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KERN COG 4D MODEL ENHANCEMENT

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EXECUTIVE SUMMARY

This report documents the 4D model enhancements for the Kern COG Travel Demand Forecasting (TDF) model. The purpose of the model enhancement is to improve the model's sensitivity to the four Ds of Smart Growth: density, diversity, pedestrian design, and access to destinations. The 4D enhancement allows the model to be used to identify vehicle trips and VMT reductions between land use scenarios to calculate changes in VMT and GhG emissions as a result of implementing smart growth principles within the County.

KERN COG TDF MODEL

The Kern COG TDF model is a four-step model for Kern County with a 2006 base year and 2035 future year scenario. The model was built on a Cube/Voyager platform and includes trip generation, trip distribution, mode choice, and trip assignment steps. The model uses socioeconomic data as a factor in determining trip generation and trip distribution.

INTRODUCTION TO THE DS

The 4Ds represent Smart Growth principles that can affect travel behavior. The 4Ds are:

Net Residential and Employment Density – Denser developments generate fewer vehicle-trips than less dense developments.

Jobs/Housing Diversity – Having residences and jobs in close proximity will reduce the vehicle-trips generated by each, allowing some trips to be made using non-motorized transportation.

Walkable Design – Many pedestrian and bicycle improvement projects are based on the assumption that improving the walking and bicycling environment will result in more non-auto trips and a reduction in auto travel.

Destination Accessibility – Households situated near the regional center of activity generate fewer automobile trips and VMT than households located far from destination centers.

ELASTICITY SYNTHESIS AND RECOMMENDATIONS

We reviewed regional and national empirical research on the effects of smart growth development on travel behavior to develop elasticity values for the 4Ds. Elasticity values represent the observed changes in vehicle trips (VT) and vehicle miles traveled (VMT) as a result of changes to the built environment. Based on information from the 4D synthesis we selected elasticity values that would represent realistic changes in VT and VMT for the characteristics of Kern County.

INITIAL SENSITIVITY TESTS

We ran four sets of sensitivity tests to determine the unmodified model's sensitivity to changes to the Ds. We found that the model was not adequately sensitive to the Density and Diversity D, but was sensitive to changes in destination accessibility. The model configuration did not lend itself to testing for changes in design. We used the results of the sensitivity tests to determine that we needed to apply the elasticity values

to changes in density and diversity through model enhancements, but that we did not need to do so for model enhancements needed to be applied to changes in density and diversity, but that elasticity values did not need to be applied to changes in destination since the model already captured the associated trip reductions.

INTEGRATION OF 4D PROCESS INTO KERN COG TDF MODEL

We developed a script to identify zones with changes to the 4Ds and to apply appropriate elasticity values to the trip tables for these locations. This process has been added to the full model run script after the Mode Choice component and before the Trip Assignment component. The process reads in the existing trip tables by trip purpose for a base scenario (Business as Usual) and an alternative scenario (Better than Usual). After looking at both scenarios, changes in density and diversity are identified and elasticity values for the changes are applied to these TAZs. The resulting vehicle trips for that location are reduced, and this model step outputs an adjusted trip table which it then used in the Trip Assignment step.

POST-D SENSITIVITY TESTS

After integrating the 4D process into the model script, we ran the sensitivity tests again to determine whether the model was now sensitive to changes in density and diversity. With the process imbedded into the model script, the model is now sensitive to changes to the density and diversity Ds in addition to its existing sensitivity to regional destination. The only D that is not integrated into the model is change in design, since the model is not set up to account for changes in sidewalk coverage or other design Ds that can affect travel behavior.

COMPARISON OF ALTERNATIVES

With the 4D process integrated into the model, we compared the preferred land use alternative for Kern County to the RTP, which follows a "business as usual" buildout pattern. We assessed the Better than Usual changes for both the Spreadsheet allocation method and UPlan allocation method. The Better than Usual land use forecasts produce lower VMT than Business as Usual prior to D implementation; however, these forecasts still produce higher VMT per capita than the 2006 Base Year model. With D implementation there's an approximate 2% reduction in VMT per capita, which is realistic for Kern County provided the land use forecasts. Better than Usual VMT per capita with enhancements is still slightly above existing VMT per capita.

