Building an area-based travel sustainability tool: rating the residential travel performance of new urban developments

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ABSTRACT

The location (or siting) of new development in relation to other elements of the urban area, such as shopping or employment centres, is known to influence travel patterns, particularly for trips such as journeys to work. Similarly, the design of a development, including such matters as density, land use mixing and connectivity, is now generally understood to influence travel patterns, especially for local trips such as journeys to shops or to schools. By altering either location or design choices it may be possible to increase the opportunities that future populations will have to access the goods and services they need. This paper is concerned with a project to develop a diagnostic tool that seeks to allow decision-makers and others to rate the residential travel performance of land use developments and to identify means to improve that performance. The project aims to measure the extent of travel made and the modes of travel used by residential populations and, with the assistance of accessibility analysis techniques, to use this information as a means to rate the effect of a development's location and design on residential travel. This work is being undertaken to assist in influencing the location and design of urban development to ensure that residential travel patterns contribute to sustainability objectives.

INTRODUCTION

This paper discusses a Griffith University project that is presently developing a diagnostic tool to rate the residential travel performance of large urban land use developments. The tool measures the extent of travel made and the modes of travel used by residential populations and, with the assistance of accessibility analysis techniques, uses this information as a means to rate the effect of a development's location and design on residential travel. This work is being undertaken to assist in influencing the location and design of urban developments to ensure that their residential travel patterns contribute to sustainability objectives. As a form of shorthand we will refer in this paper to the project as rating a development's 'residential travel performance' for sustainability.

The paper will firstly provide a conceptual understanding of the relationships between transport and land use that the tool seeks to model. Secondly, previous approaches to relating the effects of location and design on residential travel performance are discussed. Third, we provide some suggestions as to how the tool may best be used.

CONCEPTUAL FRAMEWORK

Our project aims to provide a measure of the residential travel performance likely to be produced by a land use development.

Underpinning land use interventions such as transit-oriented-development (TOD) and New Urbanism is the belief that both the location and design of new urban developments can alter accessibility to opportunities, lead to changes in mode choices and other travel behaviours (i.e. encouraging shorter journeys), and therefore change vehicle energy consumption, whilst increasing human physical activity (defined as human energy consumed during either walking or cycling trips).

The *location* (or siting) of a large-scale development in relation to the other elements of the urban area, such as shopping or employment centres, is known to influence travel patterns, particularly for trips such as journeys to work (Horner 2004).

The *design* of a development, including such matters as density, land use mixing and connectivity, is also now generally understood to influence travel patterns, especially for local trips such as journeys to shops or to schools (Ewing and Cervero 2002).

This assumes a particular set of relationships between urban form and structure (including land use arrangements and transport networks) and demographic characteristics that interact to produce accessibility and mobility decisions, that in turn lead to residential travel performance. Figure 1 demonstrates our conceptualisation of these relationships. Our research is primarily concerned with making operational these concepts so as to provide a tool that can estimate and measure the change in residential travel performance due to the location and design of new urban development.

