TECHNICAL BULLETIN

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Transportation and Community Design: the Effects of Land Use, Density and Street Pattern on Travel Behaviour

I. Introduction

Figure 11-1

A growing body of research argues that the costs associated with automobile transportation infrastructure and energy use in conventional suburban development is becoming increasingly unsustainable.[1] Conventional suburban development requires more land and road infrastructure per capita than does more compact development, increasing the per capita cost of land development. As development expands outward, more roads are needed, which in turn require more public expenditure for servicing new development. Added to this are the ecological and social costs from reduced water and air quality and increasing energy demand as a result of increased automobile use.[2] It is suggested that modifications made to land use patterns and changes to the built environment can significantly reduce travel demand (i.e., automobile trip duration and frequency, and modal choice), which results in reduced road infrastructure requirements, lower per capita energy use and lower Green House Gas emissions (GHG) related to automobile use.

This discussion paper provides an overview of recent research that focuses on the relationship between land use, travel demand and vehicle emissions. Land use features such as housing and employment density, diversity of uses, access to transit and street network, are reviewed according to their relative as well as combined impact on moderating travel behaviour.

II. Defining Neighbourhood Types

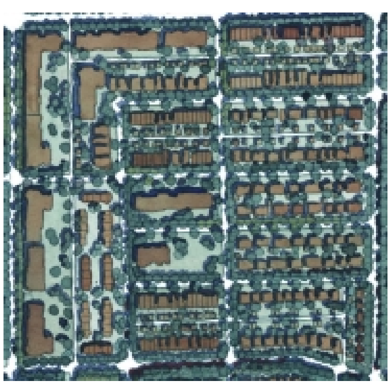

Figure 11-2 - The sprawling, status-quo street pattern (Figure 11-1) is less effecient than the compact traditional development (Figure 11-2). Narrow, interconnected streets save more land and make walking and cycling easier. Total daily vehicle kilometers travelled (VKT) in traditional development patterns can be up to 43% lower than status-quo development patterns.

Prior to comparing the relative impacts of particular land use patterns on travel behaviour, it is first useful to define the differences between conventional suburban development and more compact development patterns.

Conventional Development	Compact Development
Hierarchical street pattern	Interconnected street pattern
Streets designed for maximum car speeds	Narrow street dimensions
Parking in large, front-loaded surface areas	On-street (or underground) parking
Segregated land uses	Integrated land uses
Wide setbacks	Shallow setbacks
Low net housing (i.e. below 4 upa) and employment densities	Higher housing (i.e., above 10 upa) and employment densities
Leapfrog development	Contiguous development and infill
Automobile oriented	Pedestrian and transit oriented

III. Land use mix

As shown above, a key attribute of traditional/compact communities is an integration of land uses and a higher than average housing and employment density. Various studies show statistically significant relationships between the intensity and mix of land use and the frequency and duration of vehicle travel (measured in vehicle kilometers traveled [VKT]). An analysis of household travel patterns in a sprawling Florida county found that households living in locations most accessible to commercial and employment locations spend, on average, 40 minutes less per day traveling by vehicle than do households living in locations least accessible to commercial and employment locations, thus generating hundreds of fewer vehicle hours per year. (Ewing et al. 1994; Ewing l995b). The time savings are due almost entirely to shorter auto trips, not shifts to other modes. The land-use variable that proves significant is regional accessibility, not local density.[3]

The study by Cervero and Radisch (1996), showed that while work-trip frequencies were similar across two San Francisco Bay area communities, higher rates of walk trips were exactly matched by lower rates of auto trips for shopping and other non-work purposes among residents of a traditional community. Overall, the daily non-work VKT per resident of the traditional community was 45 percent below that of the status-quo suburb.[4]

IV. Density and Access to Transit

While there is still much dispute about the singular significance of higher densities to reduced VKT, there are several surveys that show communities designed with densities higher than that found in status-quo suburban developments have a measurable effect on vehicle use. Generally, studies show that as densities rise, trips get shorter, the share of transit and walk mode trips increase, and vehicle trip rates drop.[5] All of this translates into lower VKT.[6] Holzclaw's survey of major US and Canadian cities shows that doubling urban density results in a 25% to 30% reduction in VKT.[7] Another study, completed by the Washington State Department of Transportation, found a statistically significant correlation between urban density and travel behaviour (modal choice, travel distances and duration). With specific reference to density, it found that a) as density rises, travel time increases while trip distance and the proportion of trips made by single-occupant vehicles declines; and b) employment density and jobs/housing balance have the strongest relationship with travel behaviour. It further added that while travel behaviour is affected with small changes in land land use, significant travel behaviour patterns result if the following thresholds are met or exceeded. For reductions in work-related trips, 50-70 employees and 9-13 persons per gross acre (about 12 dwellings per net acre) is needed. For significant reductions in non-work (i.e., shopping) trips 75 employees and 18 persons per gross acre (about 20 dwellings per acre) is needed.[8]

Figure 11-3 - Integrated land use is a feature of compact development patterns. Above, high-density residential towers are set back behind single family homes.

