California Smart-Growth Trip Generation Rates Study

Final Report

Appendix A

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Summary of Findings and Recommendations

Regarding Key Definitions

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Overview

The goal of this task is to establish definitions to guide the identification of studies and practices that have direct relevance to the development of the "Trip-Generation Rates Spreadsheet for Smart-Growth Land-Use Projects". The overall project goal is to create and disseminate a spreadsheet-based tool for estimating trip generation rates for smart growth land use projects.

Smart Growth Defined

The Smart Growth Network, a joint activity of the U.S. Environmental Protection Agency (EPA) and several non-profit and government agencies, identifies ten principles of smart growth. In recent years, these have gained wide circulation as a definition of this complex development concept. We acknowledge this widely accepted set of descriptors, and define smart growth developments as land use projects compatible with the ten principles propounded by Smart Growth Network to a significant degree. In other words, a smart growth project serves to directly or indirectly:

- Mix land uses
- Take advantage of compact building design
- Create a range of housing opportunities and choices
- Create walkable neighborhoods
- Foster distinctive, attractive communities with a strong sense of place
- Preserve open space, farmland, natural beauty, and critical environmental areas
- Strengthen and direct development toward existing communities
- Provide a variety of transportation choices
- Make development decisions predictable, fair, and cost effective
- Encourage community and stakeholder collaboration in development decisions

It is noteworthy that these principles (and many smart growth proponents) point to benefits apart from transportation. For example, fostering a strong sense of place and encouraging community collaboration are non-transportation goals with clear societal benefits. Moreover, some of the ten principles with transportation implications also embody other, non-transport benefits: e.g., compact housing is often more affordable; and mixing residences and local shops and services are useful to residents even if they drive to them.

Smart Growth Transportation Principles

Closer examination reveals that four of the ten Smart Growth principles are of particular importance to transportation planning in general and this project's focus on trip generation in particular. While each of these four principles is distinct, they are synergistic in their effect on travel behavior.

- *Take advantage of compact building design:* This is a synonym (perhaps a euphemism) for development density, which countless studies over many decades has shown to be positively correlated with transportation modes other than the auto.
- *Mixed land uses*: This smart growth principle is important to take into account when estimating trip generation, as an appropriate diversity of land uses within one site tends to foster internal trips and, depending on site design, reduce overall vehicle trips.
- *Creation of walkable neighborhoods*: This principle is relevant to trip generation as walkable neighborhoods tend to encourage non-motorized travel, thus reducing overall vehicle trips. Density and land use mix play a fundamental role in the creation of walkable environments (by shortening trips and providing nearby destinations), but the presence of sidewalks, footpaths and bikeways providing direct routes between related land uses is also an essential component of walkability.
- *Provision of a variety of transportation choices*: This principle pertains to trip generation in the sense that providing various transportation choices and alternatives to the automobile can encourage reduction in overall vehicle trips. Walkability represents an essential first step toward providing transportation choice, and provision of walkways is a smart growth element that development projects should be expected to provide regardless of the scale of development.

Multi-Modalism: A Key Smart Growth Element Defined

This last principle, "provision of a variety of transportation choices" may be summarized, in a word, as *multi-modalism*. The term "multi-modal" implies the availability and use of a variety of travel modes, including personal vehicles (single occupancy vehicles and high occupancy vehicles), transit (rail, bus, etc.), and non-motorized modes (bike, walk, etc). This term is pertinent to this project as smart-growth development projects aim to foster a relatively high degree of multi-modalism and thereby reduce overall vehicle trips.

While facilities for walking and bicycling can and should be provided at the project scale, many transportation choices – e.g. rail and bus rapid transit, and complete pedestrian and bike networks – require government funding, coordination, and implementation at a regional scale. Development projects can make *provision* for non-automobile choices, but cannot on their own *provide* them.

For purposes of this study, "multi-modal" is defined as transportation systems (and analysis of such systems) that includes, at minimum, auto, transit and non-motorized (pedestrian and bicycle) travel. The need for, and feasibility of, more refined modal categories, e.g., distinguishing auto driver vs. auto passenger, types and levels of transit service, and bike vs. walk, will be determined at the conclusion of Task 4 (Expert and Practitioner Panel Review).