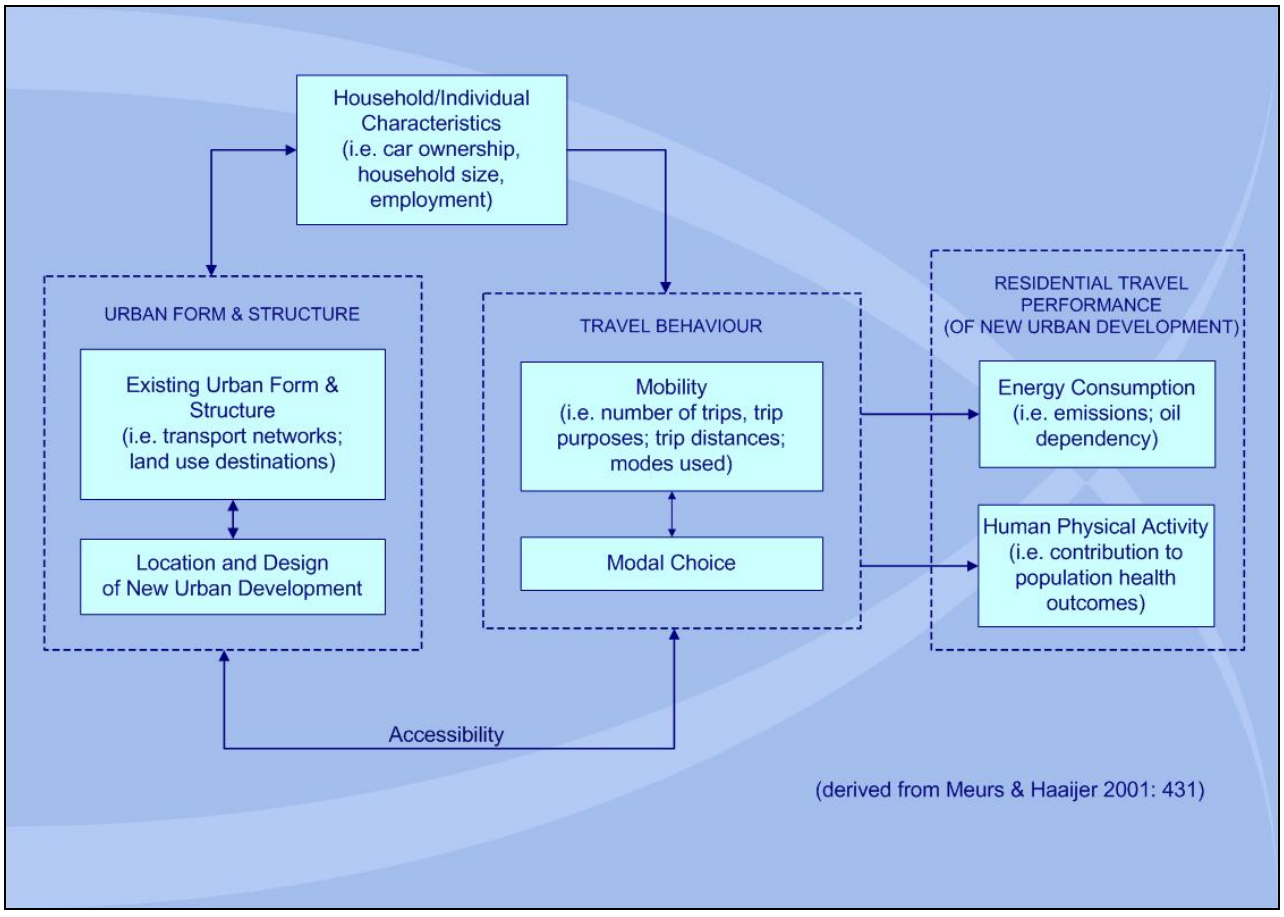

Figure 1 Conceptual model of the determinants of the transport energy consumption and human physical activity of new urban developments

We are interested in the sensitivity of the location and design of developments to such matters as vehicular energy consumption (which relates to both the distance travelled by each travel mode and

greenhouse gas emissions) and to human physical activity (given the recent policy focus towards the health implications of urban environments in terms of transport/land-use relationships).

SCALE

The developments of interest to this research are those believed to make the greatest contribution to regional residential travel performance. This is generally conceived as being residential or mixed-use developments comprising more than 100 dwellings, as well as larger retail, education or commercial developments that service more than just a local catchment. Development proposals at smaller scales generally have less influence on a region's travel performance and are often not as easily modified to achieve improved performance.

Within the set of developments of interest are in-fill mixed use and residential developments, however the principal concerns are TODs, master-planned communities (MPCs), and large conventional suburban subdivisions.

PREVIOUS APPROACHES

There have been a limited number of attempts at improving the location and design decisions of land use developers by providing techniques to estimate, measure and/or model issues relating to residential travel performance.

The simplest measures are those such as PedShed analyses that focus on one small component of the overall travel performance/land use relationship conceptualised in Figure 1. Often these focus on just one mode of travel (i.e. private motor vehicle use only) and provide a limited indicator of the potential of the development to contribute to improve residential travel performance. For instance, the *Liveable Neighbourhoods* design guidelines in Western Australia feature a process to measure a walkable pedestrian catchment or 'PedShed' that involves calculating the actual area within a 400m walking distance via the road and path network, and expressing this as a percentage of the total area within 400m geodetic (bird's eye) distance. The higher the percentage obtained, the higher the 'walkability' of the design and, it is assumed, the higher the likely energy efficiency of the development proposal (Western Australian Planning Commission 2004:157). Such analyses provide only limited insight and do not account for the full set of inter-relationships assumed to exist between urban form and structure and residential travel performance.