V. Street Network

Traditional/compact development is also characterized by an integrated street system, the reduction of an intrinsic hierarchy (i.e., wherein all streets are essentially local streets), and the level of pedestrian and bicycle-oriented design. Attributes that accompany this pattern and that significantly affect increased modal choice are:

- narrow streets (with a cross section that, on local streets, is typically no less than two travel lanes plus on street parking);
- small setbacks, wherein lateral clearance between the street edge and fixed objects such as street furniture, trees and buildings are reduced;
- on street parking;
- reduced curb radii; and
- rear lanes, which eliminate disturbances to the sidewalk, permit continuity of building fronts on the street, and increase the amount of on-street parking that can be obtained.[9]

Figure 11-4 - Shallow setbacks and on-street parking are among the humanizing features of this urban development.

A study completed by the American Society of Civil Engineers used the above attributes to compare travel demand in a status-quo suburban pattern to a traditional neighbourhood pattern. The study evaluated the performance of each pattern with respect to vehicular capacity of the street system, travel speeds, and impacts of travel times and delays, and land required for rights of ways.

As shown in Table 11-1, the study found that traffic volume/capacity is reduced on arterials and collectors by about 10% in the traditional pattern over status-quo developments, while local street volume/capacity is nearly equal. Thus, both patterns achieve close to the same capacity, however, where the traditional pattern allows traffic to be dispersed among a dense network of local streets, the status-quo pattern relies on a sparse network of major arterials. In terms of travel demand (measured in daily VKT), the conventional pattern generated 75% more travel demand on arterials than the traditional development, and up to 80% more demand on collector streets. VKT on local streets was considerably higher in the traditional pattern compared to the status-quo pattern, again, due to the integration of local streets within the traditional pattern. The total VKT in the traditional development pattern was found to be 43% lower than the conventional development pattern.

Finally, while travel speeds are typically lower in the traditional development pattern (due to more intersections and narrow streets), comparable travel times are achieved due to shorter (i.e, more direct) trip distances and reduced traffic signal delays.[10]

Table 11-1 - Summary of Vehicular Capacity

Criteria	Status-Quo Development (SQD)	Traditional Development (TD)	Difference (TD/SQD)
DAILY VEHICLE KILOMETERS OF TRAVEL			
Arterial Streets	6985	1368	SQD is 75% ↑ than TD
Collector Streets	8690	1304	SQD is 85% ↑ than TD
Local Streets	2012	7403	SQD is 4X ↓ than TD
Total VKT	**17,687**	**10,075**	**SQD is 43% ↑ than TD**
VOLUME CAPACITY RATIO			
Arterial Streets	0.92	0.83	TD↓ by 10%
Collector Streets	0.94	0.87	TD↓ by 10%
Local Streets	0.21	0.22	Almost equal

Adapted from *Benefits of Neotraditional Development* (Portland, Or.: Criterion Engineers and Planners, 1996).

VI. Pedestrian Environment Factors

The incorporation of pedestrian-oriented design elements into development patterns is shown to have measurable influence on travel behaviour. One of the most widely-cited studies is "Making the Land Use Transportation Air Quality Connection – the Pedestrian Environment," by Parsons Brinckerhoff Quade and Douglas, Inc.[11] The study evaluates the relative impact of land use variables (such as residential density, transit level-of-service, and proximity to employment activity) on travel behaviour, with a special emphasis on Pedestrian Environment Factors (PEF). (In addition to land use variables noted above, PEF is measured by considering the following variables: sidewalk continuity, street connectivity, topography). Using regression models, the study found that residents in neighbourhoods with higher density, proximity to employment, grid street patterns, sidewalk continuity, and a high PEF measure tend to make up to three times as many transit trips and nearly four times as many walking and bicycling trips as do residents of more disintegrated, lower density suburban areas with auto-oriented land use patterns.[12]

Figure 11-4 - Traditional neighbourhoods, with densities of 25 units per hectare or higher, are better connected to regional transit than status quo neighbourhoods.

