

The relationship between land use and car dependence and its application for land use planning policy in Sydney

David Holden

Sustainability Unit, NSW Department of Planning, Australia

1 Introduction

“What is the purpose of life? For us, the answer will be clear, established and for all practical purposes indisputable: The purpose of life is to produce and consume automobiles”

- Jane Jacobs, *The Death and Life of Great American Cities*, 1961, p. 370

It was not until 1989 that the term ‘automobile dependence’ was coined by Newman and Kenworthy (1989), but car dependency is not a new phenomenon. Even before Jane Jacobs wrote off American cities to the automobile, the consumption and use of cars was widespread.

With growing awareness of car dependence, many solutions have been put forward to help constrain private car use: Improvements in public transport, walking and cycling facilities, road and traffic management, congestion tax, fuel taxing, education and TravelSmart programs, parking management and more recently car sharing schemes, just to name a few. The design of cities has often been promoted as a key element in reducing car use. As such land use planning policy in NSW and other jurisdictions has largely centred around ensuring development is located close to alternative transport choices, such as public transport; based on the principle that providing people with a readily available alternative make car use less attractive.

In December 2005, the New South Wales Government released the Sydney Metropolitan Strategy City of Cities: A Plan for Sydney’s Future. The Strategy sets out a strategic plan to facilitate and manage the growth and development of Sydney over the next 25 years. Action D3 of the Strategy is to “Influence travel choices to encourage more sustainable travel”, to encourage a greater use of walking, cycling and public transport (DoP 2005). Key to the implementation of The Strategy is translating its aims and actions into local land use plans.

This paper discusses the results of research undertaken by the NSW Department of Planning which sort to quantify the key relationships between land use and vehicle kilometres travelled (VKT) in Sydney, and develop a quantitative model that can predict VKT at the household level¹. Additionally, the paper outlines current testing on the policy application of this research to land use planning in Sydney.

2 Car dependence and land use planning

There is extensive research which highlights Australia’s obsession with the automobile (including Davidson 2004, Hensher 1998, Kenworthy et al 1999). But car dependence is not specific to Australian cities. North American cities also exhibit very high dependence on the automobile, as highlighted in Figure 1.

Several studies have shown differences in urban form and urban structure as a major reason for differences in car use and public transport use amongst cities (for example Parsens, Brinckerhoff, Quade and Douglas et al. 1995, Newman and Kenworthy 1999).

¹ For more information on the development of the model, refer to Corpuz, McCabe and Ryszawa, “*The Development of a Sydney VKT Regression Model*” (ATRF 2006)

While there is some debate about the magnitude of impact, mounting evidence from empirical studies shows that land use planning can reduce car use and encourage more sustainable travel (see Ewing 1999 and TCRP 2002 for reviews of several empirical studies).

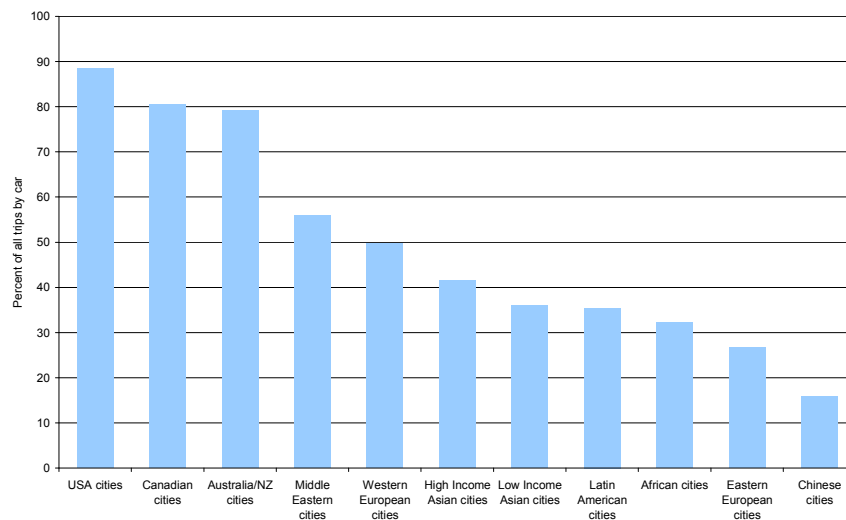


Figure 1: Percentage of all trips made by car: a comparison between cities (Kenworthy 2005)

Based on this mounting evidence, government land use policies in Australia and overseas have focused their attention on the density, mix and location of urban development to public transport.