More complex are models developed via regression analysis that seek to estimate and compare the likely greenhouse gas emissions or vehicular energy consumption that a development proposal will produce, by inserting particular characteristics of the development into linear equations. An example is the *Tool for Evaluating Neighbourhood Sustainability*, developed by the IBI Group, that assigns values to a development proposal according to whether it is considered a 'conventional suburban-type development', a 'medium density development', or a 'neo-traditional development' (which relate to design) as well as measures such as proximity to the city centre and proximity to employment (which relate to location) in order to estimate the greenhouse gas emissions likely to be produced by the development (Canada Mortgage and Housing Corporation, Natural Resources Canada and IBI Group 2000). These models often make gross simplifications of design issues (i.e. defining what comprises a 'neo-traditional development') and ignore the majority of the effects of location (i.e. access to regional shopping opportunities, higher education, etc.) though there is the potential to include for most of these issues. More problematic is that they fail to consider how these issues synergistically interact with existing urban form and structure in a real-world spatial environment, creating a particular geography of variable accessibility. For instance, increasing residential density and improving public transport services may each separately influence residential travel performance – however if densities are increased specifically near public transport

nodes, the effect is likely to be much greater. Simple linear models are generally unable to accommodate these relationships.

Alternatively, accessibility analysis offers a means to overcome this issue. This approach predicts and models future trip patterns created by a development proposal, based on procedures that estimate the ease with which individuals may access a particular set of destinations from a particular origin (usually their place of residence). Once these future trip patterns are predicted, it is possible to estimate the vehicular energy consumption and human physical activity due to a new urban development. Perhaps the most valuable accessibility-based tool currently available, the Bartlett School of Planning (2000) *Estimation of Travel, Energy and Emissions Model (ESTEEM)* uses accessibility analyses to predict the trip patterns from (but not to) urban developments for a limited number of trip purposes using an origin-constrained gravity model.

In addition, comprehensive or ‘traditional’ transport/land use models have been used to undertake analyses of the impacts of extremely large developments on city or regional residential travel performance. And these too use gravity models to predict future travel flows. However, these models are primarily concerned with predicting future travel flows on the regional transport network, ignore walking and cycling, and have limitations in terms of local trip making. Most importantly, few feature mechanisms that allow for interactions with the location and design of new urban development at each of the trip generation, trip distribution and mode assignment phases of the ‘traditional’ model.

We have selected the accessibility-based approach as it allows for interactions between both the location and design of a development proposal and its residential travel performance to be considered.

THE GRIFFITH PROJECT

The aim of the Griffith project is to develop a tool to assist in the appraisal of a development proposal by a local authority. However, there is a range of contexts within which this tool could be applied, including the testing of development scenarios at the local area scale, and in the development of local structure plans. We show these as ‘planning points/contexts’ in Figure 2.

It is believed that the tool could also be ‘embedded’ within broader sustainability rating schemes or performance standards applied to new urban developments, should it be considered appropriate for use in this manner.

PRELIMINARY APPROACH

We are seeking to develop a process that can provide and display measures of the likely residential travel performance of a development proposal using accessibility analysis. We will do this in a way that can be applied as part of a development's assessment/approval process.

This requires marrying local land use and transport information in a highly disaggregated form, and at the same time synthesising and analysing city-wide land use and transport information available in an aggregated form, of the type more conventionally used in urban transport and land use models in general.

Conceptually this requires the development of data for three specific geographical areas: the area covered by the development itself ('within development') the local area immediately surrounding the development ('peri-development') and the metropolitan area ('city-wide'), as illustrated in Figure 3.