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1. KERN COG TRAVEL DEMAND FORECASTING MODEL

The Kern COG Travel Demand Forecasting (TDF) model for Kern County has evolved over time, with several updates. The most recent model was updated by Parsons Transportation Group using the Cube/Voyager software program. It is a four step model, consisting of trip generation, trip distribution, mode choice, and trip assignment components. The model is also socio-economic based, meaning that income plays a role in the trip generation and distribution components of the model.

The first step of the Kern COG model is trip generation. In this step, the zonal land uses are read into the model and trips associated with each land use are applied. The trip generation is stratified by income group for each TAZ. The output of this step is the number of trips for each land use, by TAZ.

In the trip distribution step the trips generated by each land use are distributed throughout the model area. Friction factors, which identify the likelihood of a trip based on travel time, are used in determining the locations of origin and destination. Trip tables are developed as an output of this step, which identify the origin and destination of trips by TAZ. In this step, walking and bicycling trips are also reduced from the model.

The mode choice component further separates the distribution patterns by different transportation modes. The mode choice component takes trip purpose into account in addition to distance to transit. Some trip purposes, such as home-based work, account for drive alone and shared-ride trips in addition to walking trips to transit stops and driving trips to transit stops. Other trip purposes, including non-home-based trips solely identify transit and automobile trips. The resulting outputs are an updated set of trip matrices by trip purpose that are separated by transportation modes.

The final model step is trip assignment. The trip tables from the mode choice are read into the model and then the trips are assigned to the roadway network. The trip tables themselves are limited to having the origin TAZ and destination TAZ. The assignment step is therefore used to determine routing, based on factors such as speed, congestion, and distance. Once this is completed, the number of trips for each roadway link is calculated.

The model structure has been developed to generate and assign trips based on socioeconomic factors and land use types. As identified in the Kern COG Model Development Report (Parsons, August 2009 (Page 28)), "According to the state-of-practice, it has been assumed that the factors which determine trip production rates are mainly the size and income of each household." Based on this, it is assumed that the model's trip estimating was developed based on size and income of each household and has not been developed to be sensitive to the Ds of smart growth such that the model would intentionally behave differently should an area's density or diversity change.

Thus, sensitivity tests were undertaken to identify whether the model did behave inherently different to the Ds, and if this were not the case, then it would be necessary to enhance the model to do so. The remainder of this report summarizes the Ds, identifies how the Ds would affect the anticipated results, compares the current model to anticipated results, and identifies how to enhance the model to account for the Ds.

2. 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 Density – 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:

$$\text{Change in Density} = \text{Percent Change in } [(Population + Employment) \text{ per Square Mile}]$$

Jobs/Housing Diversity – 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:

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

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

Walkable Design – 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.

$$\text{Design Index} = 0.0195 * \text{street network density} + 1.18 * \text{sidewalk completeness} + 3.63 * \text{route directness}$$

Destination 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.

3. 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 disaggregated 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		

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	

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 to the Kern COG 4D Model Enhancements, 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 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 Kern County's employment profile – in which many employees work in location-specific natural resource industries – and select an elasticity value that would reflect foreseeable changes in travel behavior.

San Joaquin COG's elasticity values were recommended for use in the 4D model enhancement, since the urban form and travel characteristics in this area are most representative of those in Kern County. Like Kern County, San Joaquin COG is located in California's Central Valley, with substantial employment in agricultural and natural resources industries. The San Joaquin COG elasticity values were refined values from the Index 4D study, which provided extensive empirical research. In addition to confidence in the accuracy of the elasticity values for inclusion in the Kern COG 4D enhancements, we also believe that it is beneficial to be consistent with other Central Valley MPOs.

4. INITIAL SENSITIVITY TESTS

Before applying elasticity values to the model, we conducted sensitivity tests to determine whether the model was already sensitive to 4D changes. Our initial review of the model documentation and structure did not indicate any built-in sensitivity to the Ds, so the sensitivity tests were applied to confirm that the model was not already sensitive to the smart growth principles.

The model is structured such that tests could be conducted for determining the model's sensitivity to density, diversity, and destination. However, since the model does not include pedestrian design factors, such as sidewalk completeness, it was not possible to conduct a design test. We conducted four sensitivity tests to test the three aforementioned "Ds": infill diversity, diversity in a select area, balanced land use (diversity), and change in regional destination. For the select diversity and balanced land use tests, we conducted multiple versions of the test to provide additional confidence that the tests were representative of the model as a whole and not an outlier.

