-traditional' network had no links operating above this value. On the basis of these simulated results they argued that the 'neo-traditional' networks are better able to avoid link congestion.

5.3.2 Intersection congestion

With regard to the impact of local network configuration on intersection congestion, the two studies arrived at slightly different conclusions. Kulash *et al* (1990, cited by Woodhull 1992) on the one hand

¹⁰³ A volume-to-capacity ratio of 1.0 would indicate that a link is utilised to its capacity. However V/C ratios of 0.5 and 1.5 for instance would indicate links are utilised below and above capacity, respectively.

argue that the greater number of routes and intersections in 'neo-traditional' networks, increases left-turn options (in South Africa right-turn options), which, together with the size of intersections, are key to reducing congestion. The sparser the network they argue, the larger and more complex the intersections, the slower traffic is able to pass through. If there are numerous comparable routes between origins and destinations, as in the case of a 'neo-traditional' network, the number of vehicles turning across oncoming traffic lanes at any one intersection is argued to be fewer, as drivers have greater options to use alternative intersections in the event that one intersection is temporarily blocked.¹⁰⁴

McNally and Ryan (1993) on the other hand found that although their link congestion analysis indicated that the 'neo-traditional' network operates more efficiently, intersections in the 'neo-traditional' network operate at approximately the same below capacity level as the 'conventional' network (see table 5.3). This result they argue is inconsistent with Kulash *et al*'s argument that 'neo-traditional' intersections should be less congested because traffic is diffused.

Table 5.3 *Simulated comparison of intersection volume-to-capacity ratios: 'conventional' vs. 'neo-traditional' network design*

	'NEO-TRADITIONAL NETWORK DESIGN'	'CONVENTIONAL NETWORK DESIGN'
arterial / collector	0.79	0.78
collector / collector	0.78	0.77
local / collector	0.43	0.44

Source: McNally and Ryan 1993:75

5.4 EVIDENCE OF RELATIONSHIPS BETWEEN NETWORK CONFIGURATION AND MANAGEMENT AND ROAD SAFETY

What evidence is there of the impact of network configuration and management on road safety? This is discussed in terms of road accidents and casualties, as well as in terms of traffic speeds and volumes as these are argued to provide an indication of the safety of the road environment.

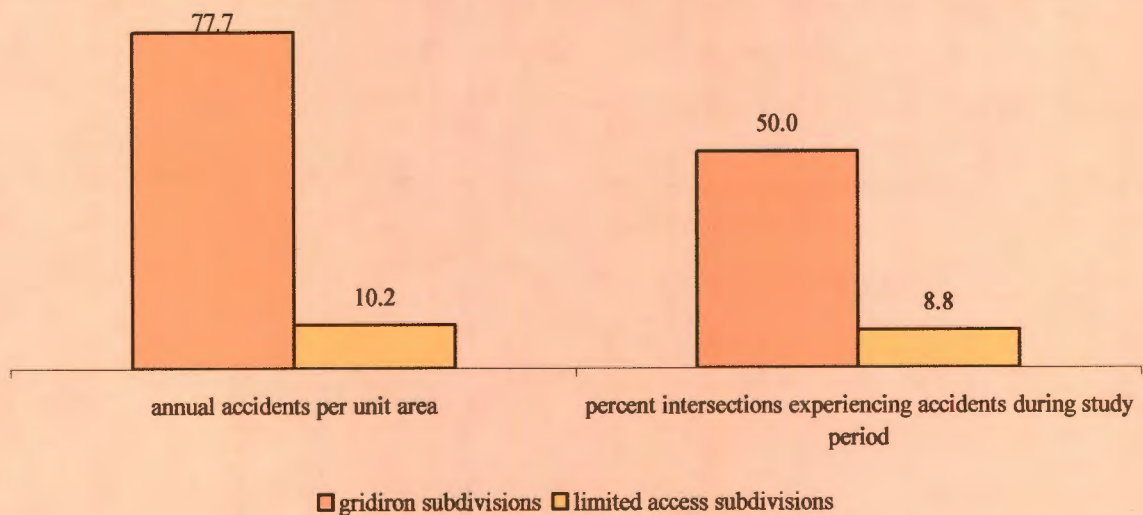
5.4.1 Road accidents and casualties

As mentioned in chapter 4, Harold Marks undertook a pioneering comparative study of accident data from gridiron and limited-access residential subdivisions in Los Angeles (California) in the early 1950s. With regard to his analysis of the 660 intersections within the 86 subdivisions studied, he found

¹⁰⁴ Kulash *et al* (1990, cited by Woodhull 1992) also argue that since the streets of a 'neo-traditional' network have fewer lanes, turns across oncoming lanes can be made more quickly and safely because the driver has only to consider gaps in a single lane. Conversely when multi-lane streets intersect, a turn across two or more oncoming lanes with heavy traffic usually means that no gap will appear simultaneously in oncoming lanes before the signal changes. The introduction of turn-only signal phase to overcome this problem is argued to lengthen the delay for the majority of cars moving straight through the intersection.

that cross-intersections had 14 times the accident frequency of tee-intersections – this he attributed to the fewer potential vehicle conflict points in the tee-intersection (3 vs. 16 in the cross-intersection). The ratio of accidents between gridiron and limited access networks was found to be 7.6:1 – this he attributed to the gridiron networks studied having 65% more intersections, and more cross-intersections in particular. Some 50% of intersections in the ‘gridiron’ network experienced at least one accident during the 5 year study period, while the corresponding percentage amongst intersections in limited access networks was only 8.8% (see figure 5.5). Taking both intersection and non-intersection accidents into account, he found an accident rate of 77.7 accidents/year for ‘gridiron’ networks, compared to 10.2 accidents/year in limited access networks.

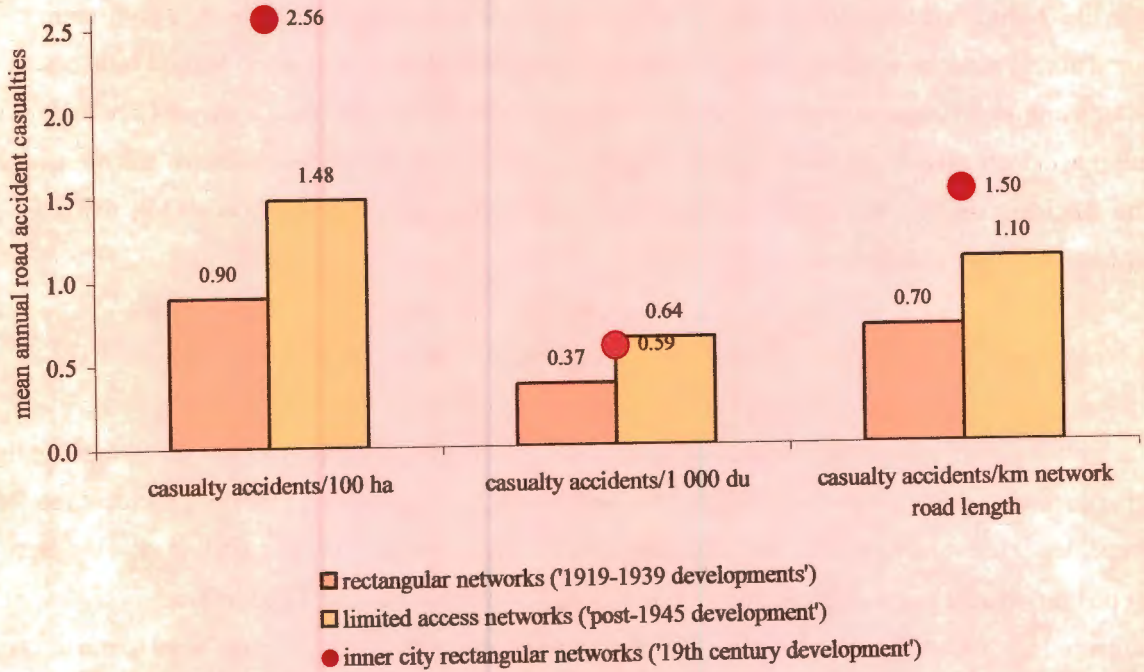
Figure 5.5 *Road accident rates: ‘gridiron’ vs. ‘limited access’ subdivisions: 1951-1956 (Los Angeles)*



Source: Cameron 1977:46

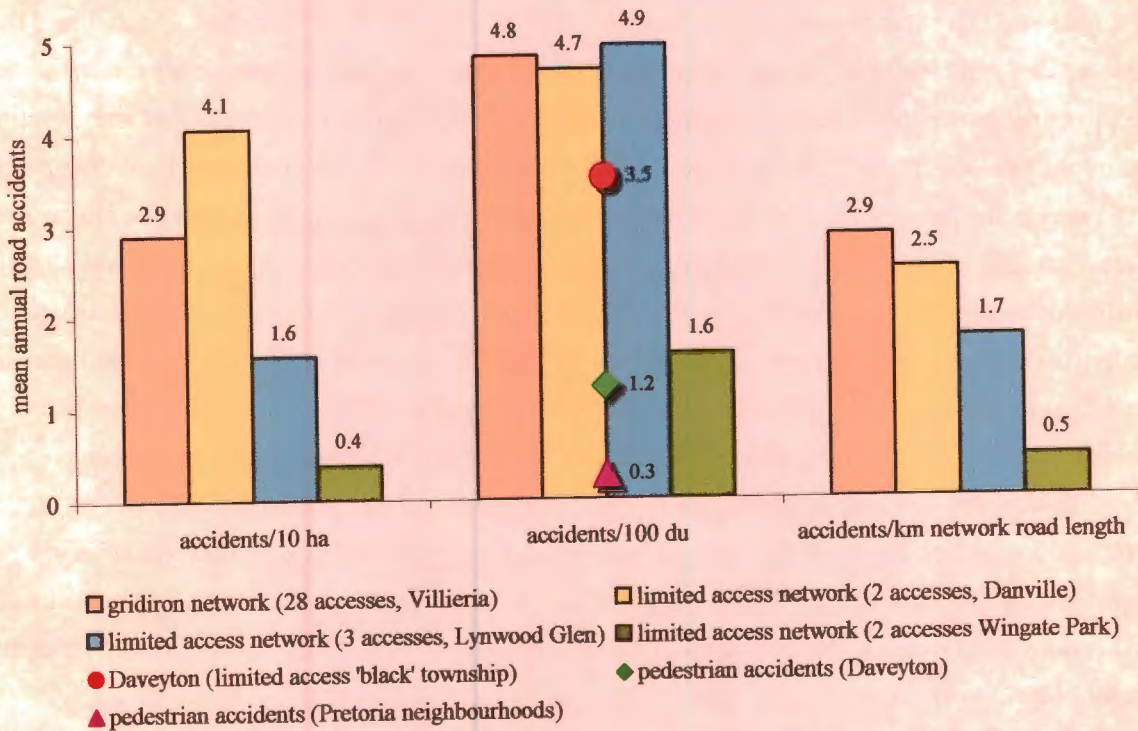
In his review of the road network:road safety literature, Bill Cameron (1977) found that Marks' findings were corroborated by later research in Richmond (California) and Seattle (Washington) in the 1960s and 1970s. Marks' conclusions regarding intersection accident rates in particular were also corroborated by Romano Del Mistro (1979) in his analysis of cross- vs. tee-intersections in Pretoria. In the United Kingdom, analysis of 4 years of casualty accident data in 17 residential neighbourhoods of Swindon, Southampton, Portsmouth and Oxford by the TRRL (1977) in the mid-1970s similarly found tee-intersections to have lower accident rates than cross-intersections (0.1-0.4 vs. 0.35-0.96 accidents/million vehicle inflow). This study however found the inverse of Marks' findings with respect to the accident impacts of network configuration (see figure 5.6). Open rectangular networks constructed in the pre-war period were found to experience 36% fewer road casualty accidents than limited access networks constructed in the post-war period (0.70 vs. 1.1 casualty accidents/km network road length). This finding was unexpected and unexplained in the research, but presumably reflects to some extent the omission of vehicle-vehicle collision data in which no casualty was sustained. The highest accident rates were found in fine-grained rectangular inner city networks where levels of vehicle and pedestrian traffic are highest.

Figure 5.6 Road casualty accident rates: pre-war rectangular vs. post-war limited-access networks: 1974-1977 (United Kingdom)



Source: TRRL 1977

Figure 5.7 Road accident rates: gridiron vs. limited-access networks: 1978-1980 (Pretoria)



Source: Del Mistro 1983:396

A contemporary study in Pretoria by Romano Del Mistro (1983) of 1978-80 accident data in gridiron and limited access networks provides insight into South African conditions. The data revealed a

pattern broadly similar, but less stark, to those found in earlier American research (see figure 5.7). The 'gridiron' network (Villieria) averaged 2.87 accidents/km of network road length per year, compared to 2.50, 1.75 and 0.45 accidents/km network road length in the limited-access networks studied (Danville, Lynnwood Glen and Wingate Park respectively). These findings represent a gridiron to limited access network accident ratio of between 1.15:1 and 6.38:1 (compared to Marks' ratio of 7.6:1). Contrary to expectations, the limited access networks of Danville and Lynnwood Glen had similar accidents rates to the gridiron network when calculated on the basis of hectares and dwelling units. Accident severity was reported to be the same across the four neighbourhoods. Only 6% of accidents involved pedestrians.

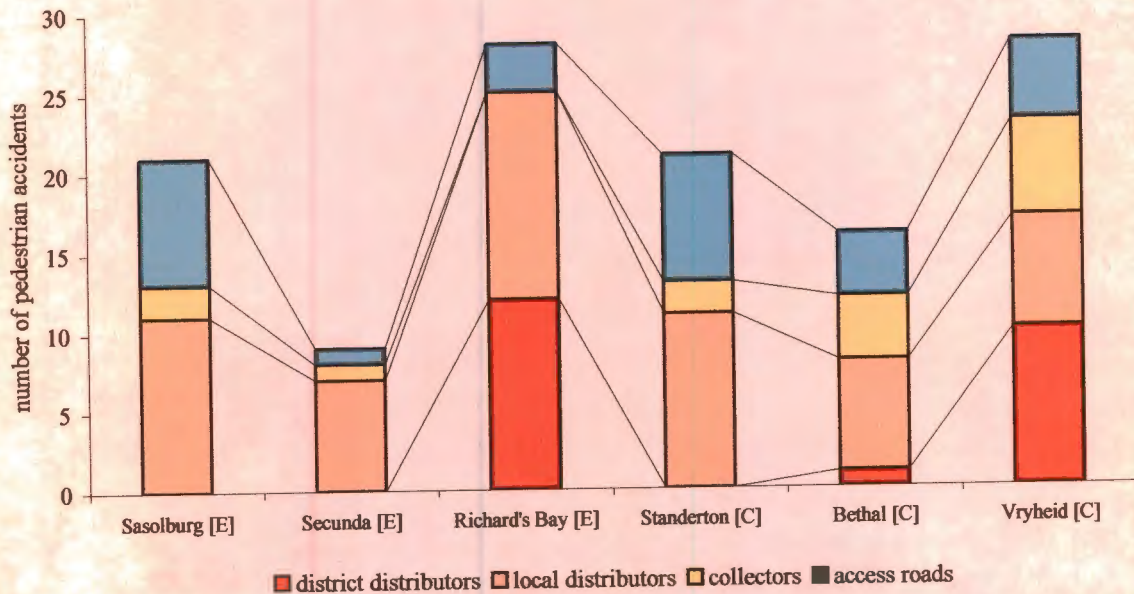
To explore pedestrian accident patterns more specifically, Del Mistro (1983) then analysed 1979-81 accident data from Daveyton – a limited access 'black' township located some 36 km outside Johannesburg. While the mean annual accident rate of 3.5 accidents/100 du was similar to those in the higher income 'white', neighbourhoods studied in Pretoria (see figure 5.7), the injury accident rate of 1.6 accidents/100 du was double that of the Pretoria neighbourhoods. This was attributed to the fact that pedestrian accidents were considerably higher in Daveyton (1.2 vs. 0.3 pedestrian accidents/100 du), and constituted 35% of all accidents. Most pedestrian accidents were found to occur on the major routes entering the township upon which vehicle speeds are highest.

Further study of pedestrian accident patterns was undertaken by Hubrecht Ribbens. Ribbens (1982) first analysed 120 national 'non-white' pedestrian commuter accident 'cluster sites' – including 51 intersections and 68 mid-block sites. Qualifying 'cluster sites' experienced 5 or more pedestrian accidents per annum for at least two years (between 1978 and 1980). 40% of the cluster sites identified were located along district distributors, while 28%, 25% and 7% were located along local distributors, CBD streets and primary distributors respectively.¹⁰⁵ More specifically, most intersection cluster sites were located in business districts or on district distributors leading to employment areas, while mid-block cluster sites were located on local distributors within residential townships. Most hazardous pedestrian locations were found to be in the vicinity of public transport, with some 73% of cluster sites located at or within 50 m of public transport facilities – in business districts, on district distributors linking 'non-white' townships with employment centres, and on local distributors in townships carrying local bus services. Ribbens (1985) then investigated national pedestrian casualties at intersections further. Amongst other things he found that the majority of pedestrian casualties at signalised intersections occur outside residential townships on the main arterials leading to business and employment areas, while the majority of pedestrian casualties at unsignalised intersections occur within 'black' townships.

¹⁰⁵ This pattern appears to apply to all accidents (as opposed to just those associated with 'cluster sites') as well. Prinsloo and Wium (1964, in Cameron 1977) for instance found that while Pretoria's road network consisted of 14% arterials, 11% collectors and 75% local roads, the distribution of road accidents followed an inverse pattern with arterials, collectors and local roads experiencing 65%, 9% and 26% of all accidents respectively. A similar study in Boksburg (Prinsloo 1965, in Cameron 1977) found 82% of all accidents (38% of which were pedestrian accidents) and 89% of fatal accidents occurred on the major arterial and collectors streets, which comprise 23% of Boksburg's road network.

In later doctoral research, Ribbens (1990) investigated the incidence of pedestrian accidents in three closed and horizontally separated ‘experimental’ networks, compared with three open grid-like ‘control’ networks. ‘Horizontal separation’ referred to the separation of pedestrians from vehicular traffic through the provision of pathways within continuous networks of public open space (as opposed to Radburn-type separation in which pathways are provided within ‘superblocks’). The ‘experimental’ networks included the then ‘white’ residential areas of Sasolburg, Secunda and Richards Bay, while the ‘control’ networks included the ‘white’ residential areas of Standerton, Bethal and Vryheid. The study found that the number of pedestrian accidents varied significantly across the ‘experimental’ networks, and in some cases, presumably counter to expectations, were higher than in the ‘control’ networks (see figure 5.8). In aggregate however the rate of pedestrian accidents in the ‘experimental’ networks was marginally lower (4.8%) than in the ‘control’ networks (12.43 vs. 13.03 pedestrian accidents/10 000 people), but nevertheless significantly different to Marks’ seminal findings in Los Angeles. Across the residential neighbourhoods studied most pedestrian accidents were found to occur along local distributors. Ribbens concluded that the separate pathway networks provided in ‘experimental’ neighbourhoods were not used as planned.