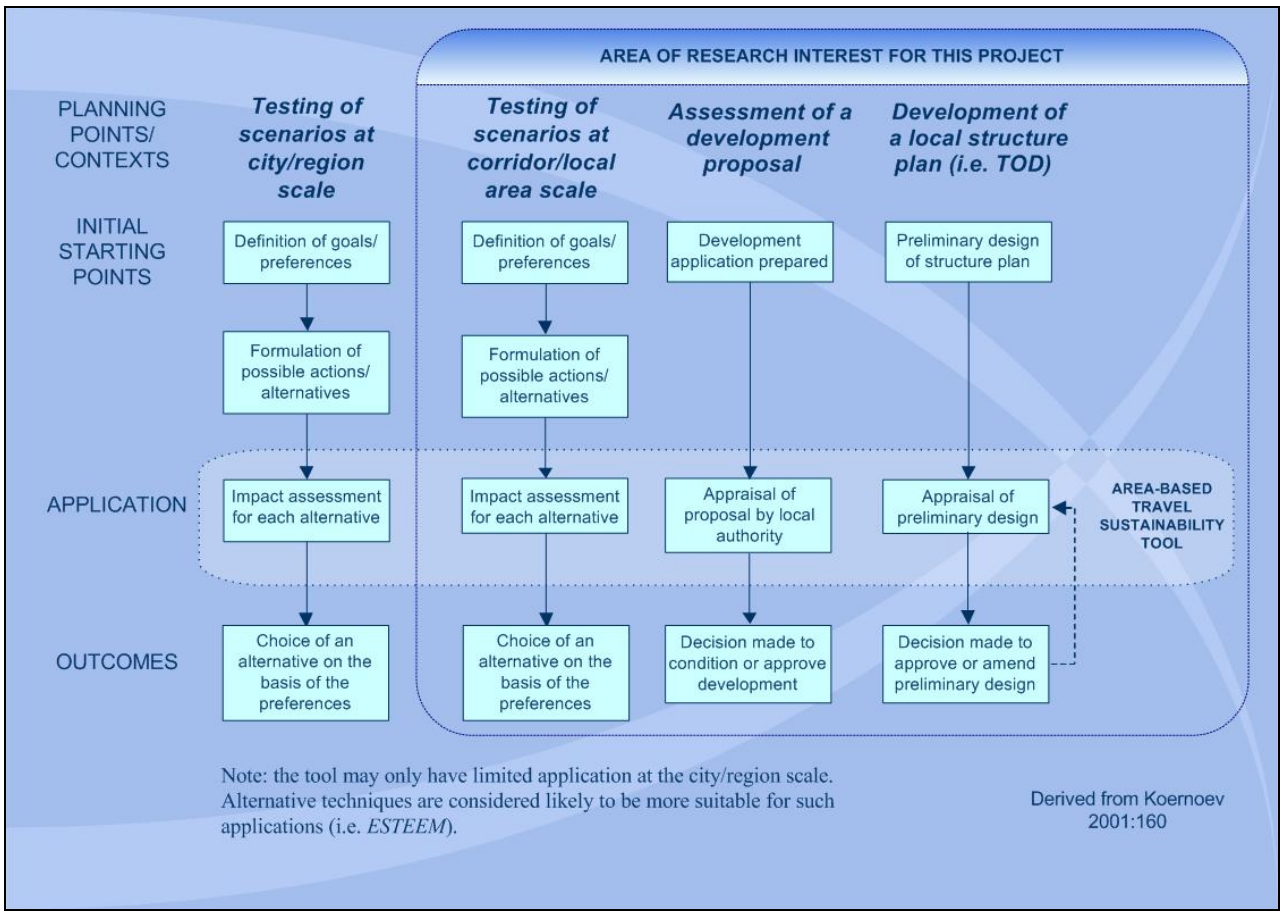

Figure 2 Potential use of an area-based travel sustainability tool in decision-making