Litman: Further Defining Smart Growth from a Transportation Perspective

Todd Litman has recently published a summary analysis of the market for Smart Growth that includes an extensive definition of Smart Growth through the lenses of transportation planning.[1] For Litman, smart growth consists of land use development patterns that emphasize *accessibility* (the ability to reach destinations) over *mobility.* Smart growth also fosters modal diversity, as opposed to dispersed, automobile dependent development, which Litman equates to *sprawl*. Table 1 summarizes Litman's comparative analysis of these two development paradigms.

Litman views smart growth as applicable to a wide range of contexts, but notes that its form and associated transportation facilities and performance will be different in different metropolitan environments:

- **Urban Smart Growth** may entail medium- and high-density mixed-use development concentrated around transit stations, e.g., *transit-oriented development*.
- **Suburban Smart Growth** typically entails small-lot and low-rise, mixed-use, walkable neighborhoods, and is often called *new urbanism* or *neotraditional planning*.
- **Rural Smart Growth** typically entails development clustered in walkable *villages*, connected by ridesharing and public transit, and roads with adequate shoulders to accommodate bicycles.

Thus, while all smart growth development is, by definition, multimodal, the modes available and their degree of use (modal share) will vary.

Table 1 **Comparing Smart Growth and Sprawl** (Based on Litman 2009, Table 2)

Variable	**Sprawl**	**Smart Growth**
Density	Lower-density, dispersed activities.	Higher-density, clustered activities.
Growth pattern	Urban fringe (greenfield) development.	Infill (brownfield) development.
Land use mix	Homogeneous (single-use, segregated).	Mixed land uses.
Scale	Large scale. Larger blocks and wider roads. Less detail since people experience the landscape at a distance, as motorists.	Human scale. Smaller blocks and roads. Careful detail, since people experience the landscape up close, as pedestrians.

[1] Litman, T. (2009). "Where We Want To Be: Home Location Preferences And Their Implications For Smart Growth" Victoria Transport Institute, 18 September.

Variable	Sprawl	Smart Growth
Public services (schools, parks, etc.)	Regional, consolidated, larger. Requires automobile access	Local, distributed, smaller. Accommodates walking access.
Transport	Automobile-oriented. Poorly suited for walking, cycling and transit.	Multi-modal. Supports walking, cycling and public transit.
Connectivity	Hierarchical road network with numerous dead-end streets, and limited, unconnected walking and cycling facilities.	Highly connected (grid or modified grid) streets and nonmotorized network (sidewalks, paths, crosswalks and shortcuts)
Street design	Streets designed to maximize motor vehicle traffic volume and speed.	Streets designed to accommodate a variety of activities. Traffic calming.
Planning process	Unplanned, with little coordination between jurisdictions and stakeholders.	Planned and coordinated between jurisdictions and stakeholders.

Operationalizing Smart Growth Components for Trip Generation Analysis: The D-Factors

For more than a decade, transportation analysts in both academia and professional practitice have attempted to isolate and measure components of smart growth that reduce vehicle trip rates and related impacts. This body of research has come to be known as D analysis due the fact the many of variables can (with some creativity) be described with terms beginning with the letter D.

The most well known Ds are local land use variables that include **D**ensity, land use **D**iversity, pedestrian-scale **D**esign, access to regional **D**estinations, and **D**istance to Transit. Other D variables include **D**evelopment Scale, **D**emographics and Travel **D**emand Management.

The D-factor terminology may be traced to research led by Robert Cervero[2]. This research found that certain characteristics of neighborhoods affected the amount and mode of travel (measured in terms of vehicle trips and vehicle miles traveled). This effect was independent of household and demographic characteristics (income, household size, number of workers, etc.) typically used in vehicle trip generation equations. Related research has found that the D variables also affect transit ridership and non-motorized trips when they occur near rail transit stations.