MODEL TEST #1: UNIFORM CHANGES IN DENSITY IN ALL TAZS

This test was conducted to evaluate the model's sensitivity to **density**. This variable is measured in dwelling units or employment per 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.

For this particular test, uniform changes in density were applied throughout the model. This would create an "infill" scenario for Kern County, whereby the land use in each TAZ is increased by the same percentage. We increased each land use category by 10%, so as not to disrupt the existing balance of land uses.

To conduct this test, we modified the following inputs in the land use (KE35socio.dbf) file by increasing them by 10%:

- Households (column 3)
- Household Population (column 5)
- Group Quarters (column 6)
- Basic Employment (columns 7, 11)
- Retail Employment (columns 8-10)
- Other Employment (column 12)
- School Enrolment (columns 13-15)

Table 7 identifies the land use changes to the base model and test model, in addition to changes to the model's vehicle trip and VMT outputs.

As shown in this table, a 10% increase in overall density resulted in a similar increase in vehicle trips. While VMT increased on a model-wide level, the proportional increase was less than that of vehicle trips. The increase in density reduced average trip length by 2.7%, indicating that the model is slightly sensitive to changes in density. The increase in density also reduced vehicle trips per capita by 0.4% and VMT per capita by 3.1%.

**TABLE 7
TEST #1: UNIFORM DENSITY INCREASE**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7,11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	417,192	1,264,081	56,907	257,143	176,039	27,417	361,968
Test 1 Model	458,947	1,390,516	62,616	282,844	193,684	30,155	398,179
Change (Test 1 Minus Base)	41,755	126,435	5,709	25,701	17,645	2,738	36,211
TRAVEL OUTPUTS							
	Base Model	Test 1 Model	Change (Test 1 Minus Base)				
VT	5,899,842	6,459,859	+560,017 (+9.5%)				
VMT	39,173,435	41,760,465	+2,587,030 (+6.6%)				
VMT / VT (Average Trip Length)	6.64	6.46	-0.18 (-2.7%)				
VT/capita	4.67	4.65	-0.02 (-0.4%)				
VMT/capita	30.99	30.03	-0.96 (-3.1%)				

Source: Fehr & Peers, 2009

MODEL TEST #2: CHANGES IN DENSITY IN SELECTED TAZS

This test was conducted to measure the model's sensitivity to specific changes in development density. This was done by changing land uses within one specific area, rather than throughout the entire model.

We ran three versions of this test. In the first sensitivity test, we selected three adjacent TAZs in East Bakersfield (372, 793, 1329). For the second test we selected a TAZ near California State University,

Bakersfield (65). For our final test we selected a TAZ near the Nottingham Estates area of Bakersfield (1423). The selected TAZs were mostly residential in nature. We wanted to maintain the land use diversity mix, so all density changes were proportional to each land use.

We modified the following inputs in the land use (KE35socio.dbf) file by increasing them by 300%:

- Households (column 3)
- Household Population (column 5)
- Group Quarters (column 6)
- Basic Employment (columns 7, 11)
- Retail Employment (columns 8-10)
- Other Employment (column 12)
- School Enrolment (columns 13-15)

After completing a model run for both the unmodified and modified versions of the 2035 model, we ran a select link assignment script (FINAL_ASSIGNMENT_SELECT_ZONE.S) to calculate vehicle trips and VMT coming from and going to the test TAZs.

Tables 8-10 identify land use changes and results of this test. As shown in these tables, the model shows minor sensitivity to changes in density of a specific TAZ. However, the directionality of the change is not always consistent with smart growth principles. In one TAZ, the model's per capita VT reduces slightly while in another it increases slightly. Overall, we do not believe that the model shows adequate sensitivity to a change in select density.