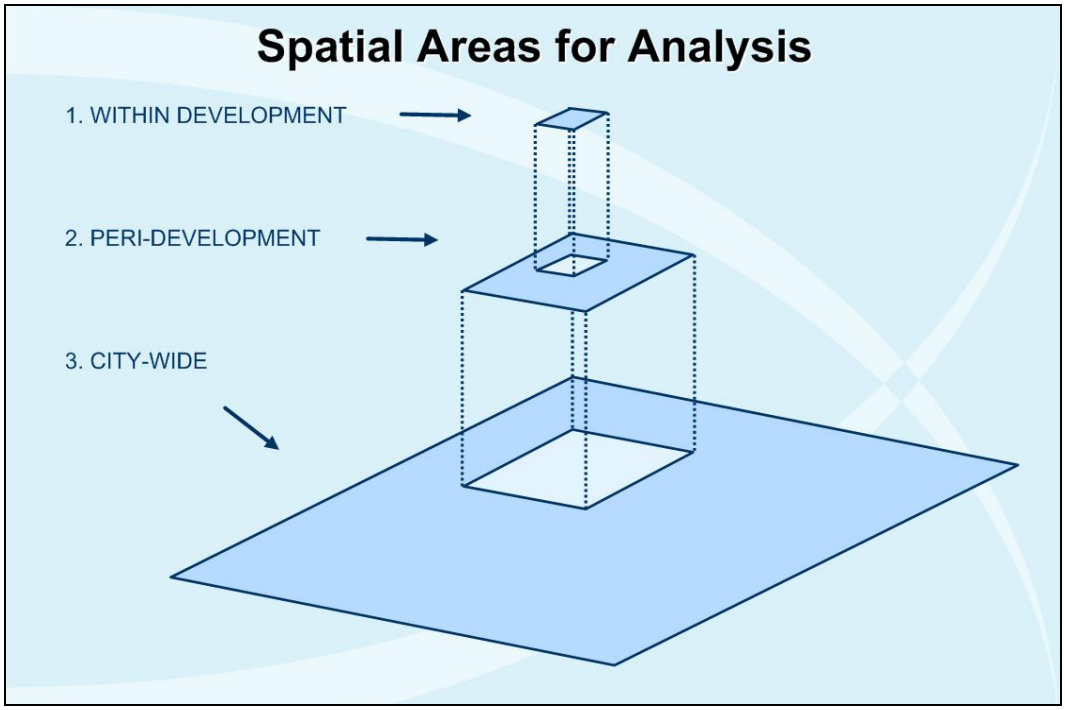

Figure 3 Three spatial areas for analysis

Structure Plans

As noted earlier, we are interested primarily in proposals of significant size and influence, MPCs, TODs, large subdivisions and in-fill developments. All such developments invariably require a coordinated structure plan that provides clear directions as to the location of the critical infrastructure, services and development patterns within the site, as well as the linkages to the

surrounding area. Such plans guide the future development of the site into the long term and must generally be approved by local and state authorities prior to development proceeding.

Structure plans normally provide information on the number of dwellings proposed for each lot within the development. And they also provide detail on the proposed location of key services, including fixed public transport sites and routes. The information contained within and developed as part of a structure plan, including street/path networks and land use information, may well be sufficient to provide a rating for the proposal in terms of residential travel performance (based on the outcomes of an accessibility analysis) - if this information can be entered, manipulated and modelled appropriately as the 'within development' element in our model.

Model Development

The spatial analysis capabilities of GIS allows for data integration and display that takes into consideration the complex spatial dimension of transport networks and land use locations necessary for use in accessibility analysis. The approach we are currently taking is to develop procedures within a GIS platform that:

- estimate the demand for travel that will be generated by the new development for particular trip purposes,
- distribute those trips to a set of destinations, and
- estimate the proportion of trips by particular modes that will travel to those destinations,

The model therefore seeks to estimate the level of access, by all transport modes, to all potential locations at which particular travel demands may be satisfied.

In terms of estimating the demand for travel that will be generated by a new development, we are developing procedures that model trips that have origins 'within development' and destinations in the 'peri-development' and 'city-wide' areas defined in Figure 3. But we are also developing procedures to model trips with origins in the 'peri-development' area and destinations 'within development', so as to capture the effects of land use destinations included in development proposals. This should allow the model to effectively model the residential travel performance of mixed-use developments and large master planned communities that feature land use destinations such as shops and schools that may attract trips from surrounding areas.

To distribute trips to a set of destinations we are developing procedures that allow for interactions with location and design - distributing trips according to the level of access from the origin of the trip to each potential land use destination. However, the best means to conceptualise the level of access from an origin to a land use destination has been the subject of considerable academic debate. Generally accessibility measures for transport and land use modelling purposes may be classified into distinct groups, including opportunities measures, location-based measures (such as distance-based and gravity-based measures), and utility-based measures (for further information on accessibility measures see Geurs and van Wee 2004; Halden 2002; Handy and Niemeier 1997). We require accessibility measures that may assist in modelling travel behaviour and must select measures according to their capacity to best represent trip-making for each trip purpose including at the local scale (i.e. journeys to school) and the regional scale (i.e. journeys to employment). We are presently developing location-based measures, including both distance-based and gravity-based measures, for use within our tool.