[2] Cervero, R. and K. Kockelman (1997) "Travel Demand and the 3Ds: Density, Diversity, and Design," *Transportation Research D* 2:199-219. Other resources used to define these factors include Fehr & Peers' *Accurate Trip Generation Estimates for Mixed-Use Projects,* and Cervero and Lee's *The Effect of Housing Near Transit Stations on Vehicle Trip Rates and Transit Trip Generation.*

One conclusion of the D-research is that trip generation analysis for traffic impact studies should include adjustments to trip-generation rates to reflect the characteristics of the area surrounding the household. This finding is in one sense well-known and acknowledged: the ITE *Trip Generation* manual has been recommending such an adjustment in its last three editions. Nonetheless, an accepted process of operationalizing smart growth trip generation analysis is still under development. With SB 375 mandating that California Metropolitan Planning Organizations (MPOs) modify regional transportation planning to be sensitive to local land use factors, the policy incentives appear to be increasing.

The "D-factors" would appear to represent a reasonable basis for such a smart growth trip generation method, since they are measurable and demonstrably affect mode choice and trip generation. Developments that typically incorporate some or all of the D factors include infill development, cluster development, mixed-use development, and transit-oriented development, (See the Appendix for definitions of the terms).

The "D-factors" that seem highly relevant to this project include the following seven interrelated variables:

- *Diversity:* The extent to which the site mixes commercial, residential, and business land uses. Increased diversity of land uses can increase the amount of internal trips.
- *Density:* The density of a site, typically measured in units such as dwelling units or employees per acre or square mile, floor area ratio (FAR), etc. Higher density developments tend to yield fewer vehicle trips per unit of measurement.
- *Design:* Specifically, design of the site's transportation networks, taking into account connectivity and walkability, both of which have the potential to reduce vehicle trips.
- *Destination-proximity:* "Accessibility to regional activities - development at infill or close-in locations reduces vehicle miles" of travel."[3] *and "*Accessibility to other activity concentrations expressed as the mean travel time to other destinations in the region."[4] The site's proximity and accessibility to interactive, compatible land uses. Land uses in close proximity to other compatible land uses tend to generate fewer vehicle trips and lower rates of vehicle miles traveled. Density and diversity both contribute to destination-proximity.
- *Distance to transit:* The site's proximity to transit stations. Closer proximity increases the feasibility of transit usage, thus reducing vehicle trips. Higher densities support more intensive transit service, thereby potentially increasing the amount of people using transit.
- *Development scale:* the size of a development project. "A 'critical mass' of acres, population, jobs provides a sufficient variety of options, and balance of opportunities."[5] Generally the larger the project, the greater the internalization of trip making, although internalization of trip making depends on the density and diversity of land uses.
- *Demand Management*: pricing and incentives for using non-auto modes can, under the right conditions, dramatically reduce auto use. Diversity, density,

[3] Walters, J., Powerpoint to the SB375 Regional Targets Advisory Committee, Feb. 3, 2009.
[4] Walters, J. and R. Ewing. (2009) "Measuring the Benefits of Compact Development on VMT and Climate Change," *Environmental Practice*, September.
[5] Walters, J., Powerpoint to the SB375 Regional Targets Advisory Committee, Feb. 3, 2009.

design, and destination-proximity all contribute to "the right conditions."
- *Demographics:* factors such as household life-cycle, income and auto ownership indisputably affect travel choices, although demographics are not directly tied to land use

Each of these seven Ds is defined and discussed in more detail below.

Discussion: Seven Critical D Variables: Characteristics, Scope and Measurement

The literature on neighborhood characteristics that affect trip generation is constantly evolving and new models of travel behaviors are always being investigated. That said, the variables described below define key land use characteristics that can be tied to a particular development project and that have been shown (via analysis of travel surveys and other empirical research) to affect trip-making and mode choice, and are therefore likely candidates for inclusion in a project-scale smart growth trip generation tool.

Density

Net *Residential Density* is measured in terms of households or dwelling units per acre. Ideally acreage should be that which is actually developed for residential uses, excluding roadways, open space and other undevelopable land. A wide body of research suggests that, all else being equal, denser developments generate fewer vehicle-trips per dwelling unit.

Similarly *Employment Density* is measured in terms of employees or building area per acre of land devoted to employment. While the research on the relationship between employment density and vehicle trip reduction is less clear than for residential density, transportation analysts generally believe that such a relationship exists.