Planning policy based on access to public transport has been embraced in the UK to minimise additional car travel, reduce trip lengths and encourage use of other, more sustainable means of travel. For example, Public Transport Accessibility Levels (PTALs) was used in *The London Plan* as a measure for public transport and accessibility in order to set housing densities and parking rates (Greater London Authority 2004). Planning policy in the UK has moved towards integrating public transport accessibility levels with the social needs of the population, reducing their reliance on the automobile and providing more accessible opportunities to socially excluded populations (UK Department of Transport 2003).

Also designed to reduce the growth of car travel, the Dutch have developed the ABC Location Policy: *'The right business at the right place'*. The policy aims to locate each business in a location with an accessibility profile in accordance with its mobility characteristics, in order to reduce the number of trips made by car (LEDA 2000).

Similarly, in NSW, a key objective of land use planning is to provide 'sustainable transport choice'. In 2001, the NSW Government released *Integrating Land use and Transport – A Planning Policy Package*. The key aim of the policy is to influence urban development towards more accessible towns and cities, moving people away from the car towards more sustainable transport modes (DUAP 2001). The recent release of the Sydney Metropolitan Strategy further supports this policy, ensuring a sustainable amount of new urban growth is located within cities and corridors around major public transport nodes (DoP 2005). Both these policies have largely centred around ensuring development is located close to public transport; based on the principle that providing people with a readily available alternative will reduce car use.

So what are the links between urban form and car dependence? Can these links be quantified? And how can urban form and land use planning influence car use?

In response to these questions, the Sustainability Unit of the NSW Department of Planning commissioned the Transport and Population Data Centre (TPDC) to investigate the socio-demographic, location and urban form variables that influence vehicle kilometres travelled, i.e. private car use, in Sydney. Based on this research, TPDC have developed a Vehicle Kilometres Travelled (VKT) model, which predicts VKT for different households based on a number of socio-demographic, location and urban form variables. The model can be used to determine the expected VKT increase or reduction from various location and urban form variables. The research findings and policy implications of this model are discussed below.

3 Research findings²

The major source of data used in the analysis of household travel behaviour was the Transport and Population Data Centre's Household Travel Survey (HTS). The HTS is the largest and richest source of personal travel data for the Sydney Greater Metropolitan Area. Using this data, the Transport and Population Data Centre (TPDC) analysed household travel behaviour from 7 years of daily travel data for approximately 16,000 dwellings across the Sydney Statistical Division.

Using variable regression analysis, 14 socio-demographic, location and urban form variables were analysed to determine each variable's influence on VKT. These variables included:

- Distance to CBD
- Distance to Regional City and Major Centres
- Access to public transport³
- Level of local employment
- Level of local services
- Land-use mix
- Housing density
- Dwelling structure (single dwelling, townhouse, unit building)
- Vehicles per household
- Persons per household
- Number of licence holders
- Persons of driving age
- Household income
- Household type

Figure 2 visually outlines the results from the research. The size of each variable's box indicates the importance of each variable in influencing household VKT. The research showed that out of the 14 variables investigated by TPDC, 6 variables were shown to have a statistically significant impact on VKT (an explanation of each variable is outlined in Appendix 1). This is not to say that the other variables do not play a role in influencing VKT; some of the non-significant variables are explained by other variables because they are highly correlated.