Figure 5.8 *‘White’ pedestrian road accidents by road classification: ‘experimental’ [E] vs. ‘control’ [C] networks (1984-1986)*

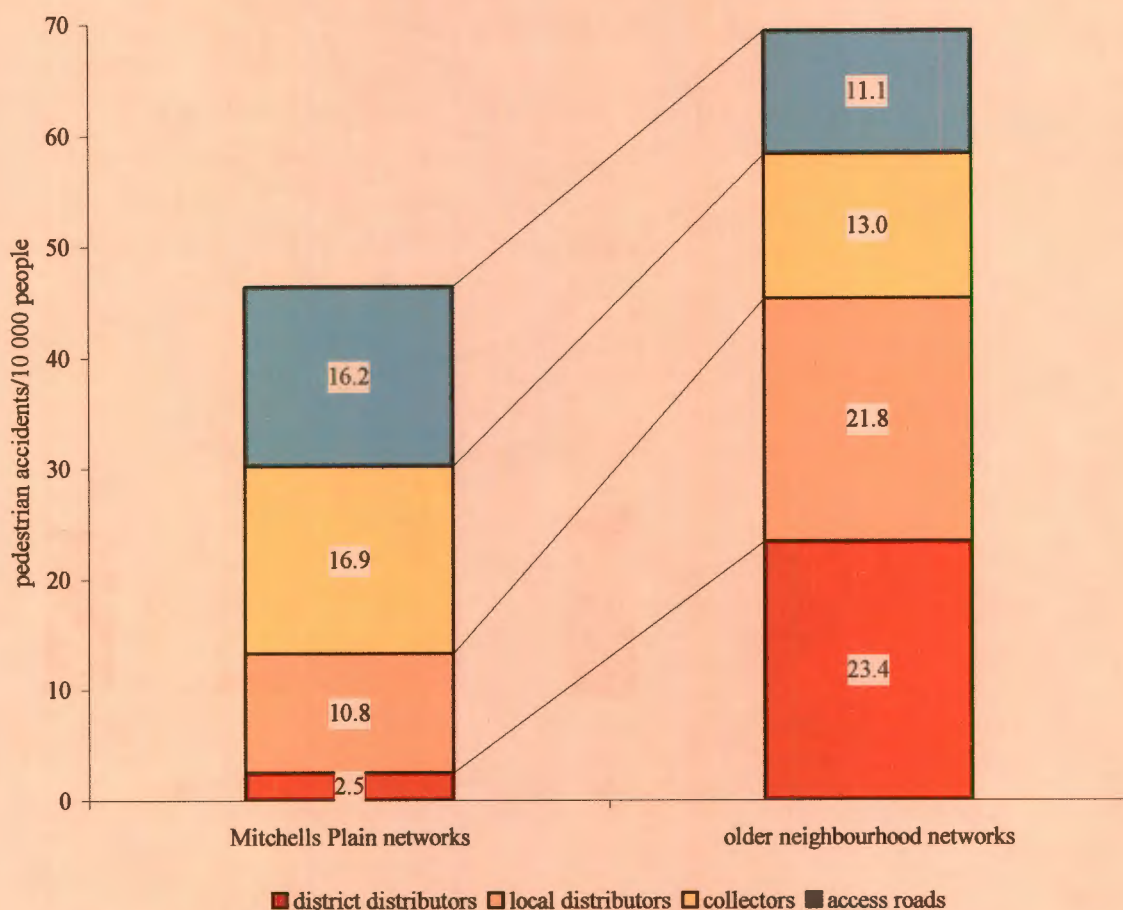


Source: Ribbens 1990:150

In a far coarser way from the perspective of local network configuration, Ribbens (1990) also analysed pedestrian accident data in ‘coloured’ census districts of the former Cape Town City Council. For the purposes of investigating network effects, these census districts were divided into two groups: the new town of Mitchells Plain as an example of newer closed network configuration practices; and ‘older neighbourhoods’ with more open grid-like networks. Mitchells Plain was found to have a lower

accident rate (48.4 vs. 69.3 pedestrian accidents/10 000 people), and, in aggregate, 'coloured' neighbourhoods were found to have significantly higher pedestrian accident levels than in the 'white' neighbourhoods studied (48-69 vs. 12-13 pedestrian accidents/10 000 people) (see figure 5.9). Surprisingly, despite the presence of numerous *culs-de-sac* and crescents, the data revealed a relatively higher proportion of pedestrian accidents on the collectors and access roads of Mitchells Plain than in the 'older neighbourhoods'. The 'older neighbourhoods' experienced a higher proportion of accidents on district and local distributors. An analysis of child pedestrian accidents in particular revealed that the number of accidents was higher in Mitchells Plain than in the 'older neighbourhoods', and that these accidents were most likely to occur on collectors and local roads.¹⁰⁶ Figure 5.10 indicates the distribution of pedestrian accidents by activity site, and from these data it can be seen that, accordingly, a greater proportion of pedestrian accidents occurred in the vicinity of houses and schools in Mitchells Plain, and most of these accidents occurred on collector and access roads.

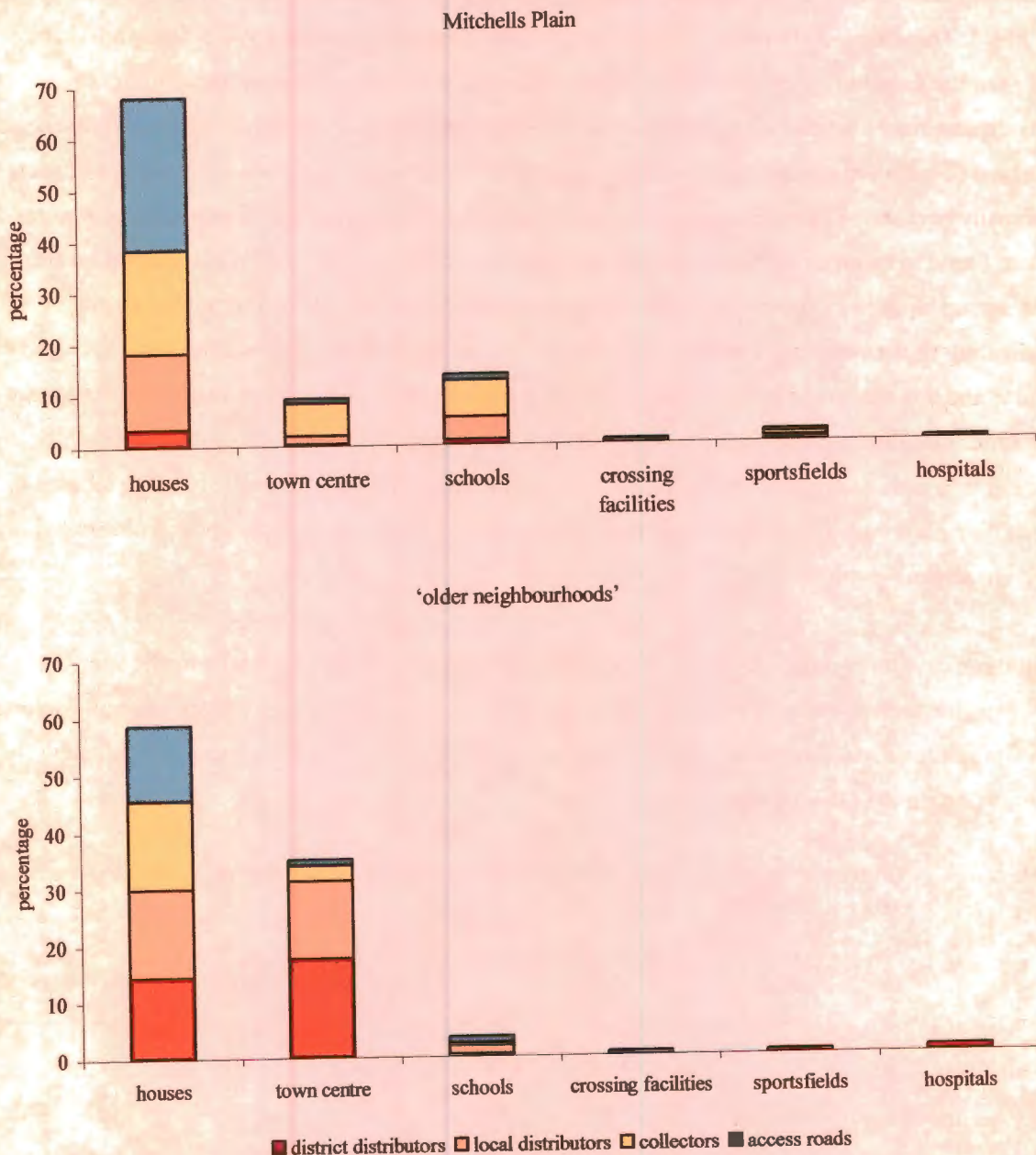
Figure 5.9 'Coloured' pedestrian road accident rates per 10 000 people by road classification: Mitchells Plain vs. 'older neighbourhoods' (1984-1986)



Source: Ribbens 1990:166

¹⁰⁶ This finding is consistent with contemporary research in the Birmingham (United Kingdom) in 1989. Here it was found that younger child pedestrians (<10 years) tend to be injured or killed more often on residential roads, and that 33% of younger child pedestrian fatalities were killed immediately outside their homes. Older child pedestrians (>10 years) were however found to be injured or killed most often on distributors. (Proctor 1991)

Figure 5.10 Percentage 'coloured' pedestrian road accidents by activity site and road classification: Mitchells Plain vs. 'older neighbourhood' networks (1984-1986)



Source: Ribbens 1990:169-170

5.4.2 Traffic speeds

The literature would suggest that network management, principally in the form of traffic calming, has a more consistent observable impact on road safety than network configuration. The impacts of traffic calming are usually measured in terms of traffic speed and traffic volume, which are two important contributing variables to road safety.¹⁰⁷ The effect of traffic calming measures on traffic speeds has

¹⁰⁷ By slowing traffic (e.g. as in the case of speed humps and chokers), reducing conflicting turning movements (e.g. as in the case of traffic circles and diverters) and heightening driver concentration (e.g. as in the case of chicanes and roadway narrowings) traffic calming has been found to reduce collision frequencies. Zein *et al* (1997) summarised the mean impacts of selected traffic measures on reducing collision frequencies from 89 European, Australian and North American case studies – their results are illustrated in figure 5.11. They found that mean collision frequencies were reduced by between

been analysed by numerous studies, the most recent and comprehensive of which is a study commissioned by the ITE and the American Federal Highway Administration (FHWA) and published in 1999.¹⁰⁸ This study, undertaken by Reid Ewing (1999), assembled around 400 before-and-after studies of traffic calming impacts in the United States and used the findings of these studies to generate summary statistics on the speed impacts of different types of measures. Ewing (2000) argues that these summary statistics are however crude, and provide only a 'ball park' indication of impacts – principally because of inconsistencies in measurement. Before-and-after speed measurements were seldom found to be taken in the exactly the same place, even though different measurement locations along a road would be expected to reveal different results depending on whether motorists are accelerating or decelerating. The time period between application and 'after' studies were also found to vary, and this too would be expected to influence measurement as motorists adapt their behaviour over time. Tim Pharaoh and John Russell (1991) also point out that the effects of individual traffic calming measures cannot easily be evaluated in isolation from the broader traffic calming scheme in which they are a part, and an individual measure might have different impacts when implemented in different scheme combinations.

With these caveats in mind, table 5.4 illustrates mean reductions in 85th percentile traffic speeds following the implementation of traffic calming measures. 85th percentile speeds are generally selected as the measure of speed reduction effectiveness as the elimination of very high speeds is arguably more important than the reduction of mean speeds.

Table 5.4 *Impact of selected traffic calming measures on mean 85th percentile traffic speeds after application*

	SAMPLE SIZE	MEAN 85 th %ile SPEED (km/h)	MEAN CHANGE IN 85 th %ile SPEED (km/h)	MEAN CHANGE IN 85 th %ile SPEED (%)
speed humps (3.66 m)	179	44.1 (6.4)	-12.2 (5.6)	-22 (9)
speed humps (4.27 m)	15	41.2 (3.4)	-12.4 (3.4)	-23 (6)
speed tables (6.71 m)	58	48.4 (12.4)	-10.6 (6.0)	-18 (8)
longer speed tables	10	50.9 (4.5)	-5.1 (3.9)	-19 (7)
raised intersections	3	55.2 (9.7)	-0.5 (6.1)	-1 (10)
circles	45	48.6 (6.9)	-6.3 (5.1)	-11 (10)
roadway narrowings	7	52.0 (4.5)	-4.2 (8.9)	-4 (22)
one-lane slow points	5	46.0 (5.0)	-7.7 (2.1)	-14 (4)
partial road closures	16	42.3 (8.4)	-9.7 (5.8)	-19 (11)
diagonal diverters	7	44.9 (8.4)	-2.3 (7.6)	0 (17)

Source: Ewing 2000:I-1/2 (summarised from appendix A of Ewing 1999)

Note: Values in parentheses represent standard deviation from the mean.

30% and 82%, and that none of the case studies experienced increased collisions after traffic calming measures had been applied. Surprisingly, given their effect on increasing speed differences between vehicles, speed humps were found to reduce collisions considerably. Less surprisingly, physical measures were found to outperform regulatory measures. Similar reductions have been observed in South Africa – Kruger *et al* (1998) for instance found a decline in road accidents in the year following the implementation in mini-circles and speed humps in Pretoria. An earlier study in the United Kingdom by Brownfield (1980) also found area-wide traffic calming reduced accidents. This study found, in addition, that diverted through-traffic did not necessarily cause an overall increase of accidents on peripheral roads.

¹⁰⁸ No equivalent compilation of before-and-after study findings has been undertaken in South Africa, and this represents an important future research need. South Africa has greater resource constraints, and probably less disciplined driver behaviour, than most countries within which traffic calming measures have been evaluated.

The speed-reducing impacts of physical (as opposed to regulatory) traffic calming measures depend primarily on their geometrics and spacing. The severity of their geometrics determines the speeds at which vehicles travel through or over the measure, while their spacing determines the extent to which vehicles can pick up speed between measures.¹⁰⁹ Physical speed management measures therefore essentially use changes in roadway or intersection alignment (e.g. humps, chicanes, circles) and narrowing (e.g. chokers, kerb extensions) to slow traffic. Of the traffic calming measures included in table 5.4, speed humps and speed tables were found to have the greatest impact on 85th percentile speeds, reducing them on average by around 12 km/h or 21%. Kruger *et al* (1998) similarly found reductions in mean speed of between 16% and 41% following the implementation of speed humps and mini-circles in four traffic calming schemes in Pretoria. Somewhat surprisingly Ewing (1999) found partial road closures had a relatively large impact on speed, whereas a more conventional speed management measure like raised intersections had a considerably smaller impact (mean 85th percentile and percentage speed reductions of 9.7km/h and 19% vs. 0.5 km/h and 1%). Only 3 before-and-after studies of raised intersections were available for the analysis however, introducing a considerably larger sampling error and perhaps accounting for much of this unexpected finding. (Ewing 2000)

5.4.3 Traffic volumes

The 1999 ITE/FHWA study also used the 400 odd before-and-after studies it assembled to generate summary statistics on the volume impacts of different types of traffic calming measures. With the same caveats in mind as before, table 5.5 illustrates mean reductions in daily traffic volumes following the implementation of traffic calming measures. (Ewing 1999)

Table 5.5 *Impact of selected traffic calming measures on mean vehicle/day traffic volumes after application*

	SAMPLE SIZE	MEAN CHANGE IN VOLUME (v/d)		MEAN CHANGE IN VOLUME (%)	
speed humps (3.66 m)	143	-355	(591)	-18	(24)
speed humps (4.27 m)	15	-529	(741)	-22	(26)
speed tables (6.71 m)	46	-415	(649)	-12	(20)
circles	49	-293	(584)	-5	(46)
roadway narrowings	11	-263	(2,178)	-10	(51)
one-lane slow points	5	-392	(384)	-20	(19)
full road closures	19	-671	(786)	-44	(36)
partial road closures	53	-1,611	(2,444)	-42	(41)
diagonal diverters	47	-501	(622)	-35	(46)
other volume controls	10	-1,167	(1,781)	-31	(36)

Source: Ewing 2000:I-1/7 (summarised from appendix A of Ewing 1999)

Note: Values in parentheses represent standard deviation from the mean.

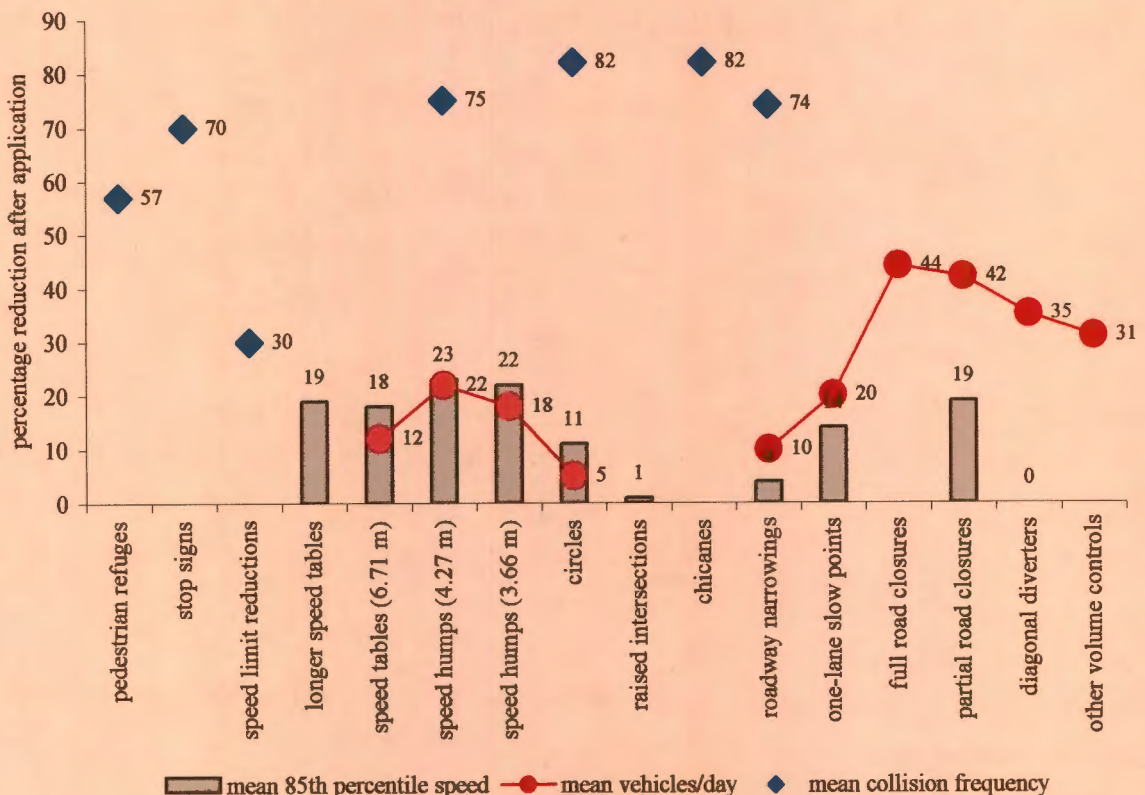
Measuring volume impacts has been found to be much more complex and case-specific than in the case of measuring speed impacts, as it is necessary to consider the entire network of which a particular

¹⁰⁹ Speed management measures should ideally be placed at 30-50 m intervals. If spaced further apart than 50 m, they enable vehicles to accelerate to 40 km/h (with 30 km/h often the desired maximum obtainable speed on residential streets). (Pharaoh and Russell 1991)

‘calmed’ road is a part (Pharaoh and Russell 1991). Volume management measures essentially use barriers to block traffic movements in one or more direction (e.g. road closures, diverters, median barriers), thereby intentionally diverting it to alternative routes and altering network connectivity. The extent to which traffic calming measures reduce and divert traffic therefore depends on factors like the availability of (and measures applied on) alternative routes, and the relative travel times of these routes. Of the traffic calming measures included in table 5.5, full and partial road closures were found to have the greatest impact on daily traffic volumes, reducing them on average by around 1 141 vehicles/day or 43%, followed by diagonal diverters and other volume controls.