TABLE 8
TEST #2A: DENSITY INCREASE IN SELECT ZONES (372, 793, 1329)

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	1,110	3,945	0	206	213	1	1,051
Test 2 Model	3,330	11,835	0	618	639	3	3,153
Change (Test 2 Minus Base)	2,220	7,890	0	412	426	2	2,102
TRAVEL OUTPUTS							
	Base Model		Test 2 Model		Change (Test 2 Minus Base)		
VT	10,945		33,392		+22,347 (+200%)		
VMT	93,042		288,019		+194,977 (+210%)		
VMT / VT (Average Trip Length)	8.5		8.7		+0.2 (+2.3%)		
VT/Capita	2.77		2.82		+0.05 (+2%)		
VMT/Capita	23.6		24.3		+0.7 (+3%)		
Source: Fehr & Peers, 2009							

**TABLE 9
TEST #2B: DENSITY INCREASE IN SELECT ZONES (65)**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	1,208	2,166	0	31	0	5	0
Test 2 Model	3,624	6,498	0	93	0	15	0
Change (Test 2 Minus Base)	2,412	4,332	0	62	0	10	0
TRAVEL OUTPUTS							
	Base Model		Test 2 Model		Change (Test 2 Minus Base)		
VT	7,373		21,941		14,568 (+198%)		
VMT	56,932		172,586		115,654 (+203%)		
VMT / VT (Average Trip Length)	7.72		7.87		0.15 (+1.9%)		
VT/Capita	3.40		3.38		-0.02 (-0.6%)		
VMT/Capita	26.28		26.56		+0.28 (+1.0%)		
Source: Fehr & Peers, 2009							

**TABLE 10
TEST #2C: DENSITY INCREASE IN SELECT ZONES (1453)**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	562	1,112	0	0	0	0	0
Test 2 Model	1,686	3,336	0	0	0	0	0
Change (Test 2 Minus Base)	1,124	2,224	0	0	0	0	0
TRAVEL OUTPUTS							
	Base Model		Test 2 Model		Change (Test 2 Minus Base)		
VT	3,403		10,356		6,953 (+204%)		
VMT	31,565		98,331		66,766 (+212%)		
VMT / VT (Average Trip Length)	9.28		9.50		0.22 (+2%)		
VT/Capita	3.06		3.10		+0.04 (+1%)		
VMT/Capita	28.39		29.48		+1.09 (+3.8%)		

Source: Fehr & Peers, 2009

MODEL TEST #3 – OPTIMIZING LAND USE MIX (DIVERSITY) OF A SINGLE TAZ

Model Test 3 is a test for **diversity**. 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.

To verify that the model was not already sensitive to the change in diversity, since documentation did not identify any inherent sensitivity, we developed a test to measure changes in vehicle trips by balancing land use to an optimal mix of employment and residential land uses. A change in the ratio of internal trips to external trips would indicate that the model is sensitive to changes in diversity. If an area is mixed-use in nature, a sensitive model would internalize a greater percentage of trips compared to an area that has only one type of land use. This is because in a mixed-use area, a resident could potentially work and shop within his immediate vicinity while in a homogenous area the resident would need to travel outside of the TAZ to work or shop.

We conducted this test in three locations: TAZ 268, located in Oildale, and TAZs 3 and 1006, located in Rosedale. These TAZs were selected because their 2035 land uses were entirely residential. We then looked at the model-wide jobs:housing ratio (1.05) and the basic:non-basic job ratio (1:3). We modified the land uses in this TAZ so that the jobs:housing ratio matched the model as a whole.

To determine changes in trip types, we used the assignment trip matrices to determine how many trips both originated and terminated in the test TAZ, and how many vehicle trips left the TAZ. Tables 11-13 identify land use changes and results.

As indicated in Tables 11-13, the model shows sensitivity to changes in diversity. Although few trips are internalized with the inclusion of balanced land uses, the ratio of internal-to-external trips increased as diversity improved. The model is gravity-based and was developed such that it would model actual traffic patterns in the area, and it would be unrealistic to assume that everyone living next door to an office park or factory would work at that location. Thus, internal trip rates generally reflect only a small portion of all trips. However, despite the model's sensitivity to diversity changes, the percentage of internal trips with balanced land use is still lower than would be expected based on empirical research.