Car ownership (number of vehicles in the household) showed the greatest influence on VKT in Sydney households. The variable 'car ownership' was highly correlated with other variables excluded from the final model, such as household income.

²A detailed technical discussion of the research findings is contained in a supporting paper by Corpuz, McCabe and Ryszawa, "*The Development of a Sydney VKT Regression Model*" (ATRF 2006)

³Access to public transport is defined the time taken to walk and then wait for a public transport service (see Appendix 1).

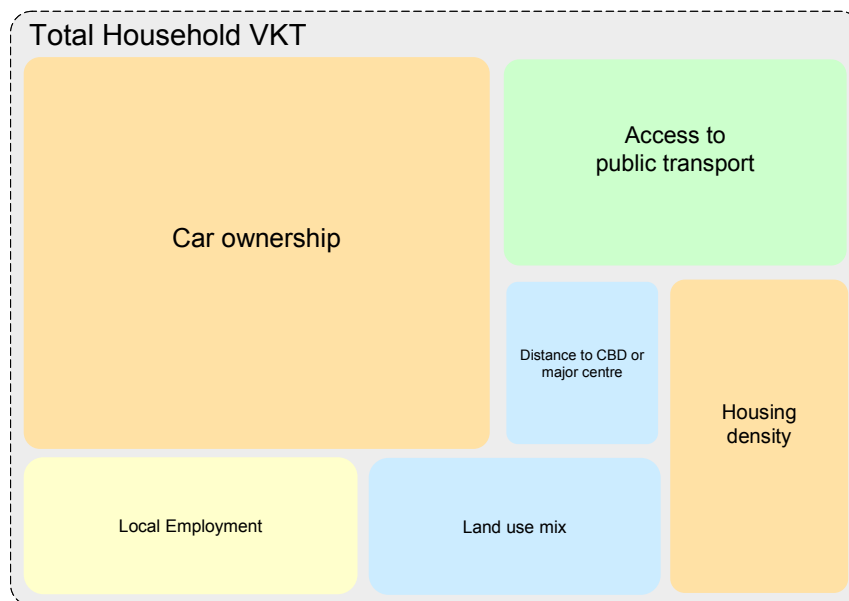


Figure 2: A visual explanation of the influence of each variable on household.

Access to public transport and housing density were also showed to have a significant impact on car use, with local employment, land use mix and distance to the nearest major centre or CBD showing a smaller influence on VKT. All these 5 variables align closely with current NSW Government policy on land use and transport contained in the policy document *Integrating Land use and Transport* (DUAP 2001). The relatively high influence of access to public transport reflecting the long thought belief that locating urban growth close to public transport of a high frequency will influence a household's use of more sustainable transport modes away from the car.

Variables excluded from the final model do not necessarily have a statistically insignificant impact on VKT. In most cases, variables were excluded because of their co-linearity with other variables, that is, two or more variables explain the same variation in VKT because they are highly correlated (see Corpuz, McCabe and Ryszawa 2006, *The Development of a Sydney VKT Regression Model* for more detail).

The research undertaken by TPDC quantitatively defines, for the first time, the major urban form variables that influence household VKT in Sydney. The next section of the paper explores how this model can be used to ensure land use planning reflects the importance of each of these variables, and land use plans reduce our reliance on the car.

4 Testing its application for land use planning policy

As mentioned in Section 1, the purpose of the development of the VKT model was to determine which variables influenced VKT so that Local Environmental Plans (LEPs) can be developed and assessed ensure they reduce car dependence. The VKT model also highlights the importance of car ownership as the most significant variable influencing car use. A possible policy response to this issue is put forward in Section 4.2.

The Sustainability Unit of the NSW Department of Planning is currently testing the model with Councils and stakeholders.