Significant volume reductions were also found to occur with some ostensibly speed management measures like speed humps and one-lane slow points. Kruger *et al* (1998) similarly found that speed humps and mini-circles reduced traffic volumes in Pretoria. Figure 5.11 illustrates percentage change in both 85th percentile traffic speed and daily traffic volume following traffic calming measure application. From this figure it can be seen that the distinction between volume and speed controls becomes somewhat blurred in practice. Speed management measures may often be sufficient in themselves in reducing traffic volumes on treated routes or diverting traffic onto alternative routes which are less sensitive environmentally. The impact of speed management measures on volumes is clearly related to the level of speed reduction relative to travel times on alternative routes.

Figure 5.11 *Percentage change in mean 85th percentile traffic speeds, vehicle/day traffic volumes and collision frequencies after application by selected traffic calming measures*



Source: Ewing 2000:I-1/2, I-1/7 (summarised from appendix A of Ewing 1999); Zein *et al* 1997:10 (for collision frequency data)

5.5 PRECEDENT FOR PROACTIVE AND AREA-WIDE LOCAL NETWORK MANAGEMENT

Having now reviewed the evidence of relationships between different local network planning practices and improved local travel conditions, this section refocuses the review presented in this chapter on to management methods (as opposed to measures), and addresses the question of what precedent there is for more proactive and area co-ordinated local network management. As mentioned at the beginning of the chapter, the need for proactive and area-wide local network management in South Africa was identified in chapter 4.

In North America, early pedestrian planning practices, developed by John Fruin (1971) and Boris Pushkarev and Jeffrey Zupan (1975) amongst others in the late 1960s and early 1970s, focussed on city centres and the efficient flow of large pedestrian volumes within fairly localised pedestrian precincts (e.g. business districts, shopping malls). They adopted planning methods similar to those used in highway planning. Consequently they analysed pedestrian demand through sequential trip generation, trip distribution and route choice stages, and developed pedestrian levels-of-service (LOS) to assess the relationship between pedestrian density and walking speed on footways, pathways and stairways.¹¹⁰ Later, in the 1980s, work by Richard Untermann (1984) began to focus on pedestrian (and bicycle) planning in residential neighbourhoods as well as city centres. More recently in the 1990s area-wide traffic calming has begun to be applied,¹¹¹ and further pedestrian and bicycle planning practices have been developed.¹¹² The Canadian Victoria Transport Policy Institute for instance has recently prepared a comprehensive best practice guide for pedestrian and bicycle planning. It argues, essentially, that pedestrian and bicycle planning should follow the conventional process followed in most planning activities, incorporating an analysis of existing conditions and problems, the setting of objectives, the development of programmes of action, followed by implementation and evaluation (Litman *et al* 2001).

In Europe, as discussed earlier in chapter 4, *verkehrsberuhigung* projects have been implemented in Germany since the late 1970s. Reviews of traffic calming practices in the United Kingdom, Germany, The Netherlands, Denmark and Sweden since then, illustrate that the European trend is from site-specific to area-wide traffic calming (Hass-Klau *et al* 1992, Proctor 1991, Brownfield 1980, Pharaoh and Russell 1991). Area-wide bicycle and pedestrian planning has also been fairly widely practiced. With regard to child cyclists and pedestrians in particular, 'safe routes to school' projects have been

¹¹⁰ The pedestrian 'levels-of-service' developed by Fruin (1971) was later included in the TRB's 1985 *Highway Capacity Manual*. (Khisty 1994)

¹¹¹ Even though, as noted by Ewing (1999), some cities like Seattle have successfully implemented area-wide traffic calming for a couple of decades.

¹¹² In their review of current pedestrian safety management practices, de Beer and Davidson (2000) cite several pedestrian plans that have been prepared in the United States in late 1990s, largely they note as a result of the stipulations of the *Intermodal Surface Transportation Efficiency Act* of 1991.

implemented in countries like Denmark and the United Kingdom (Nielsen 1990).¹¹³ More recently, in response to a steady decline in walking in the United Kingdom, comprehensive 'walking strategies' with set modal split targets have been formulated by local governments since the mid-1990s (DETR 1996). The stated purpose of these strategies is to encourage walking by making it safer, promoting its benefits as an alternative to the car (e.g. in terms of health), and generally weaving it into all policies and plans. The components of walking strategies range from public awareness campaigns, improved security (e.g. through public surveillance cameras and better lighting), the systematic reduction of physical barriers to walking, area-wide traffic calming, route and distance signposting for pedestrians, and the establishment of 'walk pools' or 'walking buses' that ensure younger child pedestrians are accompanied to and from schools.¹¹⁴

In Australia, co-ordinated local network management has been applied since the 1980s. Whereas in Europe and North America traffic calming, pedestrian planning and bicycle planning have tended to occur as independent, if overlapping, planning activities, in Australia these activities have been co-ordinated within the framework of 'local area traffic management' (Joubert and van Straten 1999, WAPC 2000). Recently (since 1998) more targeted 'pedestrian access and mobility plans' have been prepared (Henson 2000).

Throughout much of the developing world, the management of movement networks to improve conditions for non-motorised transport (NMT) has received attention, particularly in Asian cities (see for instance Khisty 1993, Kuranami *et al* 1994). Of particular interest here however is the World Bank's Sub-Saharan Africa Transport Programme of the 1990s, involving pilot non-motorised urban transport projects in Dar es Salaam (Tanzania), Nairobi (Kenya), Morogoro (Tanzania) and Eldoret (Kenya). The objectives of these projects included the identification of appropriate 'implementable' interventions that improve NMT conditions, and the documentation of their costs and benefits. The 'intervention menu' of appropriate improvements identified, included pathways, 'missing NMT links', crossing facilities, pedestrian islands, various traffic calming measures, and cycleways. It was concluded however that the resource scarcity and more frequent violation of traffic rules in Sub-Saharan Africa necessitates more robust, cheaper and more uniform infrastructure retrofits than is the case in European and North American conditions. The improvements – particularly separated pathways and cycleways, 'missing NMT links', crossing facilities and bus bays – were found to have high benefit:cost (B/C) ratios¹¹⁵ – of between 2:1 and 5:1 for pedestrian walkways, and 1.5:1 for

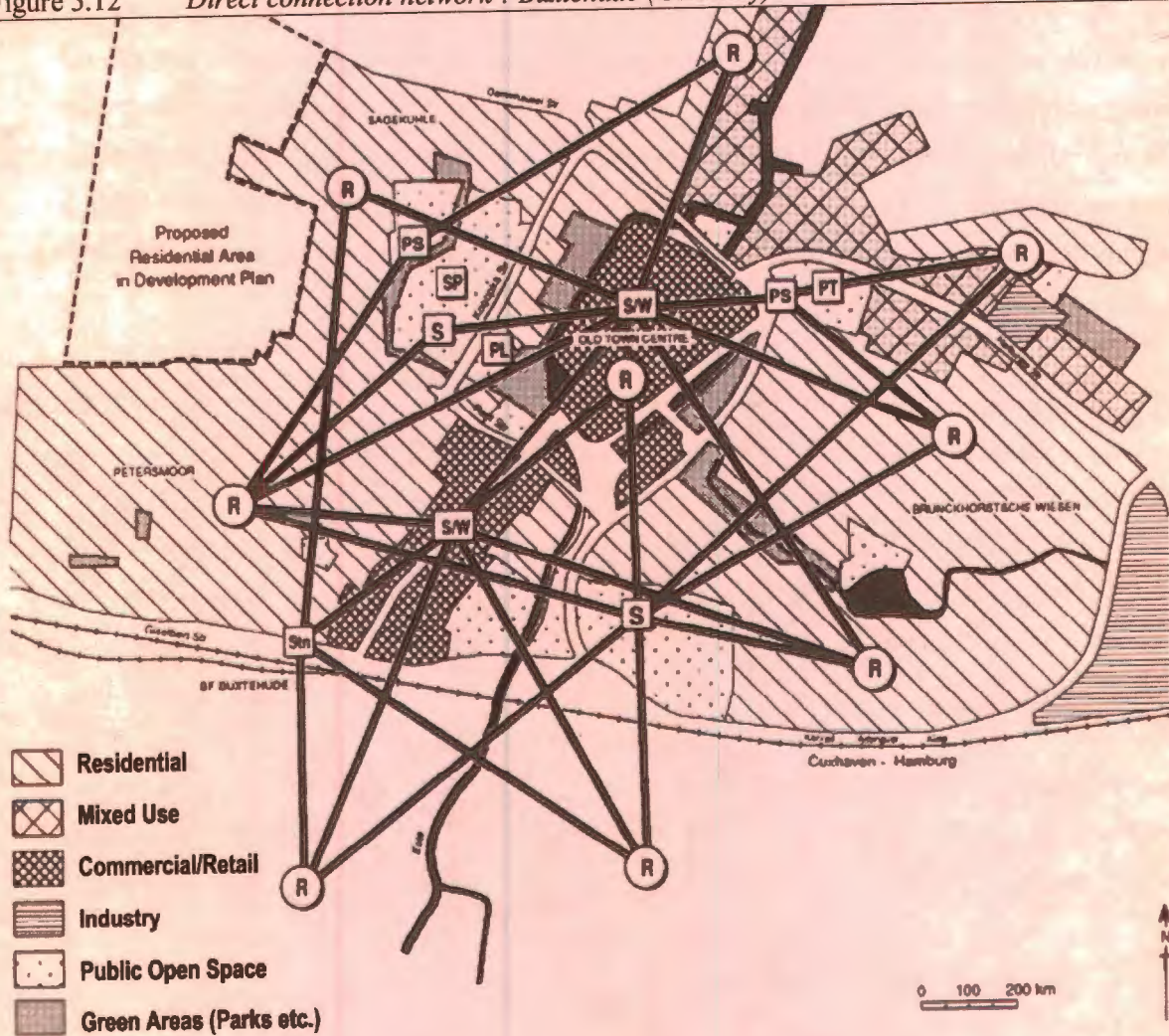
¹¹³ The most common measures implemented – on the basis of area-wide analysis of child travel patterns – have included speed zones, road narrowings, traffic islands and separated pathways and cycleways. (Nielsen 1990)

¹¹⁴ Actions typically associated with the establishment of walking strategies include: the appointment of specialist officers with responsibility for creating improved walking conditions, the establishment of a hierarchy of road users policy which prioritises walking as the first mode of transport, according greater priority to footway works in maintenance budgets, reducing vehicle capacity if necessary in footway improvements, and including walking considerations in established transport planning methods (e.g. including walking and cycling audits alongside safety audits). (DETR 1996)

¹¹⁵ A benefit:cost ratio, as described by de Langen and Tembele (2001), is calculated as the average annual benefit of the investment (i.e. travel time gain) divided by the annual cost of the investment (i.e. construction, maintenance and annuity costs). If the B/C ratio is <1:1 the benefits are lower than the costs, and if the ratio is >1:1 the benefits are greater than the costs. A B/C ratio of 1.3:1 typically represents an attractive intervention when measured in these terms.

accident cost reduction through traffic calming on collector roads. On the basis of the pilot project experiences, Marius de Langen and Rustica Tembele (2001) provide detailed guidelines for the preparation of 10-year 'urban mobility plans' for pedestrians and cyclists. As they argue it is impractical to develop a pedestrian and bicycle network plan for an entire city, they recommend three distinct geographical scales of NMT planning: 'city', 'district' (10-20 km²) and 'neighbourhood' (1-3 km²). At the district level they propose a planning process that involves identifying missing links, important future O-D desire lines, potential conflict points, the quality of routes ('user requirements'), and the cost effectiveness of improvements ('provider requirements'). (de Langen 1999, de Langen and Tembele 2000 2001, Opiyo and de Langen 1999, Rwebangira and de Langen 1999)

Figure 5.12 'Direct connection network': Buxtehude (Germany)



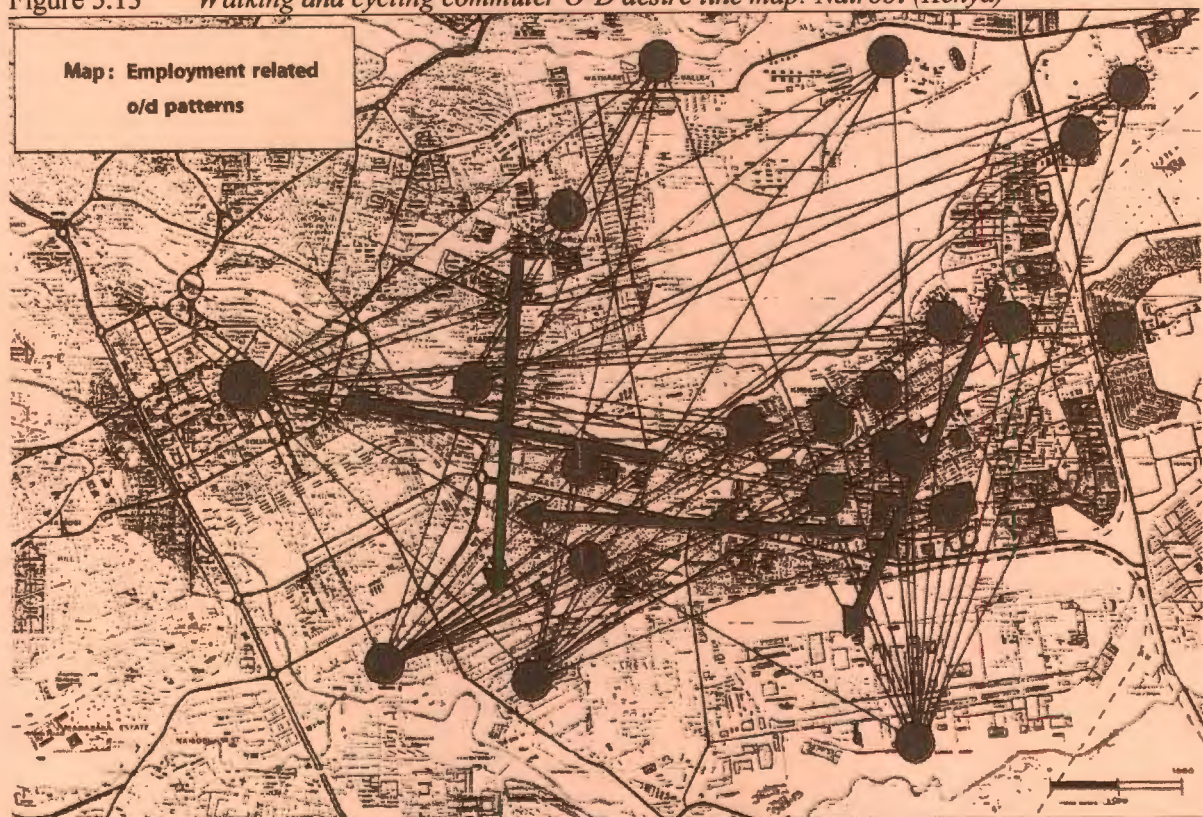
DIRECT CONNECTION NETWORK:	Origins	(R)	residential		
	Destinations	PS	primary/junior school	Stn	station
		S	secondary school	SP	sport
		PT	polytechnic	PL	public swimming pool
		S/W	ship/work		

Source: Döhlissen and Draeger 1990:269
 Note: See figure 4.12 for the resultant *verkehrsberuhigung* plan.

A variety of analytical alternatives to the 'black spot' approach have been developed in the above practices to proactively identify local area network problems like NMT barriers and conflict points. These range from manual techniques, to those requiring sophisticated computerised methods.

The earliest manual techniques took the form of NMT O-D desire line mapping, followed by the identification of discontinuities and conflicts. In the well documented German *verkehrsberuhigung* project of Buxtehude for instance, Alice Döldissen and Werner Draeger (1990) report that the planning process involved the development of a 'direct connection network' for pedestrians and cyclists which linked all important origin and destination activities (see figure 5.12). The superimposition of this network onto the existing movement network enabled barriers, discontinuities, lack of facilities and points of potential vehicle-NMT conflict to be identified. Gaps in the pedestrian and bicycle network were then closed with the gradual provision of new pathways, cycleways and lanes, bridges and subways. Tom Opiyo and Marius de Langen (1999) report that a similar method was applied in the World Bank sponsored NMT pilot project in Eastlands (Nairobi). Here a walking and cycling commuter O-D desire line map was constructed from household surveys (see figure 5.13), and then used to identify matching existing roads requiring priority footway upgrading, and network discontinuities requiring pathway links or crossing facilities.