**TABLE 11
TEST #3A: BALANCING LAND USE IN A SINGLE ZONE (268)**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	484	1,218	0	0	0	0	0
Test 3 Model	484	1,218	0	138	169	203	0
Change (Test 2 Minus Base)	0	0	0	+138	+169	+203	0
TRAVEL OUTPUTS							
	Base Model		Test 3 Model		Change (Test 3 Minus Base)		
Internal Trips	0.41		9.17		+8.76 (+2,137%)		
External Trips	2,740		6,897		+4,107 (+149%)		
Internal Trips as Percent of Total Trips	0.00%		0.13%				

Source: Fehr & Peers, 2009

**TABLE 12
TEST #3B: BALANCING LAND USE IN A SINGLE ZONE (TAZ 3)**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	164	873	0	0	0	0	0
Test 3 Model	164	873	0	178	121	19	0
Change (Test 2 Minus Base)	0	0	0	+178	+121	+19	0
TRAVEL OUTPUTS							
	Base Model		Test 3 Model		Change (Test 3 Minus Base)		
Internal Trips	1		5		+4 (+400%)		
External Trips	1,594		3,504		+1910 (+120%)		
Internal Trips as Percent of Total Trips	0%		0.1%		N/A		

Source: Fehr & Peers, 2009

**TABLE 13
TEST #3C: BALANCING LAND USE IN A SINGLE ZONE (TAZ 1006)**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	173	556	0	0	0	0	0
Test 3 Model	173	556	0	113	77	12	0
Change (Test 2 Minus Base)	0	0	0	+113	+77	+12	0
TRAVEL OUTPUTS							
	Base Model		Test 3 Model		Change (Test 3 Minus Base)		
Internal Trips	1		2		+1 (+100%)		
External Trips	1,442		2,790		+1,348 (+93%)		
Internal Trips as Percent of Total Trips	0.07%		0.07%				

Source: Fehr & Peers, 2009

MODEL TEST #4 – ACCESS REGIONAL DESTINATIONS

The final test that we conducted was for the sensitivity to access to regional **destinations**. 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.

Although model documentation did not identify any built-in sensitivity to this D, most calibrated models are sensitive to changes in destination accessibility, shown through dynamic validation testing. To verify this, we developed a test to measure changes in VMT and average trip lengths for a new TAZ. The TAZ would have a static set of land uses, but the location would differ between the activity center for Kern County (e.g. downtown Bakersfield) and outer areas of the model. We identified two locations within Bakersfield at which

to conduct the test; we maintained the model district (1) for both tests to ensure that changes in VMT or trip lengths were not attributable to a change in how the model handles internal districts.

We added TAZ 1950 and ran two iterations of the model. In the first run, TAZ 1950 was located in downtown Bakersfield, near South H Street and 21st Street. In addition to being located downtown, this location was near a transit hub. For the second run, TAZ 1950 was located in southern Bakersfield, near Union Avenue and Taft Highway. This location is further from the urban core but is still proximate to two transit lines. Thus, we were able to stabilize reductions due to transit access and instead focus on sensitivity to regional destinations with regard to land use.

After running the model, we ran the Select Zone assignment script to calculate VT and VMT specifically for TAZ 1950. This allowed us to extract the VT and VMT for trips traveling to or from TAZ 1950. Table 4 identifies the results of this test.

As shown in Table 14, the model is very sensitive to access to regional destinations. With identical land use, the downtown location produced fewer vehicle trips, likely a result of better access to public transit and walking. More strikingly, the VMT for the downtown TAZ was less than half of the VMT for the outskirts location. With better access to transit in addition to more destinations in the downtown area, residents of a city center are less likely to have to travel long distances to various attractions – such as work or shopping – whereas a resident of a suburb may work and shop in the city center, thus increasing VMT.

SUMMARY OF SENSITIVITY TESTS

Our results of the sensitivity tests are as follows:

- The model shows some sensitivity to overall increases in density. The vehicle trip increases were proportionate to increases in land use, but the VMT increased at a lower rate than VT. As a result, the average trip length was reduced by 2.7%.
- The model shows some sensitivity to changes in density in selected TAZs, however, the directionality of the sensitivity is different than what would be expected, since VMT and average trip length increased with density to these three TAZs. The model is also not significantly sensitive to the effect of local density on trip generation.
- The model's sensitivity should be enhanced, as per RTP and RTAC guidelines, through a model post-processor that accounts for changes in the Ds.