4.1 Land use plan preparation and assessment

The Sydney Metropolitan Strategy, *City of Cities: A Plan for Sydney's Future* (The Strategy), released in December 2005, sets out a strategic plan to facilitate and manage the growth and development of Sydney over the next 25 years. Seven strategies form part of the *Metropolitan Strategy*, one of which deals with Transport. A key action of The Transport Strategy is to “influence travel choices to encourage more sustainable travel” (DoP 2005). The Strategy highlights the importance of focusing activities in centres and corridors to influence people's choices about how they travel, and restates the intent of the NSW Government policy document *Integrating Land use and Transport – A Planning Policy Package* (DoP 2005).

Key to the implementation of The Strategy is translating its aims and actions into Local Environmental Plans (LEPs). METRIX is being developed by the NSW Department of Planning to ensure planning instruments, such as LEPs, give effect to key aspects of the Sydney Metropolitan Strategy. METRIX will operate as part of an electronic planning system that delivers a more effective and efficient process for preparing and assessing NSW environmental planning policies.

METRIX provides a new approach to policy implementation, moving away from a paper-based assessment of local plans to translating the intent of Government policy into clear and consistent assessment criteria. Based on an electronic and spatial platform, METRIX is being developed to:

- Ensure local plans give effect to key aspects of the Sydney Metropolitan Strategy;
- Deliver effective and efficient LEP assessments;
- Integrate many Environmental Planning Instruments and non statutory plans into a single LEP; and
- Integrate diverse data and disparate systems; and
- Provide real-time monitoring of urban development.

Delivered using an electronic spatial platform such as METRIX, the VKT model provides a consistent method against which to assess LEPs to ensure they “influence travel choices to encourage more sustainable travel” (DoP 2005).

The VKT model identifies those variables which have the greatest influence on car use. It also provides a definitive measure of the importance of each variable. At a subregional level, variables such as distance to major centre and CBD and walk and wait time to public transport can be assessed to identify, at a macro scale, the best locations for housing and employment growth, shown in Figure 3. Each variable can be assessed in turn as well as together to provide a current assessment of the relative importance of each variable on VKT, shown in Figure 4.

The VKT model also provides a basis from which to assess how changes in urban form will affect car use. An example is outlined below. As shown in Figure 5, Local Planning Authorities, such as Local Councils, can identify areas appropriate for housing and employment growth, such as within a defined distance to public transport and close to major centres. Once areas for growth have been identified, Local Councils will amend their LEP in order to accommodate this housing and employment growth. This will change variables such as housing density, land use mix and local employment. Using the VKT model on a spatial interface, changes to these variables can then be assessed so that appropriate levels of each variable are met in order to minimise car use and VKT.

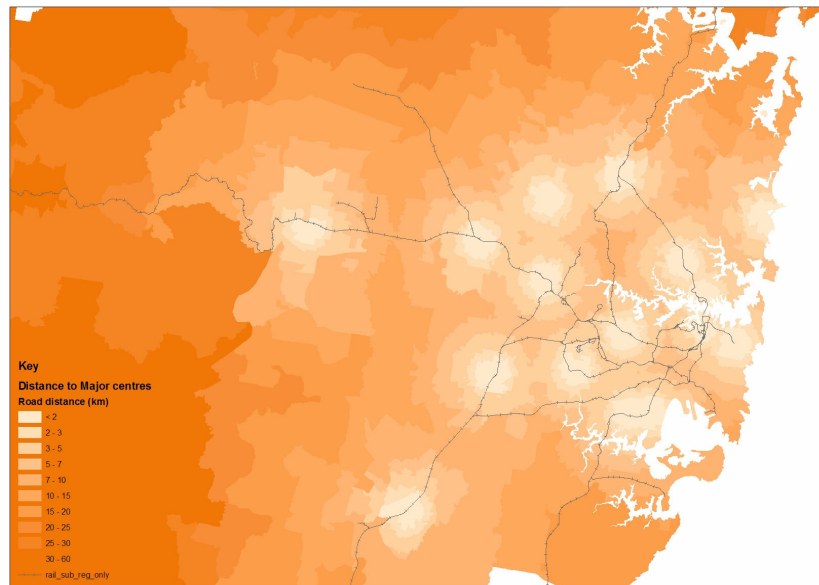


Figure 3: Distance to major centre or Sydney CBD, Sydney Statistical Division, 2004