Figure 5.13 *Walking and cycling commuter O-D desire line map: Nairobi (Kenya)*



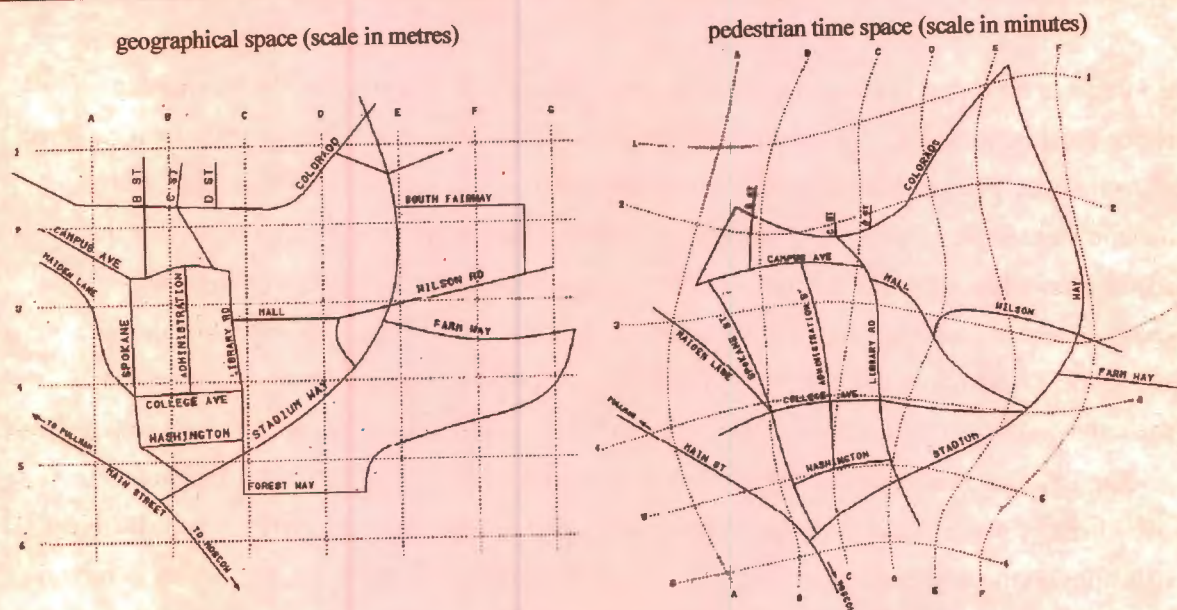
Source: de Langen and Tembele 2001:66

Note: See Opiyo and de Langen (1999:476) for the resultant pedestrian and bicycle network plan.

Later manual techniques include a variety of indices that have attempted to extend the applicability of pedestrian LOS measures. The problem with the LOS method of assessing pedestrian problems,

according to Wigan (1995) and Henson (2000), is that it is only useful where the capacity of the pedestrian or bicycle facility is the key planning issue. This is seldom the case in residential neighbourhoods. The analysis of walking, in particular, as a full travel mode requires a greater focus on route and destination choice, and on assessing the quality and connectivity of pedestrian routes. The various indices that have been developed to measure these variables include:¹¹⁶ (1) a 'pedestrian route directness' ratio;¹¹⁷ (2) a 'pedestrian environment factor';¹¹⁸ and (3) a 'walkability index'.¹¹⁹ The limitation of the latter two analytical techniques is that they only evaluate, and are unable to identify specific network points requiring retrofit improvement.

Figure 5.14 'Plastic space' map of Washington State University campus



Source: Khisty 1990:108-109

With regard to computerised techniques, efforts have been made to incorporate micro-scale design factors (e.g. accessibility and connectivity, diversity or mix of land uses, pedestrian-oriented development, etc.) into existing travel models (e.g. PBQD 2000), work has been carried out on developing new models of pedestrian movement (e.g. Batty *et al* 1998, Schelhorn *et al* 1999), and

¹¹⁶ See Schwartz *et al* 1999 for a comprehensive overview of methods to estimate non-motorised travel.

¹¹⁷ The 'pedestrian route directness' (PRD) ratio measures pedestrian connectivity through the ratio between the route distance and the geodetic (or straight line) distance (Randall and Baetz 2001). A more sophisticated variation of this is the concept of pedestrian 'geometric delay' which represents the difference between the practical walking time between two points in a network (i.e. the obstructed shortest path within the public right-of-way, taking into account various traffic control and street furniture obstructions), minus the geometrical minimum walking time (i.e. the shortest unobstructed possible path within the public right-of-way) (Wright 1985).

¹¹⁸ The 'pedestrian environment factor' (PEF), developed and applied in Portland (Oregon), measures a combination of a neighbourhood's ease of street crossing, footway continuity, street connectivity and topography. Each neighbourhood is ranked for each of these elements on a scale of 0 to 3, with higher numbers representing higher quality pedestrian environments. The overall PEF can therefore range from 0 to 12. This index has been extended to include an additional three-point rating for bicycle facilities, so the 'pedestrian and bicycle environment factor' can range from 0 to 15. (Calthorpe Associates 1995)

¹¹⁹ The neighbourhood 'walkability index' measures ten criteria (population density, off-street parking, benches, social opportunities, independent child mobility, women's safety perceptions, 'responsiveness' of public transport services, 'places of significance', proximity and quantity of public open space, and footway characteristics). Each criteria is ranked between 1 and 4, and the total score is divided by 20 to produce an index of between 0.45 and 2. (Bradshaw 1993)

pedestrian network connectivity has been measured within a GIS framework (Aultman-Hall *et al* 1997, Randall and Baetz 2001). Perhaps the most elaborate computerised technique developed however takes the form of 'plastic space' mapping. Jotin Khisty (1990) reports that in the 1980s a number of researchers examined travel time and distance relationships using this method. 'Plastic space' maps essentially plot movement networks using time as the unit of scale rather than distance (see figure 5.14). Geographical space is thus stretched and shrunk to indicate travel time by different modes across space, enabling large pedestrian route directness ratios to be illustrated graphically.

5.6 SUMMARY AND CONCLUSION

The foregoing review of evidence (in sections 5.2 to 5.4) clearly indicates that the relationship between local network planning practices and improved local travel conditions is neither always direct nor always consistent, and quite unremarkably that numerous other systemic urban, social and economic factors can influence this relationship significantly. In the case of travel behaviour the evidence shows that networks configured to reduce vehicle kilometres travelled through the encouragement of walking and public transport use in favour of car trips, may under certain circumstances have the opposite effect.¹²⁰ In the case of traffic congestion the simulated evidence ignores the possible effects of externally generated 'rat-running' traffic, thus rendering its conclusions regarding link and intersection loadings questionable. In the case of road safety, apart from outdatedness of much of the data, the evidence shows that different studies can reach quite different conclusions on the impact of network configuration. A decline in, or lower, road accidents in one area compared to another also does not necessarily imply safer streets, and may just as easily indicate adapted behaviour to increased risk.¹²¹

Nevertheless, despite such ambiguities and inconsistencies, decisions regarding local network configuration and management continue to need to be made in practice.

With regard to implications for the improvement of network configuration practices in South Africa, in the case of travel behaviour, the weight of evidence reviewed above indicates that grid-like 'neo-traditional' network configurations improve levels of accessibility to local destinations and that, despite generating more local trips, this accessibility does, in many if not most cases, reduce total vehicle kilometres travelled and increase walking and public transport share of modal split. An overarching conclusion in the United States would seem to be that the impact of network configuration

¹²⁰ A common methodological problem associated with empirical studies of travel behaviour is that, in the absence of sufficient recently constructed neighbourhoods, older 'traditional' neighbourhoods, as opposed to new 'neo-traditional' neighbourhoods, tended to be compared to suburban neighbourhoods. If other urban, social and economic factors are indeed important determinants of behaviour, it cannot necessarily be assumed that the broader socio-economic dynamics of these older, established neighbourhoods will immediately exist in newer developments simply because the urban form is similar. Hence comparisons are problematic.

¹²¹ See for instance Hillman *et al*'s (1990) study of independent child mobility in the United Kingdom.

on travel patterns is fairly small however (seldom more than 7-8% in the case of modal split comparisons), and that it may well be broader macro factors, like income and car ownership levels, that account for much of this difference. The question then is: what is the relevance of these conclusions for practice in South Africa? The obvious contextual difference between South Africa and the United States relates to levels of car ownership and modal split. Whereas American cities typically have work trip modal splits in the order of 10:80:10 (public:private:walk), South African cities have a commuter split in the order of 50:45:5 (public:private:walk). In some respects therefore the relevance of these conclusions is far greater in South Africa, than in wealthier countries. While the impacts of 'neo-traditional' network configurations in the United States are the subject of ongoing debate, particularly with regard to the degree to which they get people out of their cars and onto their feet or into public transport vehicles, the issues in South Africa are somewhat different. In South Africa the problem is only partially, and perhaps even less importantly, about getting people out of their cars, as the majority of the urban population cannot afford, or do not own, cars. The problem with regard to this group, as stated in current transport policy, relates more to improving quality of life by improving ease of access and convenience, and to preventing limited household resources from being directed at car ownership at the expense of other more pressing development needs like education and healthcare. In this regard, the conclusion of the debate reviewed in this section is that 'neo-traditional' networks significantly improve levels of accessibility and convenience for shorter trips, and are at least supportive of longer distance public transport trips.

In the case of traffic congestion, the weight of evidence indicates that networks can be configured to prioritise direct and multi-directional pedestrian movement without compromising traffic congestion, and in fact, with the caveat that large volumes of extraneous traffic are avoided, 'neo-traditional' networks can offer real benefits in diffusing traffic and reducing volumes on arterial routes.

In the case of road safety, the weight of evidence indicates that tee-intersections result in considerably fewer road accidents than cross-intersections, and the greater consistency of empirical findings regarding the safety impacts of intersection type suggest that intersections may be more important in determining road accident safety than network connectivity. The evidence also indicates that the type of road accidents included in network comparisons influences results quite significantly. Studies that included all accidents indicated quite conclusively that limited access networks have major benefits over gridiron networks, whereas studies that included only injury or pedestrian accident data in comparisons indicated far less benefits and, in some instances, a greater accident rate. Further, studies of pedestrian accidents in South Africa show that distributors, as opposed to collectors and residential roads, represent the most hazardous locations for pedestrians¹²² and, given much higher levels of walking, are probably much more important as a focus of pedestrian planning than in the developed

¹²² This is not surprising given the findings of research on the relationship between vehicle speed and pedestrian fatality. Studies have found that in collisions between vehicles and pedestrians, the pedestrian's chances of being killed rise dramatically with an increase of vehicle speed. The probability of a pedestrian fatality is 5% at 32 km/h, rising to 37% at 48 km/h, and to 83% at 70 km/h. (O'Flaherty 1997)

countries from which most network configuration practices originate.¹²³ The implication of these conclusions is that, with the caveat that unsignalised cross-intersections are avoided where possible, local networks can be configured to prioritise direct and multi-directional pedestrian movement without comprising road accident safety. Perhaps more importantly, the evidence indicates that efforts to improve pedestrian safety should be directed at arterials of various orders, as well as at local residential roads. As discussed in chapter 4, in South Africa traffic calming has been limited in the main to residential roads, and pedestrian planning has tended to focus on internal neighbourhood movements (as for instance in the case of the 'experimental' networks studied by Ribbens 1990). Greater attention in network configuration needs to be directed at the safe accommodation of the longer distance walking trips prevalent in South African cities discussed in chapter 3, in which it is necessary for pedestrians to cross arterials to gain access to neighbouring activity sites.

With regard to the implications of the reviewed evidence for the improvement of network management practices in South Africa, the evidence suggests that, if an objective in network configuration and management is to manage travel demand and encourage mode switching – as indeed it should be – it needs to be included as one of a suite of co-ordinated measures with this objective. On its own, local movement network configuration and management can be expected to yield results which, at best, will be inconsistent.

The weight of evidence also indicates that traffic calming measures have a more consistent impact on road accident reduction than network configuration – although volume management measures like road closures might be classified more as 'configuration' than 'calming'.¹²⁴ The sometimes unexpected effects of physical (as opposed to regulatory) speed management measures on traffic volume discussed earlier, illustrate the necessity for local network management measures to be applied on an area-wide, as opposed to site-specific, basis. Section 5.5 illustrates that there is precedent to draw from in the development of local network management practices in South Africa that analyse problems on an area-wide basis, and that apply network management measures across local areas systemically and proactively.

¹²³ Proctor (1991) for instance notes that American research has found that some 95% of pedestrian accidents take place at speeds under 48 km/h, indicating that accidents are more likely to occur in this context on slower moving collectors and residential roads than higher speed arterials and freeways.

¹²⁴ Boarnet and Crane (2001) in fact go further to conclude, on the basis of their econometric modelling, that traffic calming measures have a more consistent effect on reducing car trip generation, vehicle kilometres travelled and car share of modal split than network configuration.

Chapter 6

Still
of

focus on the problem
of congestion

the problem

Conclusion: towards a better match between travel need and local network configuration and management in South African cities

6.1 REVISITING THE AIMS OF THE DISSERTATION

As stated in chapter 1, my aims in undertaking the research recounted in this dissertation were primarily:

- to investigate why travel by non-motorised modes and within local areas is not accommodated adequately in South African cities;
- to investigate whether practices in analysing travel need and configuring and managing local networks can be improved; and
- to explore the implications a new policy environment (that prioritises understanding travel need, managing road space, and accommodating public transport users and pedestrians) has for such practices.

Conclusions regarding the first of these questions can be drawn from preceding chapters. In chapter 2 I demonstrate that travel by non-motorised modes and within local areas has not been well understood in past South African travel analysis. I argue that the bulk of travel data collection and analysis methods applied in South Africa have been drawn from a stream of methods developed in the United States in the 1950s and 1960s in the context of a 'predict-and-provide' transport policy environment. While these methods – principally in the form of inter-zonal O-D surveys and aggregate four-step traffic forecasting models – have been refined and improved over time, they by and large remain, procedurally and substantively, the same as those first developed in the late 1950s in cities like Detroit and Chicago. They also remain centrally focused on the problem of traffic congestion, and the construction of highways in its alleviation. A focus on traffic congestion, together with the labour transportation requirements of urban apartheid, led to a focus on home-based work trips and morning peak periods in South African travel analysis. I found that, as a result, local travel – much of which is

to non-work activities and by non-motorised modes – has thus been either overlooked or poorly understood.

It would appear reasonable then to postulate that, without sufficient knowledge of local travel need and behaviour, accommodating such need in the configuration and management of local movement networks adequately would be very difficult. In chapter 3 my primary research in Cape Town demonstrates that, while accounting for a relatively small share of commuter mode use, walking is an important travel mode. Notwithstanding the relatively low confidence interval of my sample, main mode walking trips are shown to be particularly important in satisfying the travel needs of middle- and low-income households (accounting for 43% and 61% of all trip main mode use respectively). I argue that walking, more than any other mode, rivals the motor car as a means of transportation in South African cities. My primary research also indicates that non-work and off-peak travel account for the majority of travel activity (80% and 54% respectively), and the focus on commutes and peaks in past surveys has therefore in all likelihood distorted perceptions of travel needs and patterns. In particular, I argue that, at best, the exclusion or underestimation of walking trips in past travel surveys has introduced a routine bias in the way in which the urban transportation problem has been framed and skewed the allocation of transport planning resources away from pedestrian network planning issues. At worst, it has led to neglect in the planning and design of infrastructure improvement for the poor and vulnerable road users.

In addition to an inadequate understanding of travel by non-motorised modes and within local areas, in chapter 4 I contend that local network planning practices have been imported without rigorous consideration of the contextual differences presented by South African conditions. I demonstrate in this chapter that South African codes of practice have promoted 'closed' 1.5-2 km square cells of collector and access road networks contained within delimiting grids of limited access arterials and freeways, which are supposedly introverted in terms of land use distribution and pedestrian movements. These practices have been drawn from British and American ideas concerning functional road hierarchies and through-traffic elimination developed in the 1940s and 1960s, and ideas about introverted pedestrian movement developed in the 1920s and 1930s. I argue that South African practices have thus shared, even if implicitly, the underlying assumptions of these ideas regarding the inevitability of universal access to private transport and the introverted or localised nature of walking trips, and argue that insufficient consideration has been given to how travel needs and behaviours differ in the local context. In the case of walking distances for instance, the walking trip length findings of my primary research refute assumptions regarding the introverted or localised nature of walking trips that underlie the above-mentioned imported practices. Mean (main mode) walking trip lengths amongst low-income households were found to exceed recommended parallel arterial frequencies (± 2.8 km vs. 1.5-2 km), which implies that pedestrians will often have to cross such arterial routes with the consequent danger of accidents reflected in the relevant statistics.

I also argue in chapter 4 that the implementational frameworks through which local movement networks have been managed are inadequate – offering a further explanation for why travel by non-motorised modes and within local areas has not been accommodated well. I claim that local network management practices have tended to be uncoordinated and reactive, and focussed on road safety and the efficient management of vehicular traffic. South African codes of practice, with the exception of those associated with TSM procedures, have tended to focus on the geometrics of paths and crossing facilities, and on the circumstances under which different types of retrofitting management measures might be warranted at specific sites. I argue that as a result, and as a general rule, recommended management practices have not undertaken casual analyses of problems beyond localised traffic engineering assessment of ‘road environment’ factors, and that little attention has been paid to pedestrian and bicycle network severance and connectivity.

To draw conclusions regarding the latter two research aims reiterated above – to investigate whether practices can be improved, and the implications of a new policy environment – further discussion will be required. The two questions are substantively interlinked, and I address them concurrently. The improvement of travel analysis, network configuration and network management practices are discussed in turn (in sections 6.2 to 6.4). I also identify future research needs, as an exploratory and multi-disciplinary research topic of this nature inevitably raises a number of issues that cannot be investigated to a satisfying conclusion. In the final section (section 6.5) I reflect upon where I believe I have made contributions to the research field.

6.2 TOWARDS BETTER TRAVEL ANALYSIS

How then can travel analysis practices be improved, and what future research is required to assist this process? A central argument that threads through this dissertation is that, in the context of increasing economic uncertainty and a shift towards demand-side and equity-oriented passenger transport policies, empirical observation aimed at improving understanding of current travel need and behaviour (as opposed to predicting it at some future point in time) is important and necessary, that this analysis needs to be inclusive of diversity, and that it needs to seek to unravel complexity in behavioural adaptations to changes in urban transport systems rather than simplify them. In chapter 3 I argue that to identify problems of equity between different categories of users, the scope of empirical observation needs to extend to cover all travel undertaken by all people, and that to understand travel adaptation to change, travel behaviour needs to be observed over time. Of particular importance, given the conclusions drawn above, walking needs to be analysed as a travel mode in its own right so that it can be accommodated equitably in plans and improvement programmes.

I am not suggesting that every travel survey undertaken needs to include all forms of trip-making, or that every model developed needs to include both motorised and non-motorised modes. Clearly the

purposes of different analytical exercises will continue to require particular foci and limitations of scope. What I am suggesting however is that some collection and analysis of data on all travel behaviour is required at regular intervals, of say 2-5 years (depending on resources), so that shifts in need and adaptations in behaviour can be identified. While such surveys could be administered by local transport authorities, in order to ensure data consistency and enable comparisons between geographical areas, it would probably make greatest sense for them to be conducted nationally, and would presumably therefore need to be administered under the auspices of the NDoT. As found in chapter 3, the type of survey instrument and procedure, and the timing of data collection (e.g. during or outside school terms), can have a significant effect on trip recall and travel behaviour, and in order for data from different parts of the country to be compatible these would have to be constant. Such surveys could take the form of repeated cross-sectional surveys or panels (of which the discontinued biennial national passenger panel is an example) – either way, regular time intervals would be critical to produce data that enable the dynamics of change to be analysed.