**TABLE 14
TEST #4: REGIONAL DESTINATION**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Land Use Inputs	1,000	3,030	0	0	0	0	0
TRAVEL OUTPUTS							
	Outskirts		Downtown		Change (Downtown minus Outskirts)		
VT	7,178		6,888		-290 (-4.0%)		
VMT	76,217		44,964		-31,252 (-41%)		
VHT	2083.9		1,387.9		-696 (-33%)		
VMT / VT (Average Trip Length)	10.62		6.53		-4.09 (-38.5%)		
VHT/VT (Average Travel Time in Hours)	0.29		0.20		-0.09 (-31.0%)		

Source: Fehr & Peers, 2009

- The model is sensitive to changes in diversity; with balanced land use, internal trips account for a much greater proportion of total trips. However, the percentage of internal trips within a TAZ with balanced land uses is still substantially lower than would be expected.
- The model is sensitive to destination accessibility. Although a TAZ in the downtown core has a similar number of vehicle trips compared to an identical TAZ in the city's outskirts, the average trip length is substantially lower for the downtown trips.

5. MODEL INTEGRATION

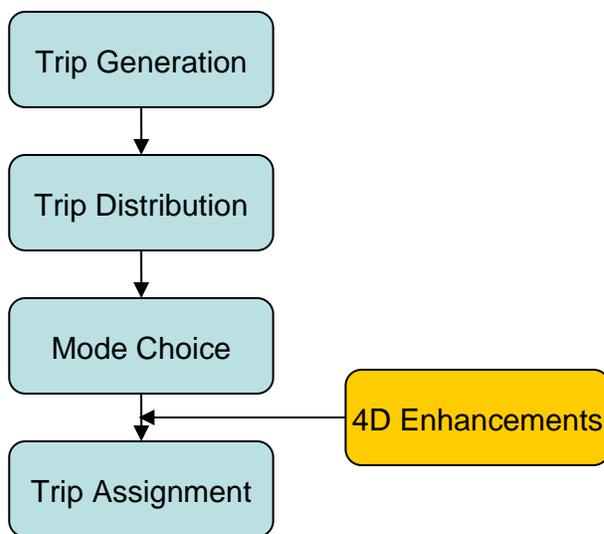
The sensitivity tests that were completed for the Kern COG model indicated that the model was not adequately sensitive to changes in density and diversity, but showed appropriate levels of sensitivity to changes in destination accessibility. As a result, the model enhancement effort focused on improving the model's sensitivity to changes in density and diversity.

A user guide and a more detailed step-by-step walk through of the model script is included in Technical Appendix A.

STRUCTURE OF MODEL ENHANCEMENTS

The 4D enhancement process was developed as a script that runs inline with the full Kern COG model. The script was first tested as a stand-alone script and then integrated into the full model script. The 4D process occurs after the Mode Choice step and before Trip Assignment, as shown on Figure 1, below.

Figure 1 – Model Steps



At this stage in the model process, trip tables have been created by trip purpose (Home-Based Work, School, etc.) and have been separated by mode choice. Walk and bicycle trips have been removed from the trip tables, and there are separate tables for transit trips and automobile trips. The trip tables are separated into number of person trips. Each trip table has an origin TAZ and a destination TAZ; the trip routing is determined in the trip assignment step.

As previously noted, the model elasticity values being used for the enhancements are consistent with the San Joaquin COG Model Enhancement elasticity values. The elasticity values and whether they are included in the enhancement efforts are identified in Table 15.

TABLE 15		
4D ELASTICITIES		
D Variable	Selected Elasticity (VT)	Embedded in Script?
Density	-0.04	Yes
Diversity	-0.06	Yes
Design	-0.02	No – will be applied off-model
Destination	-0.04	No – model already sensitive
Source: Fehr & Peers, 2009.		

INPUTS FOR 4D MODEL ENHANCEMENT

Most of the inputs needed to complete the 4D model enhancement were already developed for the Kern COG model. These include:

- Trip Table Matrices – outputs from the Mode Choice step
 - ?HBWMC.MAT – home-based work trip tables
 - ?NW2.MAT - non home-based work trip tables
 - ?SCHL2.MAT – school trips
- Land Use Files
 - ?socio.dbf – land use file used in trip generation

Within the unmodified model, the ?socio.dbf file is placed in a separate directory for the trip generation step. For the 4D enhancement, the land use files for both the test case (the full model run) and the base case (RTP) are being compared. Therefore, it is necessary to create a separate directory for each file, which will be referenced in the script.

In addition to these files, two new files are created for the 4D process. These are zonal files which identify the existing developed acreage and roadway network by TAZ. They are listed as TAZData_BASE.dbf and TAZData_TEST.dbf. This data was compiled using the UPlan outputs for each scenario on acreage by TAZ and by dissolving the GIS roadway centerline files by TAZ. If the developed acreage or roadway networks change, these files will need to be updated accordingly.

