WESTSIDE SUBWAY EXTENSION

Smart Growth Evaluation Report Appendix A

Metro

August 2010

1. INTRODUCTION TO THE DS

The literature on neighborhood characteristics that affect trip generation is constantly evolving and additional variables that affect travel behaviors are being investigated. The variables described below define key land use and development characteristics that can be tied to a particular geographic area and that have been shown (via analysis of travel surveys and other empirical research) to affect trip-making and mode choice. These are suitable to be addressed in a regional TDF model.

*Net Residential and Employment **D**ensity* – Density is defined as the amount of land use within a certain (measurable) area, or how intense the development is within a confined area. This variable is measured in dwelling units or employment per developed acre. A wide body of research suggests that, all else being equal, denser developments generate fewer vehicle-trips per dwelling unit than less dense developments. Change in density is measured according to the following formula:

Change in Density = *Percent Change in [(Population + Employment) per Square Mile]*

*Jobs/Housing **D**iversity* – Diversity is the land use mix within a particular area, whether it be a homogenous residential neighborhood or a mixed-use area with apartments perched atop ground-floor retail. Research suggests that having residences and jobs in close proximity will reduce the vehicle-trips generated by each, by allowing some trips to be made on foot or by bicycle. This variable measures how closely the neighborhood in question matches the "ideal" mix of jobs and households, which is assumed to be the ratio of jobs to households measured across the region as a whole. Change in diversity is measured using the following formula:

Change in Diversity *= Percent Change in {1-[ABS(b*population – employment)/(b*population+employment)]}*

Where: ABS = absolute value; b= regional employment/regional population

*Walkable **D**esign* – Design is an indicator for the accessibility for pedestrians and bicyclists to access a given area. 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 an equation is that there are many factors that influence the pedestrian experience and it is difficult to identify a single definition that captures them all. In any case, the walkable design variable, when isolated, usually has the weakest influence on the overall adjustment of the D variables; though it also seems to have important synergistic effects in conjunction with density and diversity. Change in design is measured as a percent change in design index.

Design Index *= 0.0195 * street network density + 1.18 * sidewalk completeness + 3.63 * route directness*

***D**estination Accessibility* – Accessibility is an indicator of a location's proximity to major destinations and access to those locations. Research shows that, all else being equal, households situated near the regional center of activity 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 a characteristic of most calibrated and validated TDF models. Changes in destination accessibility are measured follows:

Destinations (accessibility) *= Percent Change in Gravity Model denominator for study TAZs "I" : Sum[Attractions (j) * Travel Impedance(I,j)] for all regional TAZs "j"*

The most recent Draft RTP guidelines identify the inclusion of the Ds as a model post-processor to improve sensitivity to changes in travel behavior and emissions as a result of changes to land use in a model area. Furthermore, RTAC identifies the 4Ds as variables with empirical evidence to be included in target-setting for SB-375 best practices. Thus, it is important to identify sensitivity to the Ds and to apply enhancements to these variables, rather than other indicators of land use change.

2. ELASTICITY SYNTHESIS

D ELASTICITY VALUES

An “elasticity” is the percentage change in one variable that results from a percentage change in another variable. The D elasticities are defined to reflect the percentage change in vehicle trips or vehicle miles of travel given a percentage change in density, diversity, design, and regional destination location. A minus (-) in front of an elasticity number indicates a reduction in VT or VMT; otherwise, the elasticity identified increases with the increase of a D variable.

SOURCES OF D ELASTICITY VALUES

We consulted four sources to identify elasticity ranges used, as described below:

- Ewing, Reid (2009). Travel and the Built Environment – A Meta-Analysis.
- U.S. Environmental Protection Agency (2001). Index 4D Method.
- 2009 4D Analysis of SACOG Household Travel Survey 4D Analysis
- San Joaquin COG 4D Model Enhancements (2009). Prepared by Fehr & Peers.

Travel and the Built Environment

This report provides a meta-analysis of 4D elasticities used in over 50 planning studies. Studies included in the analysis were chosen because they had good sample sizes, controlled statistically for confounding influences on travel behavior, assessed statistical significance, and used disagreggated data (or data aggregated at a very local level) to analyze elasticity. The studies provided analysis on smart growth variables throughout the United States; some studies focused on a small selection of neighborhoods within a city, while others looked at changes in travel behavior within a larger region.

This synthesis provides elasticity ranges for each D variable based on a review of the published studies, which are provided in Table 1.

Index 4D Method

This document was prepared by Criterion Planners/Engineers and Fehr & Peers for the US EPA, and provides a national synthesis for 4D elasticities. Elasticities were derived for 27 studies published between 1991 and 1999 regarding smart growth and travel behavior, which covered local, regional, and national data. Elasticities were then synthesized for each D. The Index 4D provided elasticities for both vehicle trips (VT) and vehicle miles traveled (VMT). This information is provided in Table 2.