The primary research reported in chapter 3 demonstrates, I believe, the advantages of activity-based survey instruments over other instruments, notably trip diaries – suggesting that this may be the most appropriate survey method for a national survey aimed at uncovering diverse and complex travel behaviour. I argue in chapter 3 that activity-based methods are best suited to analysing travel behaviour within the context of personal and household activity schedules and survival strategies, and result in higher levels of trip recall (particularly of non-home-based and non-motorised trips). Despite not being analysed exhaustively in the dissertation, the data collected in my primary research does illustrate the detailed insights into travel needs and behaviour that can be gained through activity-based survey methods. It should be noted however that there may be better ways of applying this method in the South African context. I undertook no comparative testing of alternative survey forms, and cannot therefore claim that the instrument I used or the procedure I followed is best. Future research is required to establish criteria (e.g. item non-response, trip recall, respondent burden, respondent cognition, etc.) and to systematically evaluate the advantages and disadvantages of different survey instrument types (as discussed in section 3.3), and of different administration procedures (e.g. interview vs. self-completion, PAPI vs. CAPI, incentives, etc.). It should be further noted that my primary research experience suggests that some travellers and some aspects of trip-making could be better understood through other survey methods. I am not arguing therefore that activity-based surveys represent the only appropriate method. Further research is also required to target those travellers and trip-making activities not understood sufficiently in random household travel surveys. Important amongst these are persons engaged in informal income generating activities, the mobility impaired, pedestrians and cyclists, and the logistical detail of trip chains and mode transfers. In this regard I believe exciting potential exists to extend understanding of travel needs and constraints through the use of qualitative survey techniques, and the further application of time geographic paths and prisms. Of particular significance to the focus of this dissertation, detailed

observation and in-depth interviewing of pedestrians and cyclists¹²⁵ (particularly those acquiring low-cost bicycles through the current *Shova Kalula* initiative) would provide necessary insight into the problems facing, and improvements required by, non-motorised modes in South African cities.

Irrespective of which instrument type is used however, the experience gained from my survey illustrates that data richness comes at a price. I found that the data intensity of, and attendant difficulties in applying, activity diaries increases surveying costs significantly – even though economies of scale in larger samples would probably bring the sampling unit costs quoted in chapter 3 down. I argue in chapter 3 that activity participation and time-use data are relevant across numerous arenas of policy research, and therefore that solutions to the problem of increased survey cost lie in data sharing and the commissioning of surveys by numerous agencies. Further research is required to explore the data sharing potential of activity and time-use surveys so that the feasibility of co-commissioning and cost-sharing can be examined.

Further research is also required into the question of *why* the focus of travel analysis in South Africa has, with limited exceptions, been routinely restricted to commutes and peaks. I believe a promising means of investigating this question is offered by a conceptual framework drawn loosely from the mode of ‘critical discourse analysis’ which has been applied to the analysis of numerous urban policy sectors and practices (e.g. Hajer 1995, Spiegel *et al* 1997), and to the field of urban transportation more specifically (e.g. Banister *et al* 2000, Flyvberg 1998, Richardson 1998, Vigar 2002).¹²⁶ From a critical discourse analytical perspective, the frequent omission of non-work, off-peak and non-motorised travel in analysis could be interpreted as the result of a dominant ‘discourse’ framing the transport problem in a particular way and systemically if unintentionally ignoring alternative frames in data collection and analysis. Problems associated with equity, accessibility and sustainability, while

¹²⁵ With the caveat that the manifestly greater importance of walking is not ignored. It is of concern that current policy efforts to improve non-motorised travel in South Africa focus mainly, if not exclusively, on bicycles despite their very low utilisation beyond recreation trips – an example perhaps of the dangers of basing policy decisions on analyses of travel need and behaviour that fail to embrace diversity and complexity.

¹²⁶ ‘Critical discourse analysis’ in the field of urban policy looks for underlying power relations and struggles between different discourses. Professionals are seen to use analytical techniques, specialised vocabularies and procedures to construct particular forms of knowledge that provide legitimacy for prevailing discursive viewpoints. To address the question of why the focus of travel analysis in South Africa has been restricted to commutes and peaks it is necessary to determine how, by whom and in whose interests, and why, a particular ‘truth’ – in this instance about what constitutes significant travel need and behaviour – has been constructed and represented. Despite contributions by geographers, town planners and sociologists, and despite studies undertaken by academic and research institutions, the field of travel analysis in South Africa has been dominated by engineers and economists acting as officials of, or consultants to, public sector transport authorities. The core responsibilities of these authorities have in the past been to produce and implement urban transport plans within an essentially ‘predict-and-provide’ policy environment, and as a consequence, as was discussed earlier, travel analysis has focused on gathering the data necessary to calibrate aggregate or disaggregate four-stage models and on running these models to forecast future patterns of traffic. The four-stage model was developed in a North American policy *milieu* of accommodating rapidly increasing private motor car use through long-term and capital-intensive highway construction. It was an analytical tool essentially constructed and used to demonstrate a rational economic case for road building – an endeavour supported by numerous agencies (known as the ‘roads lobby’) with an interest in the production and retail of petroleum and motor cars, and in the construction of road space. Within the particular policy discourse of ‘predict-and-provide’, and within the analytical framework of four-stage modelling, the urban transport problem has therefore been defined as one of avoiding forecast traffic congestion through increasing road capacity supply. Because most traffic counts had found that levels of congestion are at their worst during the morning peak period, travel surveys and models were very often restricted to this period. In addition, because it was conventionally understood that work trips constituted the bulk of morning peak period trips, in some instances (e.g. the most recent metropolitan transport modelling exercise undertaken in metropolitan Cape Town) the analytical focus was further restricted to only trips with this purpose.

the subject of some research and analysis (e.g. in the form of analyses of the needs of 'special needs' passengers and the peripheralised poor), have therefore seldom assumed central importance in the prevailing travel analysis discourse.

In summary then, I argue that empirical observation aimed at improving understanding of current travel need is important and necessary, that this analysis needs to be inclusive of all travel undertaken by all people, and that travel patterns need to be observed over time in order to identify adaptations in behaviour. Of particular importance to this research, walking needs to be analysed as a travel mode in its own right. To ensure consistency and to enable comparisons between geographical areas, it would make sense for surveys that collect these data to be conducted nationally, at the same time, using the same instrument. Such surveys could take the form of repeated cross-sectional surveys or panels. Activity-based methods offer a suitable analytical framework, but random household travel surveys are unable to provide adequate data on the needs of all travellers or on all trip-making activities. Other surveys methods should therefore also be used to complement them.

6.3 TOWARDS BETTER LOCAL NETWORK CONFIGURATION

Having discussed the possibility of enhancing understanding of travel need through the improvement of travel analysis practices, I turn now to the questions of how local network configuration practices can better meet travel needs in greenfield development, and what future research is required in this regard? As discussed earlier, chapter 3 illustrates that, especially in middle- and low-income areas, pedestrian travel needs (as opposed to pedestrian safety needs exclusively) require far greater attention – both as trip segments attached to public transport trips, and as main mode trips in their own right. The data collected in my primary research indicate that for poorer households walking is by some considerable margin the most important travel mode in terms of the time allocated to it (see figures 3.48 to 3.53), and it is likely that for some younger and older individuals walking is the only available mode of daily transportation. The evidence discussed in chapter 5, and alluded to in earlier chapters, indicates that practices developed to accommodate pedestrian travel in the developed world will not necessarily be effective in South African cities, principally because their underlying assumptions concerning the nature and range of walking trips do not hold true. To develop better local network configuration practices in South Africa it will be necessary to recognise that walking trips are not always internal to residential neighbourhoods or commercial and business precincts delimited spatially by arterial grids, and will in many instances unavoidably occupy intensively used road space shared by other modes.

The relationships between network configuration and improved local travel conditions discussed in chapter 5 illustrate that the performance of different generic network types varies when viewed from different perspectives. On the one hand, while traditional and 'neo-traditional' networks improve

levels of accessibility to local destinations and increase walking and perhaps even public transport use, they can also (in the absence of effective traffic calming measures) result in high vehicle collision rates and other traffic problems associated with the intrusion of speeding through-traffic. On the other hand, while limited access suburban networks can manage through-traffic volumes effectively, they can also discourage walking by increasing trip lengths, force all local vehicular trips onto the arterial network, and (in the absence of effective speed management measures) enable high traffic speeds on collectors and local roads with consequent dangers to pedestrians and cyclists crossing or using these routes. In addition, as Homburger *et al* (1989) observe, they can force public transport vehicles frequently either to back-track or to turn across oncoming traffic lanes. It is my contention therefore that the development of better practices will not involve the selection of one network type over another, but involve the development of a sufficiently flexible and multi-layered multi-modal network able both to manage vehicular traffic and to prioritise walking and public transport.

The accommodation and management of different modes requires different levels of connectivity within the same movement network. The key to achieving this, in my view, is to conceptualise local area movement infrastructure as a network of 'public rights-of-way' or 'reserves', as opposed to being viewed simply as a road network. As defined in chapter 1 such right-of-way networks are comprised of overlaid systems of 'ways' for different travel modes, the use of which is at some points shared and at other points exclusive. Thus pedestrian travel would be accommodated on a network of exclusive footways and pathways as well as shared roadways, public transport vehicles would be accommodated on a network of shared roadways and exclusive busways, motor cars on a network of shared roadways, and so on. The creation of overlaid and variously connected networks for different modes requires that the network of public rights-of-way be configured as a topological (as opposed to orthogonal) multi-directional grid. This enables different networks for different modes to either incorporate or avoid respectively, the advantages and disadvantages of different generic network types referred to above. It would therefore be possible, for instance, to maintain direct pedestrian and bicycle movement in all directions (through the design of the footway, pathway and cycleway component of the network as an 'open' system), while at the same time preventing or limiting the safety and intrusion problems associated with speeding extraneous vehicular traffic (through the design of the roadway component of the network as a 'calmed' and 'closed' system).

Figures 6.1 to 6.3 provide a hypothetical example of how a topological public right-of-way grid might facilitate the management of speeding extraneous vehicular traffic on residential streets through the creation of a relatively 'closed' network and proactive traffic calming, while at the same time maintaining an 'open' footway and pathway network for pedestrians (and bicycles).¹²⁷ The important point to note is that the movement network is designed first to accommodate the needs of non-motorised modes, and then to accommodate the motor car, and not the other way round.

¹²⁷

This example is drawn from my own contribution to the drafting of chapter 5.1 of the 'new red book' (NDoH 2000).

Figure 6.1 (a) *Topological public right-of-way grid*

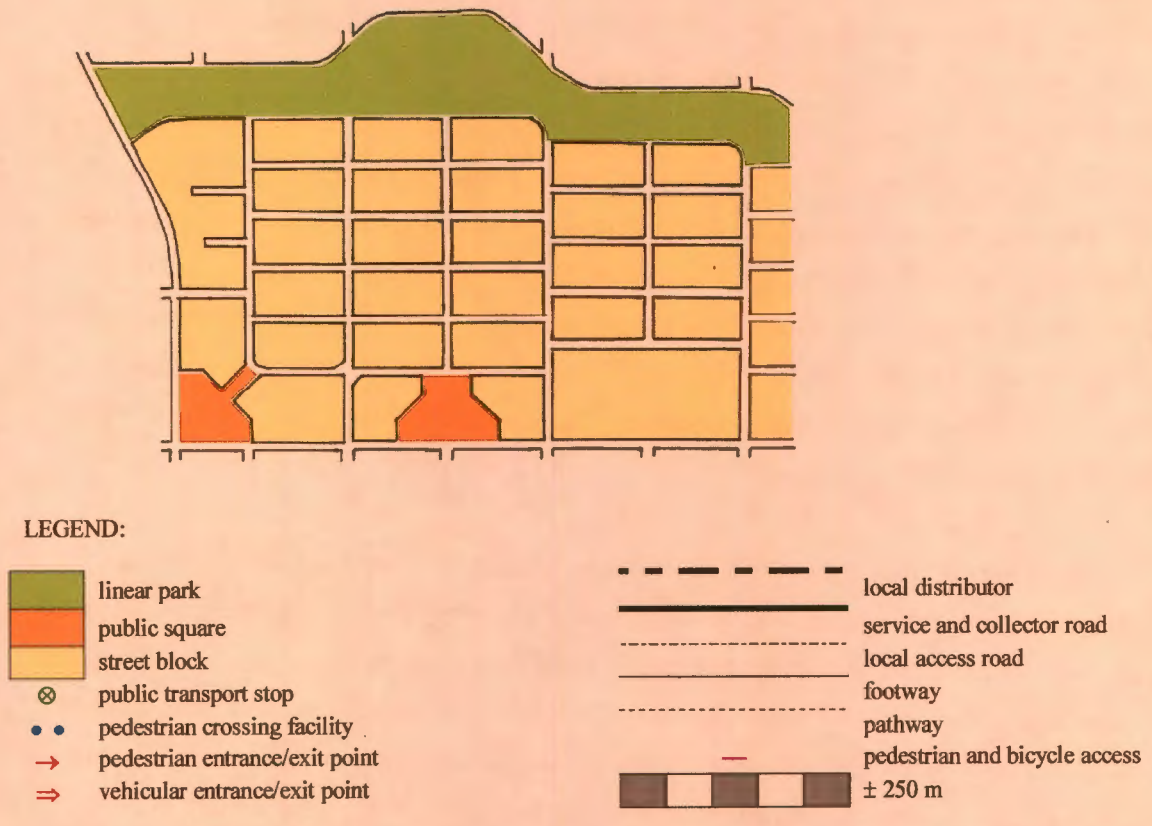


Figure 6.2 (b) *Open pedestrian network*

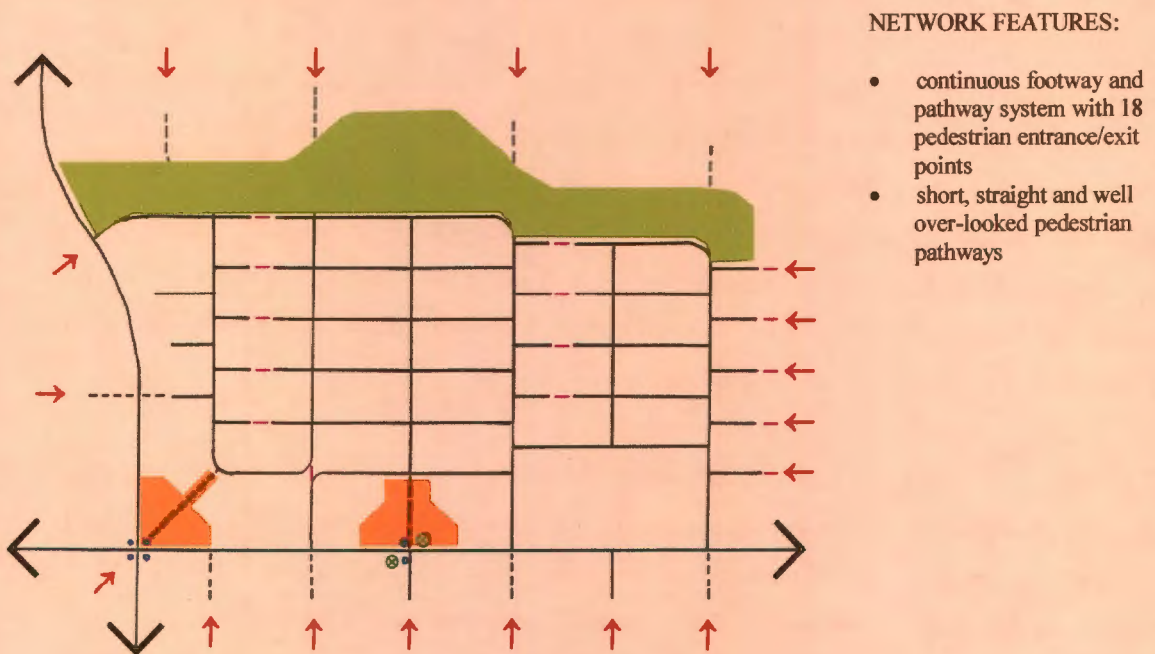
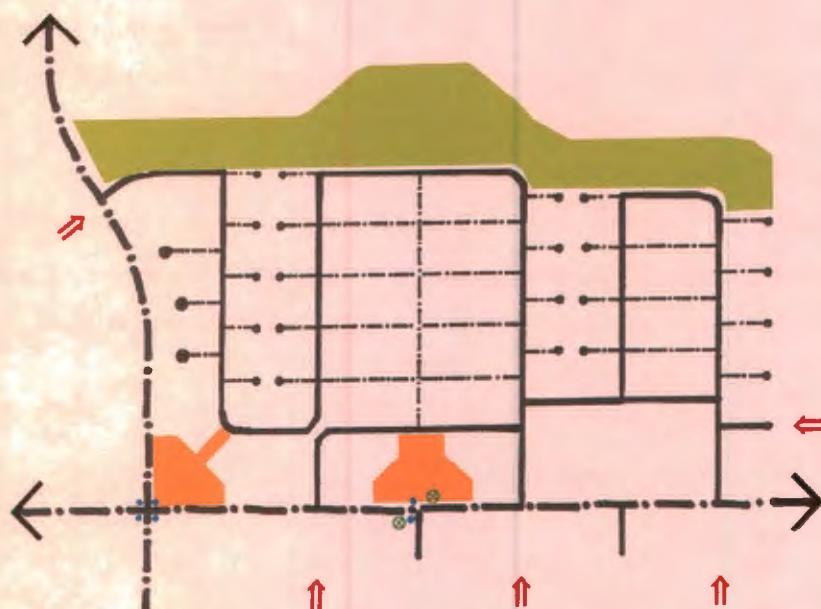


Figure 6.3 (c) *Closed vehicle network*

NETWORK FEATURES:

- discontinuous roadway system with 5 vehicular entrance/exit points
- direct public transport route
- predominance of tee-intersections (38 tee- vs. 12 cross-intersections)
- minimum spacing between tee-intersections involving (public transport carrying) local distributor and service/collector roads is ± 100 m
- minimum spacing between tee-intersections involving collector and local access roads is ± 25 m
- minimum spacing between cross-intersections involving collector and local access roads is ± 50 m

A topological public right-of-way grid, with its associated patterns of public and private land ownership, further enables the various overlaid networks described above to be adapted to become more 'open' or 'closed', and more shared or exclusive, as shifts in modal split and dynamic land use development processes alter the nature and pattern of movement demand and the functions of particular streets. As mentioned in chapter 4, movement network configurations to a large extent determine the pattern of land sub-division, which in turn forms the basis for title registration and the allocation of development rights. Given that large scale expropriation and compensation is required in order to significantly alter patterns of land ownership and development rights, discontinuous or 'dendritic' public right-of-way networks are extremely difficult to adapt and are inflexible.