Mixed-use or Land Use Diversity

A definition of mixed-use development (often abbreviated MXD) that encompasses many existing areas with interconnected, mixed land use patterns was developed by Ewing et al[6]. This definition is, in turn, based on the definition of "multi-use development" used in the Institute of Transportation Engineers' (ITE) *Trip Generation Handbook* (2008):

> "A mixed-use development or district consists of two or more land uses between which trips can be made using local streets, without having to use major streets. The uses may include residential, retail, office, and/or entertainment. There may be walk trips between the uses."

The American Planning Association (APA) defines mixed-use planning as aiming "to create pedestrian-friendly environments, higher-density development, and a variety of uses that enable people to live, work, play, and shop in one place, which can become a destination".

Two types of mixed use may be distinguished:

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[6] Ewing, R. et al. (2008). Traffic Generated by Mixed-Use Developments – A Six-Region Study Using Consistent Built Environmental Measures. Paper Presented at 87th Meeting of the Transportation Research Board, January.

- *Jobs/Housing Fit or Balance* – Research suggests that residences and jobs in close proximity can reduce the number or distance of vehicle-trips generated by each use by allowing some work trips to be made on foot or by bicycle and reducing travel distances by auto or transit. This variable is often measured by measuring how closely a project or a project neighborhood (e.g. all land uses within a half-mile, or a ten-minute walk) matches the “ideal” mix of jobs and households. For example, in a region with three million jobs and two million households, the jobs/housing ratio would be 1.5.

- *Employment Diversity* – Research also suggests that a mix of basic employment activities (e.g. offices) and retail and service employment (e.g. shops and restaurants) can reduce vehicle use for trips that originate or terminate at a work site. This variable measures how closely a neighborhood matches the “ideal” mix of jobs and households, which is often assumed to be the ratio of jobs to non-retail jobs measured across the region as a whole. In other words, a project or project neighborhood with the same ratio of retail/non-retail ratio as the region would be considered optimal in terms of internalizing trips and reducing vehicle travel.

Walkable Design

Many pedestrian and bicycle improvement projects are based on the assumption (supported by some research findings) that improving the walking/biking environment will result in more non-auto trips and a reduction in auto travel. The difficulty with using this variable in trip generation is that there are many variables that influence the pedestrian experience and it is difficult to identify a single definition that captures them all. The walkability used in some applications (e.g. the EPA SmartGrowth INDEX land use analysis software) focuses on the *presence, density,* and *directness* of pedestrian paths.

Perhaps reflecting the difficulty of capturing all relevant aspects of walkability, the walkable design variable, when isolated, usually has the weakest influence on the tripmaking of the D variables. That said, design for non-motorized transport seems to have important synergistic effects in conjunction with density and diversity[7].

Destination Accessibility

Research shows that, all else being equal, households and non-residential activities situated near regional centers of activities generate fewer auto trips and VMT than households located far from destination centers. When comparing different potential sites for the same type of development, this variable is very important. This variable can be quantified by estimating the total travel time to all destinations/attractions.

Sensitivity to variations in regional accessibility is characteristic of most well-calibrated and validated four-step travel demand models and therefore modeling can be used to estimate this D variable. Under this approach, the model calculates the total travel time (or generalized cost) of travel from one zone to all destinations of interest in a region (i.e., jobs or retail opportunities). Travel time contours by mode (e.g., the number of jobs

[7] Cervero, R. and R. Gorham. (1995) " Commuting in Transit Versus Automobile Neighborhoods" *Journal of the American Planning Association,* 61(2):210-225.

or retail opportunities within 30 minutes of a site by car or transit) are examples of Destination Accessibility measures.

Although travel demand models provide a reasonable estimate of regional accessibility, they treat local accessibility – destination accessibility within or nearby a neighborhood – in a cursory way. Most such models include a crude measurement of "intra-zonal" trips captured by nearby destinations. Examining both local accessibility, as influenced by diversity and design within close proximity of the development project, and regional accessibility, reflecting land use patterns and transportation connections throughout the region, is important in estimating vehicle trip generation and VMT.[8]

Distance to Transit

Development near transit that is higher density and has an appropriate diversity of land uses in an environment designed for easy walking and biking is likely reduce auto use for several interrelated reasons.