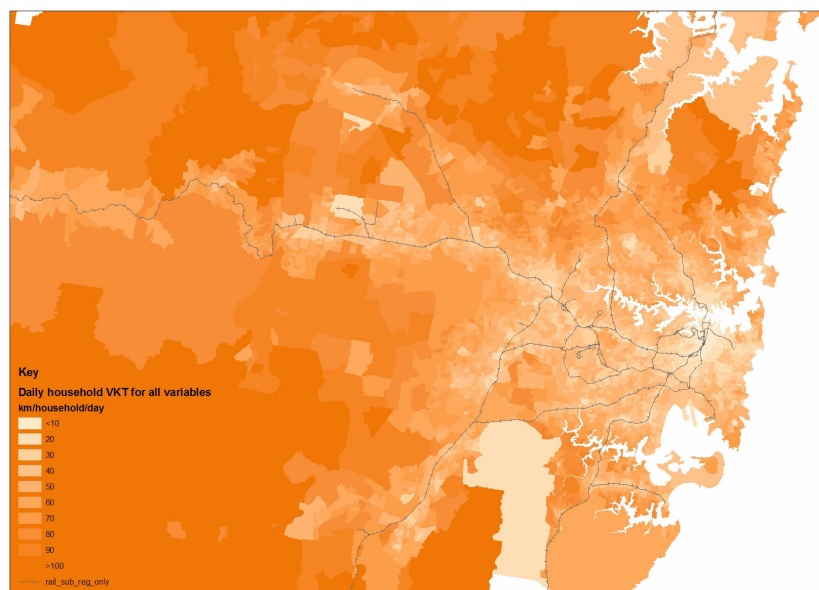


Figure 4: Total household VKT for Sydney Statistical Division, 2004

Figure 6 displays the VKT of the North Sydney area based on the land use variables: walk and wait time to public transport; housing density; local employment; land use mix; and distance to major centre or CBD. A change in these variables, through an amendment to an LEP, would influence the VKT of the area. This would be reflected in the VKT assessment of the LEP.

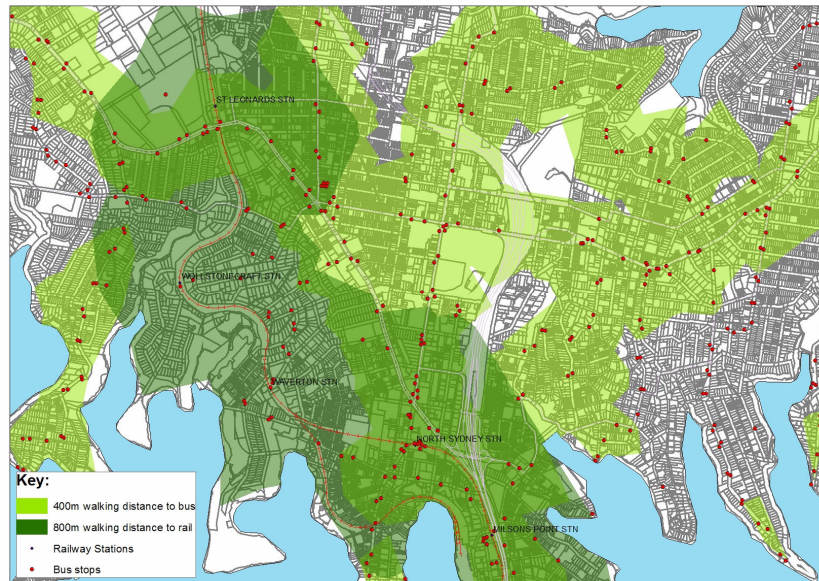


Figure 5: An example spatial interface identifying areas within walking distance of frequent public transport as defined by the NSW Government in *Land use and Transport – A Planning Policy Package*.