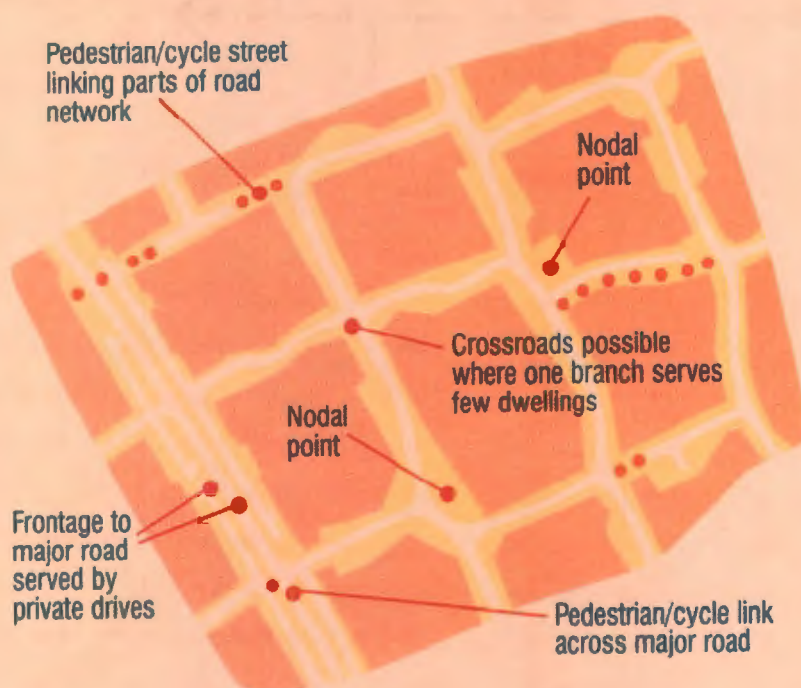
- The creation of direct and multi-directional pedestrian networks, capable of accommodating inter- as well as intra-neighbourhood walking trips, necessitates a further conceptual shift from functionally introverted or 'cellular' neighbourhoods to what Hugh Barton (2000b) terms 'fuzzy' neighbourhoods. Such fuzzy neighbourhoods are bounded by commercial strips and town centres, not centred around them, and thus are tied neither to specific population thresholds,¹²⁸ nor to particular walking catchments. In functional terms, they therefore merge into each other and are highly 'permeable' from the perspective of non-motorised travel. The pedestrian networks of such adjacent and functionally indistinct neighbourhoods need to interconnect to facilitate direct and multi-directional inter-neighbourhood walking patterns, and, where warranted by pedestrian desire lines and volumes, frequent and regularly spaced grade-separated crossing facilities need to be provided to maintain

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As was for instance the case with primary schools in Clarence Perry's 'neighbourhood unit' concept (see section 4.2.1.2).

- network continuity and enable safe pedestrian crossing of high speed arterials or railways.¹²⁹ Current
- South African pedestrian road accident data clearly illustrate that pedestrians in lower income areas
 - will take considerable risks to reduce their walking distances, and this needs to be borne in mind in the warranting and spacing of pedestrian crossing facilities. Further research is required to investigate the impact of crossing spacings on pedestrians trips lengths, and to shed light on the maximum acceptable spacing of grade-separated crossing facilities. It might be useful in this regard to analyse available road accident safety datasets to understand better the interrelationships between pedestrian casualties and road type, and more specifically to interrogate the timing, age and walking trip purpose characteristics (amongst other variables) of pedestrian casualties occurring along high speed arterials and freeways.

Figure 6.4 'Permeable' street layout



Source: EPOA 1997:11

Interestingly, the ideas I sketch above appear to have gained recent attention, apparently independently, in different parts of the world. In the United Kingdom for instance, the Essex Planning Officers Association (1997) argue that to allow free and preferential pedestrian and cycling movement, both locally and on a wider scale, the ideal would be a 'deformed grid' based on a small residential block. The advantages of *culs-de-sac* and loops in preserving amenity, quiet and security could then be combined with those of a 'permeable' network for pedestrians by bringing heads of *culs-de-sac*

¹²⁹

It is interesting to note that in Tanzanian cities, where walking shares of modal split are very similar to those of the low-income band in this research (46% in Dar es Salaam and 67% in Morogoro vs. 61% amongst low-income households), it is recommended that the parallel frequency of 'collector/distributor' routes is 1 000-5 000 m, and 4 000-10 000 in the case of 'urban corridors' (Rwebangira and de Langen 1999:5). This reflects much greater sympathy to the severance impact of arterials on pedestrian movement in lower income environments, than the South African convention of 1 000-1 500 m spacings for 'district distributors' and 2 000-4 000 spacings for 'expressways and other primary arterials' (see section 4.4).

together, by creating short pathway and cycleway links between discontinuous parts of the roadway network, and by providing crossing facilities across major roads that would otherwise form a barrier (see figure 6.4). The Association argues that pathway and cycleway links should be as short as possible, with intervisible ends, and fronted by buildings for a good part of their length. It also argues that if traffic speed and volume management measures are applied proactively, roads will be slower and safer for pedestrians and cyclists, and that there should be no need for segregated pathways – which, it asserts, can present opportunities for crime, either against pedestrians or against properties backing onto the pathway. The recent companion guide to Design Bulletin 32 similarly advocates short pedestrian links to maintain multi-directional access (DETR 1998). It cites the case of Poundbury (Dorset) as an example of a network that manages vehicular traffic while at the same time providing a permeable pedestrian network (see figure 6.5). The IHT (1997) adopt a similar approach.

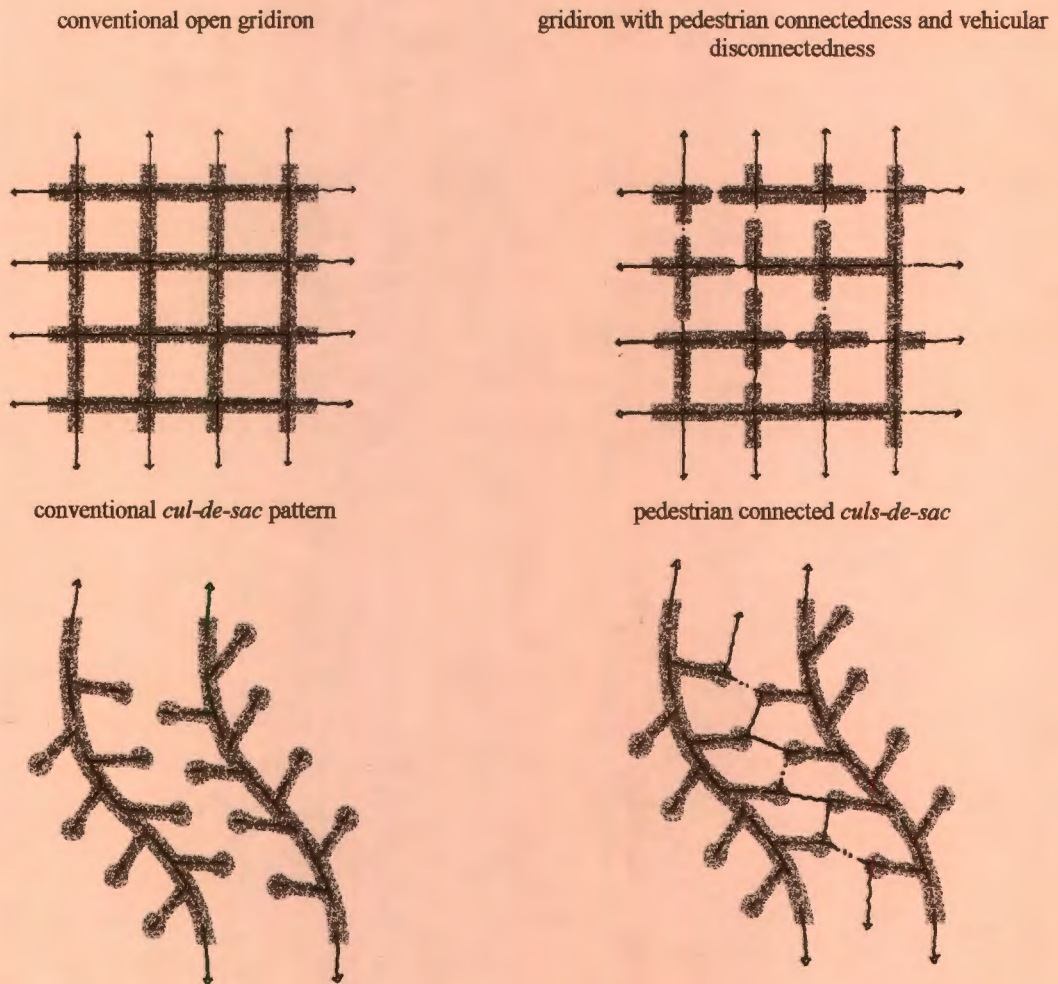
Figure 6.5 Poundbury (Dorset)



Source: DETR 1998:30

In the United States, Michael Southworth and Eran Ben-Joseph (1997) envisage a suburban residential environment in which vehicle movement is controlled and limited to collector and arterial routes, while pedestrian and bicycle movement has the kind of interconnectedness of the classic 'gridiron'. In a defence of the *cul-de-sac*, they argue that the pedestrian network can parallel the vehicular system, but also connect *culs-de-sac* and loops with each other, thus creating a completely interconnected system (see figure 6.6). Michael Replogle (1999) also refers to 'traffic cells' which restrict through movements by private car while permitting full access to non-motorized and public transport.

Figure 6.6 *Interconnected pedestrian networks and limited access vehicle networks in gridiron and cul-de-sac subdivisions*



Source: Southworth and Ben-Joseph 1997:126

Further research is required to investigate how the basic concept discussed here might inform the development of detailed design codes and specifications applicable to a variety of socio-economic (e.g. high-income vs. low-income households) and developmental (e.g. 'greenfield' vs. 'brownfield' development) situations in South African cities. As mentioned in chapter 1, however, effecting changes in practice will require more than just new design codes. Additional research is therefore also required – perhaps using the same mode of 'critical discourse analysis' discussed earlier in relation to travel analysis – to investigate the limitations of, and potential for, effecting changes in practice in the context of South Africa's political transition with its attendant changes in patterns of decision-making power. This would involve an engagement with a now considerable literature which deals with the nature of political transition in South Africa, in all its political, economic and social complexity, a task that goes well beyond the scope of the literature reviewed in this dissertation.

In summary then, I argue that improved network configuration practices will require a realignment of priorities in which networks need to be designed first to meet the travel needs of pedestrians, bicycles, public transport users and public transport operators, and then to accommodate motor cars.

Reorienting network configuration practices around non-motorised modes, not cars, will require the conceptualisation of local area movement infrastructure as topological grids of public rights-of-way, as opposed to road networks conceived simply in terms of motorised travel needs. Within such topological public right-of-way grids pedestrians and cyclists would be accommodated on a continuous network of footways, pathways, cycleways and shared roadways, while motor cars would be accommodated on a network of roadways deliberately designed to be discontinuous where necessary. The accommodation of inter- as well as intra-neighbourhood walking trips, will require a further conceptual shift from functionally introverted or 'cellular' neighbourhoods, to functionally 'fuzzy' and permeable neighbourhoods bounded by, not centred around, commercial strips and town centres. The pedestrian and bicycle networks of adjacent neighbourhoods therefore need to interconnect, and when unavoidably severed by high speed arterials or railways and warranted by pedestrian desire lines and volumes, connected by grade-separated crossing facilities.

6.4 TOWARDS BETTER LOCAL NETWORK MANAGEMENT

Having discussed improved configuration practices in greenfield development, how then can local network management practices meet travel needs in existing settlements better, and what future research is required to assist this process? Earlier (in chapter 4), I identified the components of local network management practices as the addition or extension of various infrastructures for pedestrians and cyclists, and the control of vehicular traffic speeds, volumes and accesses through roadway retrofitting. I concluded that in South African cities, despite TSM guidelines for comprehensive management measures across study areas, these practices have typically been conducted on a piecemeal and reactive, or 'black spot', basis. I argued that these management practices should instead be proactively co-ordinated across local areas, and indeed if the boundaries between local areas are to be 'fuzzy', (at least for non-motorised modes) as discussed above, they should be co-ordinated between local areas as well. Proactive and spatially co-ordinated local network management enables causal analysis of problems beyond reactive localised traffic engineering assessment (e.g. analysis of the role of land use patterns and non-motorised trip purposes, the severance effect of arterials, route choice and security factors in network problems), and better anticipation of the systemic consequences of network interventions (e.g. rerouting of vehicular traffic as a result of changed travel times).

In chapter 5 I identified international precedent for proactive and area-wide local network management, and for analytical alternatives to the 'black spot' approach, from which South African practices might be developed. Further research is required to develop criteria and evaluate the identified alternative methods of assessing NMT network performance and of identifying connectivity, severance, safety and security problems for pedestrians and cyclists.

How then might proactive traffic calming, pedestrian planning, bicycle planning and other local road safety or TSM measures in South African cities be co-ordinated within a single implementational framework, which addresses local travel issues at a range of scales, and is integrated with broader development, transport and spatial planning frameworks? Frameworks for planning and managing South African cities are currently in a state of change. Three recent pieces of legislation provide the basic statutory framework within which urban settlement planning and management is to occur. The first, the *Local Government: Municipal Systems Act (No 32)* of 2000, requires municipalities to formulate 'integrated development plans' (IDPs). In terms of section 26 of the Act an IDP must include a vision, an assessment of the existing level of development, priorities and objectives, development strategies, a spatial development framework, operational strategies, disaster management plans, a financial plan, and key performance indicators and targets. The second, the *National Land Transport Transition Act (No 22)* of 2000, requires metropolitan transport authorities, or in their absence designated municipalities, to formulate 'integrated transport plans' (ITPs) for metropolitan transport planning areas. In terms of section 27 of the Act an ITP is an annually updated five-year strategic plan which includes a detailed budget for the next financial year and a list of priority projects for the five year horizon. Section 18 of the Act requires that ITPs must be accommodated in, and form an essential part of, IDPs. The third, the *Draft Land Use Management Bill* of 2001, requires that every municipality formulate a 'spatial development framework' (SDF) as part of its IDP. In terms of section 16 of the draft Bill the SDF must include a land use policy, a spatial plan, guidelines for a land use management system, a capital expenditure framework, and a strategic assessment of environmental impact.

While this emerging legislation sets out planning frameworks at the metropolitan scale fairly clearly (even if the link between IDPs, ITPs and SDFs is at times vague), frameworks for planning at sub-metropolitan scales remain unclear and undeveloped. As a result of its essentially proselytising stance, the international literature unfortunately provides little insight into the detailed institutional and planning frameworks required for effective local area transport planning, beyond stressing the importance of thorough public participation and communication in achieving acceptance and avoiding litigation (see for instance Homburger *et al* 1989, de Langen and Tembele 2001).¹³⁰ A possible framework through which integrated local area transport planning might occur is however proposed in recent research by Vanessa Watson (2001) into an appropriate spatial planning framework for metropolitan Cape Town. Watson (2001) argues that a level of sub-metropolitan planning is required which is local in nature (at a scale determined by the nature of the problem), which is relatively precise in terms of demarcating interventions, yet is clearly guided by metropolitan plans and strategies. In the context of Cape Town at least, she concludes that it will not be possible, due to resource limitations, to develop such local plans for all parts of the metropolitan area at any one time.

¹³⁰ A further objective of the earlier mentioned pilot projects in Sub-Saharan Africa was to find a feasible organisational model of planning, implementing and maintaining non-motorised improvements at a municipal level. The conclusions de Langen (1999) draws in this regard also offer little insight, as he concludes that Kenyan and Tanzanian municipal governments have the capacity to undertake neither transport planning functions generally nor local network management specifically, and that external planning and implementation expertise is therefore required in these contexts.

There would therefore need to be strategic identification, in any five year planning cycle, of those local areas which will require, for a variety of reasons, the drawing up of such local plans. She argues that these plans would require some kind of legal status in order to bind decision-makers. She notes that while the *Draft Land Use Management Bill* is silent on the need for this level of planning, *Draft Municipal Integrated Development Planning Regulations* prepared in 2001 allow for 'localised implementation plans', which municipalities could approve as bylaws – thereby according them some form of legal status. If sub-metropolitan transport planning and management is to be integrated with spatial planning and management, as it should in terms of the spirit of the emergent planning legislation, then local movement network management could form an important component of these local area plans, and local traffic calming, pedestrian and cycling issues could be important motivating factors in the strategic identification of local area planning needs.

The emerging framework for planning at a sub-metropolitan scale nevertheless remains unclear, and research is required that develops appropriate institutional, budgetary and legal structures through which integrated local area plans can be formulated and implemented. From the perspective of the dissertation's focus, the role of pedestrian planning, bicycle planning and traffic calming in these local area plans would require particular attention.

In summary then, I argue that improved network management practices will require co-ordinated and proactive pedestrian planning, bicycle planning and traffic calming, integrated within wider spatial development and travel demand management frameworks, and informed by analytical techniques that go beyond hazardous road accident, or 'black spot', identification. The planning frameworks emerging from recent legislative change in South Africa however, focus almost exclusively on the metropolitan scale and provide little indication of how such co-ordinated and integrated practices might be implemented, and by whom. It is likely that resource limitations will prevent entire metropolitan areas from being covered by local plans. Local areas, and their geographical extents, will therefore need to be identified and prioritised strategically. Within such a strategic and integrated local planning framework, local transport issues will need to be central to the content of local area plans, as well as to the strategic identification of those parts of cities requiring localised integrated planning attention.

6.5 CONTRIBUTION TO KNOWLEDGE

It was my intention, in formulating responses to the dissertation's research question, to make a number of contributions to knowledge within the research field. There would appear to be numerous ways in which an original contribution to knowledge can be made (see for instance Phillips and Pugh 1994). The interpretation of this important concept can however vary. It is my understanding that the conventional interpretation of an original contribution is, in essence, research that either develops new ideas, explores a new field and provides a new body of information, analyses and interprets existing

information in a different way, synthesises existing material that has not been synthesised before, develops an innovative research technique, or applies an established research technique in a new context or in a different discipline. With this interpretation in mind, I will now highlight where I believe my contribution has been made.

Firstly, I contend that the origins and development of travel analysis practices traced in chapter 2, and the origins and development of local network configuration and management design codes traced in chapter 4, have not been synthesized and interpreted in South Africa in this way before. I anticipate therefore that these two historical reviews represent a contribution.