To estimate the proportion of trips by particular modes that will travel to those destinations we are again seeking to develop procedures that allow for the location and design of the development to the mode assigned to a particular trip, based on the accessibility by alternative modes such as public transport, walking and cycling.

Therefore, if developed in accordance with our conceptual model, the system should allow for the interactive effects of changes in the location and design of new urban development to influence the outcomes of modelling processes such as trip generation, trip distribution and modal assignment.

How Might it Look?

Figure 4, below, suggests a possible output display of the information provided by an assessment using the tool, illustrating how a development's attributes may be used to develop multiple indices, and how modelling could be used to identify the impacts of modifications to a development's location or design.

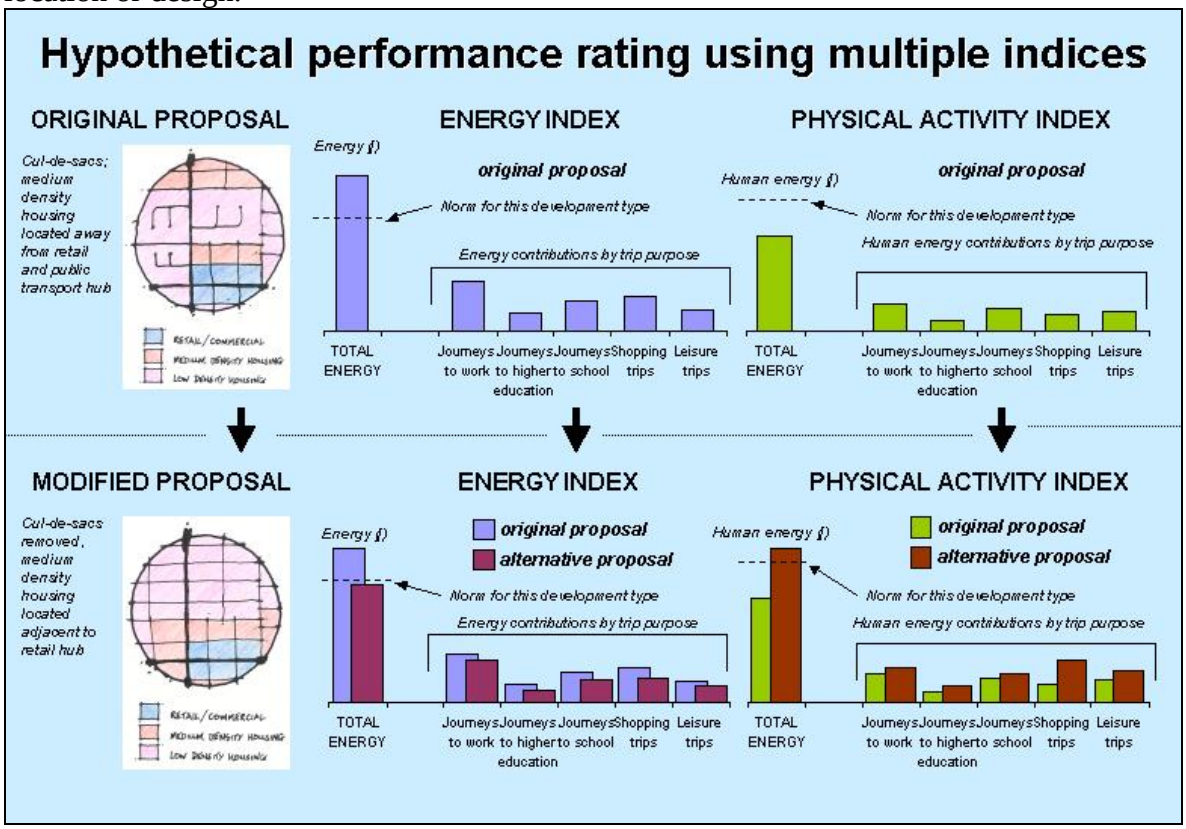

Figure 4 Possible outputs of accessibility analysis demonstrating residential travel performance

Figure 4 shows how two separate indices, representing vehicular energy consumption and physical activity, can be used to rate a development proposal. The display provides the energy contributions by trip purpose and the sum total of the energy consumed (across all trip purposes).