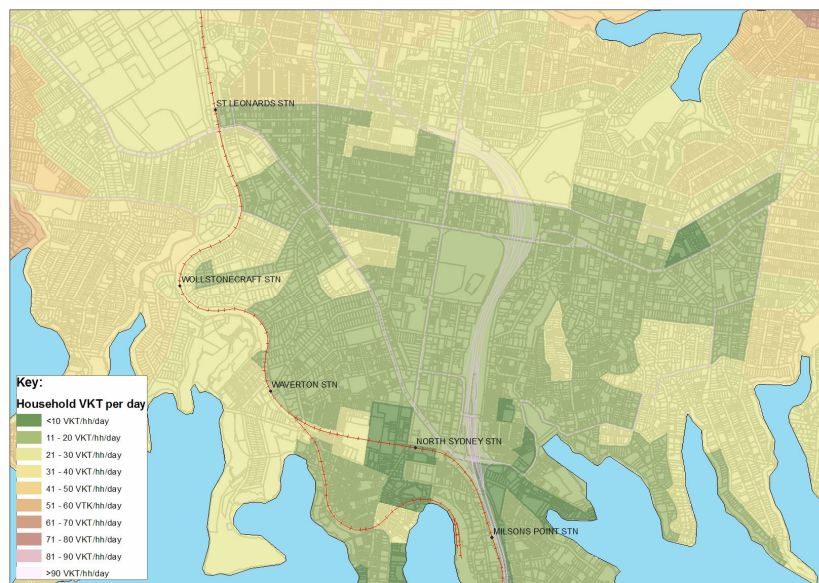


Figure 6: An example spatial interface displaying the VKT of different areas based on the land use variables: walk and wait time to public transport; housing density; local employment; land use mix; and distance to major centre or CBD.

The NSW Department of Planning is currently testing the VKT Model for its application in land use planning. The examples above outline an approach to implementing a policy which aims to reduce car dependence, providing a framework within which to prepare and assess LEPs to ensure their consistency with the Sydney Metropolitan Strategy. Further testing on this model and its application in land use planning will be undertaken through the next year.

The variable of car ownership, however, is not addressed in the discussion above. This will be discussed in Section 4.2 below.

4.2 Car ownership and car parking

The most significant variable shown to influence VKT in Sydney was the number of vehicles in a household (car ownership). Car ownership has mainly been investigated as a function of socio-economics (Soltani 2005). This has been supported in the VKT research by TPDC, showing that car ownership is largely influenced by household income (refer Section 3).

Some studies have shown that urban form and neighbourhood characteristics can influence a householders' decision to own a vehicle (Soltani 2005), and can be said to influence the need to own a larger number of vehicles. Many of these variables, such as density, proximity to public transport, jobs and services, are captured in the variables mentioned in section 4.1.

Literature has also touched on the relationship between car parking and car ownership. Although there is no data on the direct relationship between car ownership and car parking, several points can be concluded. Firstly, reducing parking spaces in new developments will result in pressure on current parking spaces, making multiple car ownership less attractive. Conversely, generous residential parking provisions is a major incentive for owning and using a car as it bundles the cost of a parking space into the cost of housing by forcing households to pay a major expense of vehicle ownership whether they want to or not (Litman 2005).

Under Action D3.2 of the Sydney Metropolitan Strategy (The Strategy), the NSW Government is committed to developing a metropolitan-wide parking policy. The objective of the parking policy is to ensure local parking policies set appropriate levels of car parking to support the use of public transport and reduce car dependence (DoP 2005).

4.3 A note on benchmarking and target setting

For the 5 years from 1999 to 2003, VKT has grown in Sydney by approximately 6 percent. During the same period, per person VKT has also increased.