Secondly, I claim that the application of time geographic and activity-based analytical methods in chapter 3, while not necessarily the first application within this methodological stream, is nevertheless innovative in the South African context and thus also represents a contribution.

Thirdly, despite a constrained sample size and associated large confidence intervals, the data collected in my primary research do, I believe, provide a new body of information and add original insights into travel needs and behaviour in metropolitan Cape Town (as a case study of a South African city) overlooked by, or poorly understood in, past surveys. Chapter 3 generally, in my view, illustrates the benefits of undertaking travel surveys that look beyond commutes and peaks, and of analysing travel from the perspective of household activity schedules and survival strategies.

Fourthly, I contend that the multi-faceted review and discussion of the evidence of links between local network configuration and management practices and improved local travel conditions in chapter 5 is more comprehensive than has previously been the case, certainly in South Africa, and anticipate that this too represents a contribution.

Finally, while not entirely unique in international terms, the ideas presented in this chapter for improving network configuration and management practices are different from South African praxis.

It is probably inevitable that exploratory research, because of its pioneering and heuristic nature, can be brought to a less satisfying conclusion than descriptive or explanatory research projects which investigate topics in detail, advance knowledge and build theory. Concluding this dissertation with a discussion on future directions that need to be taken to improve practices, and on future research that would need to be undertaken to facilitate this, is a little frustrating. Nevertheless I believe that I have fulfilled the aspirations that motivated me to undertake the project. In chapter 1 I articulated these to be a desire to contribute to the improvement of practices with regard to the planning and management of transport systems that manifestly fail to accommodate the needs of the poor and vulnerable, to examine the implications for practice of a changed post-apartheid transport policy environment, and to reframe and clarify what is at issue in inter-disciplinary contestation in the field of local network

configuration and management. The improvements I suggest in this concluding chapter would go some way to addressing my concerns for the travel needs of the poor and vulnerable and for the alignment of practices to more equitable policy objectives, and I have engaged with concepts and methods from various disciplines in framing and clarifying the issues at hand. I believe I have demonstrated that there is a strong case for South African practices in the fields of travel analysis and local network planning to be reviewed and amended. In many respects a fundamental reframing of the transport problem, and how it should be addressed, is required. I am under no illusion however that effecting such 'real life' change is easy to accomplish. The translation of new ideas into action remains a difficult and slow process and, as demonstrated in the historical reviews of practices presented earlier, has very often required strong intervention. The task of getting the professionals involved in the fields of practice dealt with in the dissertation to reconsider their approaches and perceptions presents a major challenge in South Africa.

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Appendix A. RELATED DOCTORAL RESEARCH PRODUCTS

Behrens R, 1998: "*The evolution of 20th century movement network design ideas*", Working Paper No 55, Urban Problems Research Unit, University of Cape Town. ISBN 0 7992 1914 2

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Kane L and Behrens R, 2000: "*The traffic impacts of road capacity change: A review of recent evidence and policy debates*", South African Transport Conference, "Action in Transport for the New Millennium", Pretoria.

Behrens R, 2000: "*Activity-travel analysis: A review of theoretical origins, recent developments and local application*", South African Transport Conference, "Action in Transport for the New Millennium", Pretoria.

Behrens R, 2001: "*The diversity and complexity of travel needs in South African cities, with specific reference to metropolitan Cape Town*", Working Paper No 2, Urban Transport Research Group, University of Cape Town. <http://www.utrg.uct.ac.za>

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Behrens R, 2001: "*Looking beyond commuter travel in Cape Town: Methodological lessons from the application of an activity-based travel survey*", International Conference on Transport Survey Quality and Innovation, "How to Recognise It and How to Achieve It", Workshop A-4 "Instrument Design", Berg-en-Dal.

Behrens R and Wilkinson P, (forthcoming): "*Housing and urban passenger transport policy and planning in South African cities: A problematic relationship?*", in Harrison P, Mayekiso M and Huchzermeyer M (eds), "Housing and integrated urban development", Wits University Press, Johannesburg.

Behrens R, (forthcoming): "*Looking beyond commuter travel in Cape Town: Methodological lessons from the application of an activity-based travel survey*", in Stopher P and Jones P (eds), "Transport survey quality and innovation: How to recognise it and how to achieve it".

Behrens R, 2002: "*A critique of travel analysis practices in South Africa with respect to the travel needs of the poor*", CODATU X, Lome.

Behrens R, 2002: "*Findings of an activity-based household travel survey in Cape Town, with particular reference to walking as a travel mode*", South African Transport Conference, "Towards building capacity and accelerating delivery", Pretoria.

Kane L and Behrens R, 2002: "*Transport planning models: An historical and critical review*", South African Transport Conference, "Towards building capacity and accelerating delivery", Pretoria.

Appendix B. SURVEY INSTRUMENTS

UNIVERSITY OF CAPE TOWN



Urban Problems Research Unit

C# Cottage, Lower Campus
Private Bag
Rondebosch, 7701
Telephone: (021) 650 3601
Facsimile: (021) 686 0152

24 October 2000

Dear Sir / Madam

HOUSEHOLD TRAVEL SURVEY

The market research firm *AC Nielsen MRA* is currently undertaking a survey of household travel patterns. The survey will provide important information on the travel needs of Cape Town's population. It has been commissioned by the Urban Problems Research Unit at the University of Cape Town.

Your participation in the survey will be greatly appreciated. Please note that any information you provide will be kept **strictly confidential**.

Yours faithfully

P B WILKINSON
DIRECTOR, URBAN PROBLEMS RESEARCH UNIT

INFORMATION SHEET



for AC Nielsen MRA interviewers on an

ACTIVITY-BASED HOUSEHOLD TRAVEL SURVEY IN THE CAPE METROPOLITAN AREA

conducted as part of a PhD research project undertaken by Roger Behrens

of the Urban Problems Research Unit, Faculty of Engineering and the Built Environment,
University of Cape Town

Why is the survey being done?

The survey forms part of a broader PhD research project on movement and road network design within local residential areas. The research is funded by the National Department of Transport.

A review of the available literature on travel patterns in Cape Town has indicated that our understanding of the complexity and diversity of travel behaviour is limited. In the past the passenger transport problem has been seen simply as one of traffic congestion, and this has resulted in a sometimes exclusive focus on either work trip-making (i.e. commuting) or morning peak periods when congestion is at its worst. The implicit underlying assumption being that a transport system which satisfies the need for travel during the commuter peak, will be able to satisfy all other travel needs.

It would appear that we understand little of non-work, informal work and off-peak trip-making; of household constraints on travel decisions; of so-called 'equity gaps' in transport supply; and, with particular relevance to the above-mentioned research topic, of non-motorised and shorter distance travel patterns.

The survey will attempt to fill some of these gaps in understanding, or at least indicate how big they may be. Its primary objective will be to demonstrate the diversity of travel needs and behaviour. It will attempt to demonstrate that our current understanding of travel needs is problematically incomplete, rather than claim that the findings are statistically representative of the whole Cape Town population.

What will the data be used for?

The data will be used in the preparation of a PhD thesis. It will be used to construct an argument that the above-mentioned gaps in understanding lead to a routine underestimation of the role of non-motorised modes and local area movement systems in satisfying travel needs, and that this is more or less of an issue for different kinds of individuals.

It will be argued that the restricted scope of past travel analysis has in fact introduced a routine bias in the way in which the urban transportation problem has been understood, and in the nature of the interventions that have been implemented as a result. More specifically that a perception has been created that shorter slower journeys are less important than longer faster journeys, and that shorter distance non-motorised travel, depended upon by many without private transportation, has thus either been underestimated or neglected in the planning and design of movement infrastructure.

Instructions on how to explain the previous day diary interview to the respondent

To explain the previous day diary interview to the respondent, show a printed example of a completed diary sheet, and explain the following points:

1. The diary is for a **24 hour** period - from the midnight of the day before yesterday, to the midnight of yesterday.
2. The diary needs to account for how you spent **all the time** during this 24 hour period. It is important that there are no gaps in time missing from the diary that we fill in.
3. We will be filling in what **activities** you did, when they started, when they finished, and where you did them.
 - An activity is something that you did in **one place**, except when that activity was travelling. In other words, if the activity was not travelling, it has a travelling activity directly before and after it
 - We do not need to fill in all the different **little activities** you did in one place. For example, we need not fill in that the you dressed, ate breakfast, cleaned your teeth and fed the dog before going to work. We can just fill in 'got ready for work' for instance.
4. When the activity we fill in was an activity that involved **travelling**, we will fill in some more information, like how you travelled, who if anyone you travelled with, and how often you make that particular trip.
 - It is important that we fill in **all the** travel activities (or **trips**) that you made, no matter how short or unimportant you may think they are.
 - If a trip was broken by a **stop** somewhere to complete a quick activity of less than 10 minutes (e.g. to drop a child at school, or to buy a loaf of bread), we will record these two movements and the in-between activity as **separate activities**.
 - We will record each part of a trip as a separate activity. In other words, if **different travel modes** (e.g. walking, bus, train) were used within the same trip (e.g. walked to bus stop → waited at bus stop → took bus → walked from bus stop), we will fill these in as **separate activities**.
 - It is important that **waiting** for public transport should be recorded as a **separate activity**.

CAPI transcript

- | | |
|---------------------------------------|---------------------------|
| 1. Please indicate your home language | 1. Dui asb u huistaal aan |
| Afrikaans | Afrikaans |
| English | Engels |
| Xhosa | Xhosa |
| Other (State) | Ander (Noem) |

→ *Ask all informants*

→ *Single answer*

- | | |
|--|--|
| 2. Interviewer: Record number of members in household from Question 1 on Screener. | 2. Ondervraer: Noteer hoeveel lede in huishouding vanaf Vraag 1 op "Screener". |
|--|--|

OPEN NUMERIC ANSWER, Range 1 to 10

→ *Ask all informants*

→ *Open numeric answer*

Interviewer: Record number of people present and available from Question 2 on Screener.

Ondervraer: Noteer aantal mense hier en beskikbaar vanaf Vraag 2 op "Screener".

OPEN NUMERIC ANSWER, Range 1 to 10

→ *Ask all informants*

→ *If <70% then ask "Available form"*

→ *If >= 70% then ask question 4*

Available form:

Interviewer: Record whether anyone would be capable of answering on others behalf from Question 3 on Screener.

Ondervraer: Noteer of enigiemand in staat is om vir ander te beantwoord vanaf Vraag 3 op "Screener".

Yes

Ja

No

Nee

→ *Ask all informants*

→ *Single answer*

→ *If "Yes" then ask question 4*

→ *If "No" then go to "End interview Form", close and substitute*

Interviewer: Record Area

Ondervraer: Noteer Area
Qualifying income category:

Rondebosch

3

Kleinbosch

3

Welgelegen

3

Salt River

2

Woodstock

2

Rocklands

2

Westridge

2

Langa

1

Mfuleni

1

→ *Ask all informants*

→ *Single answer*

4. Interviewer: Record income category from Screener.

- | | |
|--|--|
| <ol style="list-style-type: none"> 1. Less than R1800 per month 2. Between R1801 and R5500 per month 3. More than R5501 per month | <ol style="list-style-type: none"> 1. Minder as R1800 per maand 2. Tussen R1801 en R5500 per maand 3. Meer as R5501 per maand |
|--|--|

→ *Ask those who qualify*

→ *Single answer*

→ *If income does not fall within qualifying income category for area or refused go to "end interview form", CLOSE AND SUBSTITUTE*

→ *If income falls within qualifying income category for area continue with interview*

End Interview Form:

For the interview to qualify, 70% or more of the household must be present (or someone must be available to answer for those not), to give info about their travel habits; as well as fall within the specified income category. This interview will close and must be substituted

- | | |
|---|--|
| <ol style="list-style-type: none"> 5. Where do you live? <p>σ COMPLETE ADDRESS AND THEN ASK NAME AND CONTACT NUMBER. (FOR CHECK BACK PURPOSES)</p> <p>Street address: OPEN TEXT</p> <p>Suburb: OPEN TEXT</p> <p>Name of person who can be contacted about the questionnaire: OPEN TEXT</p> <p>Contact telephone number (if available): OPEN NUMERIC</p> | <ol style="list-style-type: none"> 5. Waar woon u? <p>σ VOLTOOI ADRES EN VRA DAN NAAM EN KONTAKNUMMER. (VIR OPVOLG DOELEINDES)</p> <p>Straat adres:</p> <p>Voorstad:</p> <p>Naam van persoon wat oor die vraelys gekontak kan word:</p> <p>Kontaknummer (indien beskikbaar):</p> |
|---|--|

→ *Ask those who qualify*

→ *All information must be entered*

- | | |
|--|--|
| <ol style="list-style-type: none"> 6. Does your household have any of the following ways of travelling, and if so, how many? <p>σ HOUSEHOLD AS A WHOLE</p> <p>Motor car (in running order): OPEN NUMERIC, Range 1-9</p> <p>Motorbike (in running order): OPEN NUMERIC, Range 1-9</p> <p>Bicycle: OPEN NUMERIC, Range 1-9</p> <p>Other (Specify)</p> <p>None of the above SINGLE ANSWER</p> | <ol style="list-style-type: none"> 6. Het u huishouding enige van die volgende maniere van reis, en indien wel, hoeveel? <p>σ HUISHOUDING AS 'n GEHEEL</p> <p>Motorkar (inlopende toestand)</p> <p>Motorfiets</p> <p>Fiets</p> <p>Ander (Spesifiseer)</p> <p>Geen van die bogenoemde</p> |
|--|--|

→ *Ask those who qualify*

→ *Open numeric boxes with "None of the above" a single answer*

- | | |
|---|---|
| <ol style="list-style-type: none"> 7. Would household members be prepared to answer more questions on their travel at a later date? <p>Yes</p> <p>No</p> | <ol style="list-style-type: none"> 7. Sal die lede van die huishouding bereid wees om meer vrae oor hul reis op 'n later stadium te beantwoord? <p>Ja</p> <p>Nee</p> |
|---|---|

→ *Ask those who qualify*

→ *Single answer*

- | | |
|---|---|
| <ol style="list-style-type: none"> 8. Who makes up your household? | <ol style="list-style-type: none"> 8. Uit wie bestaan u huishouding? |
|---|---|

→ **REPEAT QUESTION 8 FOR EACH MEMBER IN THE HOUSEHOLD**

Household member {'x'}:

8.1 What is the person's name?

8.1 Wat is die persoon se naam?

OPEN TEXT ANSWER

→ *Ask those who qualify*

→ *Open text answer*

8.2 How old is {'x'} ?

8.2 Hoe oud is {'x'} ?

OPEN NUMERIC ANSWER, Range 1-100

→ *Ask those who qualify*

→ *Open numeric answer*

8.3 What is the sex of {'x'} ?

8.3 Wat is die geslag van {'x'} ?

Male
Female

Manlik
Vroulik

→ *Ask those who qualify*

→ *Single answer*

8.3.1 What disability, if any, does {'x'} have ?

8.3.1 Watter gestemdheid, indien enige, het {'x'} ?

None
Mobility impaired, but get around without a walking aid
Use a wheelchair
Use a walking frame
Use crutches
Blind
Have limited vision
Deaf
Have limited hearing
Mentally impaired
Other

Geen
Beweging verswak maar kan rond beweeg sonder hulpmiddels
Gebruik 'n rolstoel
Gebruik 'n loopraam
Gebruik krukke
Blind
Gedeeltelike sig verlies
Doof
Gedeeltelike gehoorverlies
Verstandelik gestrem
Ander

→ *Ask those who qualify*

→ *Multi answer with "None" a single answer*

8.4 What is {'x'}'s relationship to the youngest person in the household?

8.4 Wat is {'x'} se verwantskap met die jongste lid van die huishouding?

Father
Mother
Brother
Sister
Youngest
Grandmother
Grandfather
Aunt
Uncle
Nephew
Niece
Cousin
Unrelated - Lodger
Unrelated - Housemate
Extended family relation

Vader
Moeder
Broer
Suster
Jongste
Ouma
Oupa
Tannie
Oom
Kleinneef
Kleiniggie
Neef/niggie
Nie verwante loseerder
Nie verwante huismaat
Uitgebreide familie

Other (State)

Ander (Noem)

- *Ask those who qualify*
 → *Single answer*

8.5	Does {'x'} contribute to the household income?	8.5	Dra {'x'} by tot die huishouding se inkomste?
	Yes		Ja
	No		Nee

- *Ask those who qualify*
 → *Single answer*
 → *If "Yes" ask question 8.6*
 → *If "No" skip to question 8.7*

8.6	How does {'x'} contribute to the household income? (e.g. Salary, street trading, pension etc.)	8.6	Hoe dra {'x'} by tot die huishouding se inkomste? (b.v. Salaris, staathandel, pensioen ens.)
-----	--	-----	--

OPEN TEXT ANSWER

- *Ask those who qualify, and contribute to the household income (in question 8.5)*
 → *Open text answer*

8.7	Interviewer: Does the household have children? (Record from family tree)		Ondervraer: Is daar kinders in die huishouding? (Noteer vanaf stamboom)
	Yes		Ja
	No		Nee

- *Ask those who qualify*
 → *Single answer*
 → *If "Yes" then ask question 8.8*
 → *If "No" skip to question 8.9*

8.8	Does {'x'} look after the children, during normal working hours?	8.8	Pas {'x'} die kinders op, gedurende normale werksure?
	Yes		Ja
	No		Nee

- *Ask those who qualify, and if there are children in the household (from question 8.7)*
 → *Single answer*

8.9	Does {'x'} do housework (eg. Cooking, cleaning, etc.) during normal working hours?	8.9	Doen {'x'} huiswerk (bv. Kosmaak, skoonmaak, ens.) gedurende normale werksure?
	Yes		Ja
	No		Nee

- *Ask those who qualify*
 → *Single answer*

→ *Ask question 8.10 only if there is access to a car in question 6*

8.10	Does {'x'} drive the car(s) that you mentioned earlier?	8.10	Ry {'x'} met die kar wat u voorheen genoem het?
	Yes		Ja
	No		Nee

- *Ask those who qualify, and have access to a car in question 6*

→ *Single answer*

8.11 Does {'x'} have a multi-trip clipcard bus ticket?

Yes
No

8.11 Het {'x'} 'n multi-reis knipkaart buskaartjie?

Ja
Nee

→ *Ask those who qualify*

→ *Single answer*

σ **SHOW CARD 9**

READ OUT INSTRUCTIONS

1. The diary is for a **24 HOUR** period - from midnight of the day before yesterday, to midnight of yesterday.
2. The diary needs to account for how you spent **ALL THE TIME** during this 24 hour period. It is important that there are no gaps in time missing from the diary that we fill in.
3. We will be filling in what **ACTIVITIES** you did, when they started, when they finished, and where you did them.
 - An activity is something that you did in **ONE PLACE**, except when that activity was travelling. In other words, if the activity was not travelling, it has a travelling activity directly before and after it.
 - We do not need to fill in all the different **LITTLE ACTIVITIES** you did in one place. For example, we need not fill in that you dressed, ate breakfast, cleaned your teeth and fed the dog before going to work. We can just fill in 'got ready for work' for instance.
4. When the activity we fill in was an activity that involved **TRAVELLING**, we will fill in some more information, like how you traveled, who, if anyone, you traveled with, and how often you make that particular trip.
 - It is important that we fill in **ALL** the travel activities (or trips) that you made, no matter how short or unimportant you may think they are.
 - If a trip was broken by a **STOP** somewhere to complete a quick activity of less than 10 minutes (e.g. to drop a child at school, or to buy a loaf of bread), we will record these two movements and the in-between activity as **SEPARATE ACTIVITIES**.
 - We will record each part of a trip as a separate activity. In other words, if **DIFFERENT TRAVEL MODES** (e.g. walking, bus, train) were used within the same trip (e.g. walked to bus stop → waited at bus stop → took bus → walked from bus stop), we will fill these in as **SEPARATE ACTIVITIES**.
 - It is important that **WAITING** for public transport should be recorded as a **SEPARATE ACTIVITY**.