When the development proposal is modified, say by introducing a grid-network street system or by including more medium density housing within the development, it is possible to identify changes in energy consumption for individual trip purposes, and in turn, changes in the sum total. In this way, opportunities to modify the development proposal so as to increase its residential travel performance may be identified and tested.

A ‘normative’ level is also identified in the display that may be calibrated via household travel survey data for developments of a particular type. This may be compared with the development proposal's residential travel performance, if desired.

CURRENT ACTIVITIES

We are presently working to operationalise the conceptual model in Figure 1 and to develop an effective tool. Our present tasks include:

- Identifying the set of trips that really matter in terms of identifying differences in residential travel performance across urban environments. It is not yet certain which particular

population groups, times of day and trip purposes are those that are most sensitive in affecting a development's performance in particular areas. And the set of trips that are of greater importance for vehicular energy consumption are not the same set of trips that are of greatest importance for human physical activity.

- Selecting and developing appropriate accessibility measures and moulding them into an effective modelling process. Developing travel demand models is problematic as these require considerable resources in terms of data, computing capacity, modelling capabilities and skill.
- Calibrating these accessibility measures to known behaviours obtained via household travel survey data, so as to better represent travel behaviour.
- Conceptualising the public transport system. While we wish to allow for a range of interactions between land use and mode choice, it is not possible to include for the full range of issues that comprise public transport operations (i.e. locations of stops, routing, service frequencies, travel times, hours of operation, fares, comfort levels). Yet these issues influence mode choice decisions and residential travel performance.

CONCLUSION

The Griffith projects seeks to produce a means to identify a development proposal's expected residential travel performance, via the process of looking at the contribution of particular trip purposes. We hope the end-product of our research might also be used as a diagnostic tool to identify means to improve that expected performance.

There is increasing interest in the development of tools to rate residential travel performance at the local area scale, evidenced by the release for discussion of the US Green Building Council's (2005) *LEED for Neighbourhood Developments* sustainability rating scheme (which includes for the rating of residential travel performance by a tool such as the one we are currently developing). It is hoped that our work may therefore lead to better outcomes in new urban developments as a contribution towards meeting sustainability objectives.

REFERENCES

Bartlett School of Planning (2000) *ESTEEM: Estimation of Travel, Energy and Emissions Model London: Bartlett School of Planning*; http://www.bartlett.ucl.ac.uk/Esteem/index.htm

Canada Mortgage and Housing Corporation (CMHC), Natural Resources Canada, and IBI Group (2000) *Greenhouse Gas Emissions from Urban Travel: tool for evaluating neighbourhood sustainability* Ottawa, Canada: CMHC; http://www.cmhc.ca/publications/en/rh-pr/index.html

Ewing, R., & R. Cervero (2002) 'Travel and the Built Environment: a synthesis', *Transportation Research Record*, 1780, pp. 87-114.

Geurs, K. & B. van Wee, (2004) 'Accessibility Evaluation of Land-Use and Transport Strategies: review and research directions', *Journal of Transport Geography* 12(2), pp. 127-140.

Halden, D. (2002) 'Using Accessibility Measures to Integrate Land Use and Transport Policy in Edinburgh and the Lothians', *Transport Policy*, 9(4), pp. 313-324.

Handy, S. & D. Niemeier (1997) 'Measuring Accessibility: an exploration of issues and alternatives', *Environment and Planning A*, 29(7), pp. 1175-1194.

Horner, M. W. (2004) 'Spatial Dimensions of Urban Commuting: a review of major issues and their implications for future geographic research', *Professional Geographer*, 56(2), pp. 160-173.

Koernoev, L. (2001) 'Strategic Environmental Assessment and the Decision-Making Process', pp. 157-173 in *How Green is the City: sustainability assessment and the management of urban environments*, New York: Columbia.

Meurs, H. & R. Haaijer. (2001) 'Spatial Structure and Mobility', *Transportation Research Part D: Transport and Environment* 6(6), pp. 429-446.

US Green Building Council. 2005. *LEED for Neighborhood Developments Rating System - Preliminary Draft* Washington, D.C.: US Green Building Council.

Western Australian Planning Commission. 2004. *Liveable Neighbourhoods: Edition 3 - DRAFT*. Perth, Western Australia: Western Australian Planning Commission.