Table 1: Historic VKT for the Sydney Statistical Division

	1999	2000	2001	2002	2003
Vehicle travel (VKT)	79,496,000	81,237,000	81,364,000	83,867,000	84,245,000
VKT per capita	20.1	20.3	20.0	20.4	20.4

Source: TPDC 2005

A key objective of the NSW Government Policy is to *reduce the growth* in VKT (DUAP 2001, DoP 2005). The data in Table 1 provides a benchmark growth in VKT and the target is to reduce this growth.

This approach was tested using the Sydney Metropolitan Strategy housing and employment growth targets for 2031. The Sydney Metropolitan Strategy includes housing and employment targets for each subregion across Sydney, and directions on where this growth should be located. Local Councils are then required to accommodate this housing and employment growth through amendments to their LEPs.

As a Local Council amends their LEP to accommodate growth in housing and employment, the impact on VKT can be assessed. The 2031 housing and employment numbers used for the Sydney Metropolitan Strategy were entered into the VKT model. Due to the location of housing and employment growth in areas close to centres, public transport and increases in housing and employment densities and land use mix, average household VKT is predicted to

decrease between 2006 and 2031 by around 2.6 VKT per household per day, or around 1 kilometre per person per day.

An increase in population growth will overshadow a decline in average household VKT. From the testing above, between 2004 and 2031 total Sydney Metropolitan VKT is predicted to increase by approximately 14.5 million VKT per day. This will grow at an increase of 22 percent on the 2006 figure with an average yearly increase of approximately 0.8 percent (compounded), a reduced growth in VKT compared to the growth in the last 5 years.

Table 2: Predicted VKT for the Sydney Statistical Division*

	2004	2031	Growth 1999-2003	% Growth 1999-2003	% Growth per year
Projected vehicle travel (VKT)	68,125,605	82,839,646	14,714,041	21.60%	0.79%
Projected VKT per household	42.7	40.0	-2.6	-6.18%	-0.26%

* Note: VKT in this table is produced using theoretical projections from the VKT model. Although relative differences in VKT are considered accurate, actual VKT will differ from the predicted data above.

5 Further research

The VKT model was developed using the best data available for household travel patterns in Sydney. The model highlighted the importance of car ownership and Section 4.2 of this paper has suggested a practical approach to this variable, considering the issue car parking in new residential developments. Although the relationship between car ownership and car parking is not unfounded, further research could investigate the direct relationship between car ownership and car parking. This should be considered along side the impact of parking management at the destination, such as centres, to gain a quantifiable understanding of how these variables influences VKT.

6 Conclusion

Land use planning is just one solution to help reduce our reliance on the automobile. Traditionally, this has focused on creating compact centres, with a mix of use located around public transport stops, providing the opportunities for people to walk and catch public transport. The VKT Model supports this approach for Sydney, indicating that access to public transport, land use mix, housing density, and provision of local employment have a significant impact on VKT.

The paper also outlines a new approach to implementing land use policy, moving away from a paper-based assessment of local plans to translating the intent of Government policy into clear and consistent assessment criteria (METRIX). Based on the electronic and spatial platform of METRIX, the VKT model provides an efficient and effective method for land use planning to help reduce car dependency in Sydney.

7 Acknowledgments

The author would like to acknowledge the Transport and Population Data Centre for their work on the development of the VKT model as well as Bruce Taper and Gavin Speak for their assistance in the development of the paper.