- Better regional accessibility – especially via high-capacity transit, reduces auto commuting

- More local opportunities lessen the need for auto use

- Diversity of uses near transit stops encourages station-area residents to ride transit by allowing "trip chaining" (i.e., walking to nearby shops en route to residences from stations after work).

There may also be reduced vehicle trips and vehicle miles of travel due to:

- Fewer autos owned
- More trips by walking
- Shorter auto trips

Detailed analysis by the Metropolitan Transportation Commission (MTC) of its 15,000 household Bay Area travel survey data base from the year 2000 confirms the effects of proximity to high quality transit services, even when accounting for other D variables such as density. MTC found that residents living within a half mile of a rail transit or ferry station are four times more likely to use transit than those living more than a half mile from a transit or ferry station. This is consistent with findings on variation in modal splits by distance to transit found by Cervero (1994) and Lund et al. (2003). The Bay Area survey results show that residents living and working within a half mile of transit or ferry stations average 42% of their daily trips by transit, walking or biking, Nearly a third of households within a half mile of ferry or transit stations have no vehicle. Households within a half mile of ferry or rail transit stations generate half the VMT of suburban and rural residents.

Development Scale

[8] Handy, S. (1996) "Understanding the Link Between Urban Form and Nonwork Travel Behavior," *Journal of Planning Education and Research*, 15(3):183-198 .

Research indicates that a “critical mass” of acres, population, and jobs provides a sufficient variety of options and balance of opportunities.[9] Development Scale affects trips due to the fact that, all else equal, the larger the scale of a development, the higher the percentage of trips likely to be internalized. The degree to which this occurs will depend on factors such as the first four D variable of density, diversity, design and regional destination proximity. In addition, in larger the scale of the development, the internalized trips are more likely to made by automobile rather than non-motorized modes, given the increase in travel distance, all else equal.

Demand Management

Travel Demand Management (TDM) -- pricing and other incentives for the use of alternate modes -- can also have a marked effect on travel behavior. The table below, which is focused on parking demand as an example, shows that the potential effectiveness of such a TDM is significant. The difficulty with incorporating TDM in trip generation analysis arises from the fact that unless TDM performance measures are established by law or contract (a rarity in California today) the predictability of TDM implementation and thus effects is uncertain. In sum, TDM can significantly alter travel behavior, but absent a legally binding agreement, many analysts would not be comfortable relying on substantial vehicle trip reductions based on TDM.

Table 2 Estimated Effects Demand Management Strategies on Parking Demand

Demand Management Strategy	**Potential Parking Reduction**	**Cost to Implement for Developer**
Shared Parking	10-20%	More detailed parking analysis during planning stages
Transit Pass Purchase	5-20%	Developer includes in price of building, overall decrease in cost because of fewer parking spaces
Charging for Parking	5-20%	Charge tied to use of parking
Unbundled Parking	5-10%	None
Car-Sharing	2-5%	Developer dedication of parking spaces to car-sharing operations
Source: Fehr & Peers, October 16, 2009, Draft Memo, *Smart Growth Parking Requirements and Strategy Review*		

Demographics

Demographic variables – e.g., family size, life-stage, income class, and vehicle ownership -- clearly affect trip generation as well as vehicle trip-making and vehicles

[9] Walters, J., Powerpoint to the SB375 Regional Targets Advisory Committee, Feb. 3, 2009.

miles traveled. The main issue for trip generation analysis arises from the fact, with some notable exceptions (e.g., age-restricted and income-restricted housing) it is extremely difficult to forecast demographic characteristics of residents and users of new development projects. Thus while the predictive value of demographic variable may statistically valid, the challenge of accurately predicting them may diminish the value of demographic variables in practice.

Conclusion

While the ongoing literature review may reveal other key variables beyond those discussed, the seven Ds as defined above represent a reasonable guide for identification of studies and practices that have direct relevance to the development of the end goal for this project, a tool capable of more accurately analyzing the trip generation characteristics of smart growth land use development projects.