TABLE 1 ELASTICITIES FROM META-ANALYSIS OF PLANNING STUDIES		
D variable	**Number of Studies**	**VMT Elasticity Range**
Density	25	-0.12 - 0.25
Diversity	22	-0.11 - 0.05
Design	16	-0.29 - 0.00
Destination	22	-0.27 - 0.06
Note: Elasticities included are limited to studies included in meta-regression. Source: Ewing (2009), Fehr & Peers, 2009		

TABLE 2 ELASTICITIES FROM INDEX 4D		
D variable	**VT Elasticity**	**VMT Elasticity**
Density	-0.043	-0.035
Diversity	-0.051	-0.032
Design	-0.031	-0.039
Destination	-0.036	-0.204
Source: US EPA (2001), Fehr & Peers, 2009		

4D Analysis SACOG Household Travel Survey

In 2000-2002, Fehr & Peers and the Sacramento Council of Governments (SACOG) conducted preliminary research on the relationships between the built environment and travel survey data in the Sacramento region. In 2009, we enhanced this data with additional 4D survey information. Elasticities were derived from the travel survey information by trip purpose in addition to types of density, diversity, design, and destinations. A summary of VT and VMT elasticity ranges from this analysis are provided in Table 3.

San Joaquin COG 4D Model Enhancements

Fehr & Peers recently completed model enhancements to the San Joaquin Council of Governments' Travel Demand Forecasting Models to improve 4D sensitivity. For this project, we used data and equations from the Index 4D National Synthesis to derive vehicle trip elasticities for density, diversity, and design). It should also be noted that, for this model enhancement project, the model was not enhanced to modify the VMT elasticities – it was modified only to be sensitive to the VT elasticities. This information is provided in Table 4.

TABLE 3

ELASTICITIES FROM SACOG HOUSEHOLD TRAVEL SURVEY ANALYSIS

D variable	VT Elasticity Range	VMT Elasticity Range
Density	-0.339 - -0.117	-0.444 - -0.133
Diversity	-0.059 - -0.044	-0.459 - -0.160
Design	-0.032 - 0.000	-0.032 - 0.000
Destination	-0.0822 - -0.041	-1.405 - -1.234
Source: SACOG Household Travel Surveys (2000-2002), Fehr & Peers, 2009		

SYNTHESIS OF 4D ELASTICITIES

We summarized the elasticities from the four sources previously described to provide VT and VMT elasticity ranges that can be applied, shown in Table 5. As shown in this table, there are wide ranges in the elasticities derived between the four studies.

Additionally, we have found that 4D elasticities are not valid for extremely large changes in the 4D variables. For example if a zone is redeveloped from 1 unit per ten acres to one unit per acre, this is a nominal increase of 1000 percent, but one would not expect a 40% drop in vehicle trip generation implied by a -4% elasticity, since the area would still be fundamentally low density and auto-oriented. In view of this we, recommend "ceiling and floor" values be applied when calculating large changes in D variables; these values are identified in Table 6.

TABLE 4

ELASTICITIES FROM SJCOG 4D MODEL ENHANCEMENTS

D variable	VT Elasticity
Density	-0.04
Diversity	-0.06
Design	-0.02
Source: Fehr & Peers, 2009	

TABLE 5

SUMMARY OF ELASTICITY RANGES

D variable	VT Elasticity Range	VMT Elasticity Range
Density	-0.339 to -0.043	-0.444 to 0.25
Diversity	-0.059 to -0.044	-0.459 to 0.05
Design	-0.032 to 0.000	-0.29 to 0.00
Destination	-0.0822 to -0.020	-1.405 to 0.06
Source: Fehr & Peers, 2009		

TABLE 6

FLOOR AND CEILING VALUES FOR MAJOR CHANGES IN 4D VARIABLES		
D variable	**Minimum**	**Maximum**
Change for ANY variable	-80%	500%
Change in trip generation related to ANY single D variable	-30%	30%
Change in TAZ trip generation for ALL D variables	-25%	25%
Source: Fehr & Peers, 2009		

We would also note that when applying elasticity values, we used a regional average for TAZs whose D values are lower than the regional average. This is done so that a TAZ with little land use can still be sensitive to the Ds if it were to become dense or diverse compared to the regional average.

RECOMMENDED ELASTICITY VALUES

When selecting appropriate elasticity values, it is important to consider the locational context and existing travel behavior. Although changing land use according to smart growth principles affects travel behavior, there are other factors, such as job types and the regional built form that will also have an impact on how and where trips are made. While placing office buildings near residents can change the travel behavior for office workers, an agricultural employee's travel behavior would not change since the location of that job type is location-specific. Likewise, an existing urban center may show smaller changes in travel behavior with the implementation of the 4Ds since residents may already be using alternative transit modes. Therefore, it is important to be cognizant of the employment profile and select an elasticity value that would reflect foreseeable changes in travel behavior.