VII. Impact Fee Reductions

In an attempt to reflect the costs of road infrastructure and traffic impacts as a result of land use patterns, the City of Orlando recently revised its impact fee structure for new developments. In its analysis of the relative impacts of various development types within the City limits, it concluded that developments within inner city areas, which have high access to regional public transit, and a high interdependency of land uses, could receive an almost 38% reduction in impact service fees, over less efficient land use patterns. Areas outside the inner city core, but with attributes of traditional development patterns (as outlined above), would receive slightly lower impact fee reductions, but still measurable compared to status-quo suburban development patterns.[13]

VIII. Conclusion

In summary, the traditional development pattern appears to offer numerous benefits when compared to the status-quo development pattern. These include: travel time savings (lower frequency and duration of vehicle travel); high access to public transit and frequency of transit use; more effecient land use; higher pedestrian environmental factors; and reduction in impact service fees. We recognize that increased traffic on local streets may be a politically contentious issue for residents to accept. However, the interconnected street pattern results in greater overall neighbourhood safety through slower traffic speeds, more "eyes on the street", lower VKT, and increased pedestrian traffic.

The dramatic results cited in this bulletin are based on the assumption that all new development locates in cities or in higher density, mixed-use constructs. Only to the extent that we can change our current land use patterns, will we approach these results. A better relationship between land use and transportation in the future will be achieved by carefully planning uncommitted lands and by redeveloping existing sites over time.

Notes

[1] Robert Burchell 1998, *The Costs of Sprawl Revisited*, (Washington DC.: National Academy Press, Transportation Cooperative Research Program Report 39); Patrick Mezza and Eben Fodor, 2000, "Taking its Toll: The Hidden Costs of Sprawl in Washington State (Seattle, Washington: Climate Solutions); Todd Litman, 2001, "Land Use Impact Costs of Transportation, (Victoria, BC: Victoria Transport Policy Institute).
[2] Transportation energy is typically the largest end-use sector in a community, often accounting for 40% to 50% of total energy use annually. (Criterion Inc., 1996, *Using Place[3]s to Create More sustainable Communities*, Centre for Excellence in Sustainable Development, Office of Energy Efficiency and Renewable Energy, US Department of Energy).
[3] From"Alternative Views of Sprawl: Counterpoint – Is Los Angeles-Style Sprawl Desirable? Reid Ewing. *Vol. 63, No. 1, Winter 1997. °American Planning Association, Chicago, IL.*
[4] Cervaro, R. and C. Radisch, 1996, "Travel Choices in Pedestrian Versus Automobile Oriented Neighbourhods," *Transport Policy,* Vol. 3, pp. 127-141.
[5] Frank, L.D. and G. Pivo, 1994, *Relationships Between Land Use and Travel Behavior in the Puget Sound Region*, Washington State Department of Transportation, Seattle, pp. 9-37; Criterion, 1996, 12.
[6] Holtzclaw, J, 1994, *Using Residential Patterns and Transit to Decrease Auto Dependence and Costs*, Natural Resources Defense Council, San Francisco, pp. 16-23; Parsons Brinckerhoff Quade Douglas, 1993, *The Pedestrian* Environment, 1000 Friends of Oregon, Portland, pp. 29-14; Cervero, Robert and K. Kockelman, 1996, "Travel Demand and the 3Ds: Density, Diversity and Design," *Transportation Research D*.
[7] Holtzclaw 1994, 6-8 and 21.
[8] Frank and Pivo, 1994.
[9] Criterion, 1996. 15.
[10] Ibid., 18.
[11] Parsons Brinckerhoff Quade and Douglas, Inc. and Cambridge Systematics,Inc. and Calthorpe Associates, "Making the Land Use Transportation Air Quality Connection – the Pedestrian Environment," (Portland, Or.: 1000 Friends of Oregon, 1993).
[12] Ibid.
[13] City of Orlando Planning and Development Transportation Planning Bureau, "Applicability of Vehicle Miles of Travel to Transportation Planning," (Orlando, Florida: City of Orlando Planning and Development Transportation Planning Bureau, 1999).
For additional discussion of combined cost reductions of neotraditional development see Criterion, 1996, pp. 22-30 and Eben and Fodor, 2000.

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