→ *Info form*

σ **TOON KAART 9**

LEES INSTRUKSIES VOOR

1. Die dagboek is vir 'n **24 UUR** peiode – vanaf middernag van eergister, tot middernag van gister.
2. Die dagboek moet in ag neem hoe u **AL DIE TYD** spandeer het gedurende hierdie 24 uur periode. Dit is belangrik dat daar geen gapings is in die dagboek wat ons invul nie.
3. Ons gaan invul watter **AKTIWITEITE** u gedoen het, waneer hulle begin het, waneer hulle geëindig het, en waar u hulle gedoen het?
 - 'n Aktiwiteit is iets wat u in **EEN PLEK** gedoen het, behalwe as die aktiwiteit reis was. Met ander woorde, as die aktiwiteit nie reis was nie, het dit 'n reis aktiwiteit direk voor en na dit.
 - Ons hoef nie al die **KLEIN AKTIWITEITE** wat u in een plek gedoen het, in te vul nie. By voorbeeld, ons hoef nie in te vul dat u aangetrek het, ontbyt geëet, tande skoon gemaak het en die hond gevoer het voor u werk toe gegaan het, nie. Ons kan net invul 'reggemaak vir werk' by voorbeeld.
4. Waneer die aktiwiteit wat ons invul 'n aktiwiteit wat **REIS** ingesluit het, sal ons nog informasie invul, soos hoe u gereis het, wie, indien enigiemand, u mee gereis het, en hoe gereeld u daardie spesifieke reis maak.
 - Dit is belangrik dat ons **AL** die reis aktiwiteite (of ritte) wat u gemaak het, invul, maak nie saak hoe kort of onbelangrik u mag dink hulle is.
 - As 'n rit gebreek was met 'n **STOP** iewers om 'n vinnige aktiwiteit van minder as 10 minute klaar te maak (bv. Om 'n kind by die skool af te laai, of om 'n brood te koop), sal ons hierdie twee bewegings noteer en die tussen-in aktiwiteit as **APARTE AKTIWITEITE**.
 - Ons sal elke deel van die rit as aparte aktiwiteite noteer. Met ander woorde, as **VERSKILLENDE REIS METODEDES** (b.v. loop, bus, trein) in dieselfde rit gebruik was (b.v. na die busstop toe geloop → gewag by die busstop → bus gevat → van die busstop geloop), sal ons hierdie as **APARTE AKTIWITEITE** invul.
 - Dit is belangrik dat die **WAG** vir publieke vervoer as **APARTE AKTIWITEITE** noteer is.

10. INTERVIEWER: To which day does this diary apply?

Monday
Tuesday
Wednesday
Thursday

10. ONDERVRAER: Op watter dag is hierdie dagboek van toepassing?

Maandag
Dinsdag
Woensdag
Donderdag

Friday
Saturday
Sunday

Vrydag
Saterdag
Sondag

- *Ask those who qualify*
→ *Single answer*

11. INTERVIEWER: Date diary kept.

11. ONDERVRAER: Datum waarop dagboek gehou.

OPEN TEXT ANSWER

- *Ask those who qualify*
→ *Open text answer*

Is {'x'} present and available or will someone else answer on their behalf?

Is {'x'} hier en beskikbaar of gaan iemand anders vir hom antwoord?

Present and available
Someone else will answer
Not present/available, No one to answer on their behalf

Hier en beskikbaar
Iemand anders gaan antwoord
Nie hier/beskikbaar nie, Niemand om vir hom te antwoord nie.

- *If "Present and available" or "Someone else will answer", continue with question 12*
→ *If "Not present/available, No one to answer on their behalf" skip to next household member.*
→ *Ask those who qualify*
→ *Single answer*

→ **REPEAT QUESTION 12 FOR EACH ACTIVITY FOR THE DAY RECORDED**

This diary was kept on {'x'} day of the week.

Interviewer: The next questions will record all activities done by the Household member {number} : {name} on {day in question 10} starting from Midnight (24h00) to Midnight the next day

Previous activity mentioned: {'x'}
Start time: {'x'}
End time: {'x'}

Vorige aktiwiteit genoem: {'x'}
Begintyd: {'x'}
Eindtyd: {'x'}

Start time of activity:
OPEN TEXT ANSWER

Begintyd van aktiwiteit:

What kind of activity was this? (describe the activity using only a couple of words e.g. "slept", "travelled to school", etc.)
OPEN TEXT ANSWER

Watter tipe aktiwiteit was dit? (Beskryf die aktiwiteit deur slegs 'n paar woorde te gebruik, b.v. "slaap", "maak gereed vir skool", ens.)

Where did you do it?
OPEN TEXT ANSWER

Waar het u dit gedoen?

In which suburb?
OPEN TEXT ANSWER

In watter voorstad?

End time (for last activity of day, select "Until Midnight")
OPEN NUMERIC ANSWER, Range 1-24

Eindtyd (vir die laaste aktiwiteit van die dag, selekteer "Tot Middernag")

Until Midnight
SINGLE ANSWER

Tot Middernag

12.6 Interviewer: Does this activity involve travelling?

Yes
No

- *Ask those who qualify*
 → *Single answer*
 → *If "Yes" ask questions 12.7 to 12.10*
 → *If "No" skip to next activity/day*

12.7	How did you travel when {'x'} ?	12.7	Hoe het u gereis toe u {'x'} ?
	By walking		Deur te loop
	By bicycle		Met 'n fiets
	By mini-bus taxi		Met 'n mini-bus taxi
	By bus		Met 'n bus
	By train		Met 'n trein
	Car driver		A 'n motorbestuurder
	Car passenger		As 'n motorpassassier
	Other (State)		Ander (Noem)

- *Ask those who qualify, and those who traveled for the activity mentioned*
 → *Single answer*

NO QUESTION 12.8

12.9	Who, if anyone, did you travel with when {'x'} ?	12.9	Wie indien enigiemand, het saam met u gereis toe u {'x'} ?
	Traveled alone		Alleen gereis
	Traveled with an adult member from my household		Gereis saam met 'n volwasse lid van my huishouding
	Traveled with a child (under 16 years old), from my household		Gereis met 'n kind (onder 16 jaar oud) van my huishouding
	Traveled with an adult member who is not from my household		Gereis met 'n volwassene wat nie in my huishouding is nie
	Traveled with a child (under 16 years old), who is not from my household		Gereis met 'n kind (onder 16 jaar oud) wat nie in my huishouding is nie

- *Ask those who qualify, and those who traveled for the activity mentioned*
 → *Multi answer with "Traveled alone" a single answer*

12.10	How many times per week do you usually make this trip to {'x'} ?	12.10	Hoeveel keer per week onderneem u gewoonlik hierdie reis/uitstappie om {'x'} ?
	0 / Almost never		0 / Amper nooit nie
	1		1
	2		2
	3		3
	4		4
	5		5
	6		6
	7		7
	8		8
	9		9
	10		10
	11		11
	12		12
	13		13
	14		14
	15		15
	16+		16+

- *Ask those who qualify, and those who traveled for the activity mentioned*
 → *Single answer*

Appendix C. COMPARISON OF SURVEY FINDINGS

VARIABLE	COMPARED DATA	SOURCE	STUDY DATA (2000/1, n = 204 households)	DIFFERENCE	% DIFFERENCE
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Trip generation

mean weekday trips/household (middle income households)	8.20	SA trip generation rates (1995)	9.69	1.49	18.17
mean weekday trips/household (low income households)	6.10	SA trip generation rates (1995)	8.21	2.11	34.59
mean weekday trips/household ('black'/low income households)	6.79	VKE squatter study (1992, n = 592 households)	8.21	1.42	20.91

Weekday home-based trip purpose distribution

Percentage home-based work trips ('white'/high income households)	36.4	NITRR Survey (1981, n = 180 households)	25.0	-11.40	-31.32
Percentage home-based education trips ('white'/high income households)	15.9	NITRR Survey (1981, n = 180 households)	30.0	14.10	88.68
Percentage home-based shopping trips ('white'/high income households)	15.2	NITRR Survey (1981, n = 180 households)	26.7	11.47	75.44
Percentage home-based social/recreational trips ('white'/high income households)	32.5	NITRR Survey (1981, n = 180 households)	18.3	-14.17	-43.59
Percentage home-based work trips ('coloured'/middle income households)	30.3	NITRR Survey (1981, n = 106 households)	25.9	-4.37	-14.44
Percentage home-based education trips ('coloured'/middle income households)	36.2	NITRR Survey (1981, n = 106 households)	33.3	-2.87	-7.92
Percentage home-based shopping trips ('coloured'/middle income households)	9.7	NITRR Survey (1981, n = 106 households)	14.8	5.11	52.73
Percentage home-based social/recreational trips ('coloured'/middle income households)	23.8	NITRR Survey (1981, n = 106 households)	25.9	2.13	8.93

Morning peak period trip purpose distribution

Percentage weekday morning peak period trips to home	3.10	GPMC Survey (1998/9, n = 7883 households)	7.00	3.90	125.81
Percentage weekday morning peak period trips to work	35.60	GPMC Survey (1998/9, n = 7883 households)	36.00	0.40	1.12
Percentage weekday morning peak period trips to part of work	1.30	GPMC Survey (1998/9, n = 7883 households)	1.00	-0.30	-23.08
Percentage weekday morning peak period trips to school/college	43.40	GPMC Survey (1998/9, n = 7883 households)	35.00	-8.40	-19.35
Percentage weekday morning peak period trips to serve passenger	6.90	GPMC Survey (1998/9, n = 7883 households)	5.50	-1.40	-20.29
Percentage weekday morning peak period trips to shops/doctor/hospital	5.70	GPMC Survey (1998/9, n = 7883 households)	9.50	3.80	66.67
Percentage weekday morning peak period trips to recreation/social	0.30	GPMC Survey (1998/9, n = 7883 households)	2.00	1.70	566.67
Percentage weekday morning peak period trips to visiting	1.60	GPMC Survey (1998/9, n = 7883 households)	4.00	2.40	150.00

Trip timing

Percentage morning peak trip timing ('white'/high income households)	25.00	NITRR Survey (1981, n = 180 households)	19.85	-5.15	-20.60
Percentage afternoon peak trip timing ('white'/high income households)	24.00	NITRR Survey (1981, n = 180 households)	22.34	-1.66	-6.92
Percentage rest of day trip timing ('white'/high income households)	51.00	NITRR Survey (1981, n = 180 households)	57.81	6.81	13.35

Percentage morning peak trip timing ('coloured'/middle income households)	29.00	NITRR Survey (1981, n = 106 households)	25.12	-3.88	-13.38
Percentage afternoon peak trip timing ('coloured'/middle income households)	32.00	NITRR Survey (1981, n = 106 households)	21.55	-10.45	-32.66
Percentage rest of day trip timing ('coloured'/middle income households)	39.00	NITRR Survey (1981, n = 106 households)	53.33	14.33	36.74
Percentage morning and afternoon peak hour trip timing (middle income households)	56.00	SA trip generation rates (1995)	23.19	-32.81	-58.59
Percentage rest of day trip timing (middle income households)	44.00	SA trip generation rates (1995)	76.81	32.81	74.57

Percentage morning and afternoon peak hour trip timing (low income households)	38.00	SA trip generation rates (1995)	20.00	-18.00	-47.37
Percentage rest of day trip timing (low income households)	62.00	SA trip generation rates (1995)	80.00	18.00	29.03

Vehicle availability

motors cars/1000 people	170.00	Moving Ahead (1998)	217.75	47.75	28.09
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percentage with no motor car ('white'/high income households)	9.00	MOS survey (1991/2, n = 100 households)	5.88	-3.12	-34.64
percentage with 1 motor car ('white'/high income households)	44.00	MOS survey (1991/2, n = 100 households)	36.15	-7.85	-17.85
percentage with >1 motor car ('white'/high income households)	47.00	MOS survey (1991/2, n = 100 households)	57.97	10.97	23.34

percentage with no motor car ('coloured'/middle income households)	57.00	NPP (1994, n = 192 persons)	50.39	-6.61	-11.59
percentage with 1 motor car ('coloured'/middle income households)	43.00	NPP (1994, n = 192 persons)	39.10	-3.90	-9.08
percentage with >1 motor car ('coloured'/middle income households)	0.00	NPP (1994, n = 192 persons)	10.51	10.51	

percentage with no motor car ('black'/low income households)	95.00	NPP (1994, n = 100 persons)	96.87	1.87	1.97
percentage with 1 motor car ('black'/low income households)	5.00	NPP (1994, n = 100 persons)	3.13	-1.87	-37.44
percentage with >1 motor car ('black'/low income households)	0.00	NPP (1994, n = 100 persons)	0.00	0.00	

percentage of households with no motor car	46.00	AMPS (1999)	50.49	4.49	9.76
percentage of households with 1+ motor car	54.00	AMPS (1999)	49.51	-4.49	-8.32

percentage with no bicycle ('white'/high income households)	64.00	MOS survey (1991/2, n = 100 households)	72.11	8.11	12.67
percentage with 1 bicycle ('white'/high income households)	17.00	MOS survey (1991/2, n = 100 households)	7.78	-9.22	-54.24
percentage with 2 bicycle ('white'/high income households)	14.00	MOS survey (1991/2, n = 100 households)	9.25	-4.75	-33.93
percentage with 3 bicycle ('white'/high income households)	3.00	MOS survey (1991/2, n = 100 households)	3.08	0.08	2.78
percentage with 4+ bicycle ('white'/high income households)	2.00	MOS survey (1991/2, n = 100 households)	7.78	5.78	288.99

percentage with no bicycle ('coloured'/middle income households)	93.00	MOS survey (1991/2, n = 200 households)	91.18	-1.82	-1.96
percentage with 1 bicycle car ('coloured'/middle income households)	5.00	MOS survey (1991/2, n = 200 households)	8.82	3.82	76.47
percentage with 2 bicycle car ('coloured'/middle income households)	2.00	MOS survey (1991/2, n = 200 households)	0.00	-2.00	-100.00

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percentage with 3 bicycle car ('coloured'/middle income households)	1.00	MOS survey (1991/2, n = 200 households)	0.00	-1.00	-100.00
percentage with 4+ bicycle car ('coloured'/middle income households)	0.00	MOS survey (1991/2, n = 200 households)	0.00	0.00	

percentage with no bicycle ('black'/low income households)	99.00	MOS survey (1991/2, n = 200 households)	96.77	-2.23	-2.25
percentage with 1 bicycle car ('black'/low income households)	1.00	MOS survey (1991/2, n = 200 households)	3.23	2.23	222.58
percentage with 2 bicycle car ('black'/low income households)	0.00	MOS survey (1991/2, n = 200 households)	0.00	0.00	
percentage with 3 bicycle car ('black'/low income households)	0.00	MOS survey (1991/2, n = 200 households)	0.00	0.00	
percentage with 4+ bicycle car ('black'/low income households)	0.00	MOS survey (1991/2, n = 200 households)	0.00	0.00	

Work trip main mode use

percentage walk (high income households)	6.00	OHS (1997)	8.88	2.88	47.94
percentage minibus-taxi (high income households)	5.00	OHS (1997)	0.00	-5.00	-100.00
percentage bus (high income households)	6.00	OHS (1997)	1.85	-4.15	-69.14
percentage train (high income households)	4.00	OHS (1997)	1.72	-2.28	-56.90
percentage car (high income households)	60.00	OHS (1997)	85.82	25.82	43.04
percentage other (high income households)	19.00	OHS (1997)	1.72	-17.28	-90.93

percentage walk (middle income households)	9.00	OHS (1997)	19.15	10.15	112.81
percentage minibus-taxi (middle income households)	14.00	OHS (1997)	18.68	4.68	33.45
percentage bus (middle income households)	14.00	OHS (1997)	14.11	0.11	0.81
percentage train (middle income households)	12.00	OHS (1997)	10.05	-1.95	-16.27
percentage car (middle income households)	40.00	OHS (1997)	38.00	-2.00	-4.99
percentage other (middle income households)	11.00	OHS (1997)	0.00	-11.00	-100.00

percentage walk (low income households)	19.00	OHS (1997)	23.41	4.41	23.22
percentage minibus-taxi (low income households)	18.00	OHS (1997)	18.33	0.33	1.84
percentage bus (low income households)	18.00	OHS (1997)	10.53	-7.47	-41.52
percentage train (low income households)	19.00	OHS (1997)	30.31	11.31	59.52
percentage car (low income households)	8.00	OHS (1997)	5.17	-2.83	-35.34
percentage other (low income households)	18.00	OHS (1997)	12.25	-5.75	-31.94

percentage walk (total sample)	10.69	OHS (1997, n = 30000 households)	17.15	6.46	60.41
percentage minibus-taxi (total sample)	15.48	OHS (1997, n = 30000 households)	12.34	-3.15	-20.32
percentage bus (total sample)	7.59	OHS (1997, n = 30000 households)	8.83	1.24	16.31
percentage train (total sample)	23.68	OHS (1997, n = 30000 households)	14.03	-9.65	-40.76
percentage car (total sample)	37.56	OHS (1997, n = 30000 households)	43.00	5.44	14.48
percentage other (total sample)	5.00	OHS (1997, n = 30000 households)	4.66	-0.34	-6.74

Work trip travel time

mean minutes travelled ('white'/high income households)	32.0	OHS (1995)	24.0	-8.00	-25.00
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mean minutes travelled ('coloured'/middle income households)	47.0	NPP (1994, n = 192 persons)	38.0	-9.00	-19.15
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mean minutes travelled ('black'/low income households)	67.0	NPP (1994, n = 100 persons)	60.5	-6.50	-9.70
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mean minutes travelled (total sample)	43.0	OHS (1997, n = 30000 households)	41.0	-2.00	-4.65
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