8 References

- Davidson, G. (2004) *Car Wars: How the Car Won Our Hearts and Conquered Our Cities*, Allen and Unwin, Sydney.
- DoP (NSW Department of Planning) (2005) *City of Cities: A Plan for Sydney's Future*, Sydney.
- DUAP (NSW Department of Urban Affairs and Planning) (2001) *Integrating Land use and Transport – A Planning Policy Package*, Sydney.
- Ewing, R. (1999) *Pedestrian and Transit-Friendly Design: A Primer for Smart Growth*. Smart Growth Network.
- Greater London Authority (2004) *The London Plan*, Greater London Authority, London.
- Hensher, D. (1998) The imbalance between car and public transport use in urban Australia: why does it exist? *Transport Policy*, 5 (4), 193-204.
- Jacobs, J (1961) *The Death and Life of American Cities*, Random House, New York.
- Kenworthy, J.R and Laube, F. (1999) Patterns of automobile dependence in cities: an international overview of key physical and economic dimensions with some implications for urban policy, *Transport Research Part A: Policy and Practice* 33 (7-8), 691-723.
- Kenworthy, J.R (2005) *Sustainable Urban Transport and Land Use Patterns for More Sustainable Cities in Australia: Some Key Policy Implications from An International Comparative Study*, A Submission to The House of Representatives Standing Committee on Environment and Heritage Inquiry into Sustainable Cities 2025, Murdoch University, Perth.
- LEDA (2000) *LEDA Measure: ABC localisation policy: getting the business in the right place*, retrieved July 2006 from <http://www.leda.ils.nrw.de/database/measures/meas0251.htm>
- Litman, T (2005) *Parking Requirement Impacts on Housing Affordability*, Victoria Transport Policy Institute, British Columbia, Canada.
- Newman, P.W.G., and Kenworthy, J.R. (1989) *Cities and Automobile Dependence: A Sourcebook*. Aldershot: Gower Technical.
- Newman, P.W.G. and Kenworthy, J.R. (1999) *Sustainability and Cities: Overcoming Automobile Dependence*, Island Press, Washington DC.
- NewUrbanism.org (2001) *New Urbanism*, Retrieved June 2006 from <http://www.newurbanism.org/>
- Parsons, Brinckerhoff, Quade and Douglas, Inc. Cervero, R., Howard/Stein-Hudson Associates, and Zupan, J. (1995) *Regional Transit Corridors: The Land Use Connection*. Washington DC: Transit Cooperative Research Program, National Research Council, H-1 Project.
- Soltani, A and Somenahalli, S (2005) *Household Vehicle Ownership: Does Urban Structure Matter*, paper presented at the 28th Australasian Transport Research Forum, Sept 2005.
- TCRP (Transit Cooperative Research Program) (2002) *Transit-Orientated Development and Joint Development in the United States: A Literature Review*, Research Results Digest October 2002, No. 52.

TPDC (Transport and Population Data Centre) (2005) *Transfigures: 2003 Household Travel Survey Regional Estimates*, NSW Department of Planning, Sydney.

UK Department of Transport (2003) *Land use planning and Accessibility*, Retrieved June 2006 from <http://www.dft.gov.uk>.

APPENDIX 1: Explanation of variables included in VKT Model

Variable description	Definition
Distance to CBD OR Major Centre	Network Distance (m) from the household XY to centroid of CBD OR Regional Centre as defined by Sustainability Unit (straight line x 1.3)
Accessibility to nearest train, ferry, light rail, or high frequency bus	Wait plus walk time from the household XY to the nearest frequent (every 15 mins between 7-9am) service
	number of jobs within 5 km radius from centre of each CD ('000)
Vehicles per household	The number of vehicles usually parked at the household overnight
Land-use mix	$\sum = (p_i) * \ln(p_i) / \ln(s)$ where p_i = area of each land-use (i.e. separate houses; multi unit, commercial & mixed-use), \ln – is the natural log, S = the number of land-uses (i.e. 4)
	As above but reviewed and refined by the Sustainability Unit
Housing density	No. dwellings / LEP zoned within 2km buffer (Residential+Business+Mixed) (if total LEP < 1km – variable is equal to no. dwellings/1256.626)

A detailed explanation of the variables and methodology used to develop the VKT model can be found in the technical paper by Corpuz, McCabe and Ryszawa, “*The Development of a Sydney VKT Regression Model*”.