OUTPUTS FOR 4D MODEL ENHANCEMENT

The 4D process has five major outputs. Two are merely intermediary checks for quality assurance. These are labeled _ALT_Ds.dbf and _VT_ADJ.DBF. The former file identifies the D adjustments for each TAZ, while the latter file identifies the vehicle trip reductions by TAZ.

The other three files are modified versions of the trip table input matrices. These share the same names as the input files but with an _ADJ.MAT suffix. These files are:

- ?HBWMC_ADJ.MAT – home-based work trip tables
- ?NW2_ADJ.MAT - non home-based work trip tables

- ?SCHL2_ADJ.MAT – school trips

We have updated the model script for the Trip Assignment step so that the input files read into this step are the adjusted trip tables rather than the trip table outputs from the Mode Choice step.

MODEL ENHANCEMENT PROCESS

The model enhancement process takes place in three major parts. A step-by-step guide to the model enhancements is included in the technical appendix.

PART A – Defining Inputs, Calculating Ds, and Calculating Trip Adjustments

Before any calculations are made in the model, the user specifies the parameters for the 4D enhancement by identifying the number of TAZs and the names of the test and base scenarios. This portion of the script has been set for Kern COG in evaluating the Preferred Alternative Scenario compared to the RTP, but can be adjusted to test various scenarios. In this section of the model, we also define the input and output files for the 4D enhancements.

In this portion of the enhancement process, we also provide regional averages for the Ds. As noted in our discussion of elasticity values, we want to ensure that areas that have land use changes but whose Ds were below the regional average do not receive additional trip reductions. For instance, if an agricultural TAZ had one home and a second home was built on the TAZ, we would not anticipate a change in travel behavior, since the area is still not dense. However, without a control for regional averages, an additional house in the TAZ would indicate a 100% increase in density and would consequently apply the density elasticity value.

The regional averages were calculated using data from UPlan on developed acreage and the Kern County land use files. The averages were all calculated off-model and were hard-coded into this process. They can be changed by the user.

After defining the regional averages, the Ds are calculated for each TAZ using the model land use file and the zonal data file. The Ds are calculated for both the base and test scenarios and the change between the test and base scenarios is documented. The resulting Ds are then compared to the regional average. TAZs with a change in the Ds in which the Ds are also above the regional average will receive a reduction in vehicle trips according to the elasticity values.

After calculating the change for each D by TAZ, the change to the vehicle trips are calculated. This is done by multiplying the change for each D by that D's elasticity value. These calculations are conditional; when floor or ceiling values are met, then the appropriate value is assigned. These calculations are made by each trip purpose.

Part B – Applying Trip Adjustments to Trip Tables

After Part A, we have identified the vehicle trip adjustment factors for each TAZ by trip purpose. In Part B, the adjustments are applied to the trip tables that were created in the Mode Choice step of the full model run.

The trip tables from the mode choice step and the D adjustment factors from Part A are read into the process. Overall floor and ceiling values are also defined at this time to ensure that the cumulative adjustment remains realistic with implementation of the Ds.

The trip table matrices are defined in Table 16.

TABLE 16			
MATRIX TRIP TABLES			
Table Number	?NW2.MAT	?HBWMC.MAT	?SCHL2.MAT
1	Home-Based Shop Auto	Drive Alone	Elementary School Auto
2	Home-Based Other Auto	2 Passenger Carpool	High School Auto
3	Non-Home-Based Work Auto	3 Passenger Carpool	College Drive Alone
4	Non-Home-Based Other Auto	4+ Passenger Carpool	College 2 Passenger Carpool
5	Walk to Transit	Walk to Transit (local)	College 3 Passenger Carpool
6	Drive to Transit	Walk to Transit (premium)	College 4+ Passenger Carpool
7		Drive to Transit (informal)	El-Hi Walk to Transit
8		Drive to Transit (formal)	El-Hi Drive to Transit
9			College Walk to Transit (local)
10			College Walk to Transit (premium)
11			College Drive to Transit (informal)
12			College Drive to Transit (formal)
Note: bold denotes trip adjustments applied			
Source: Fehr & Peers, 2009			

In applying the vehicle trip adjustments, first the change in vehicle trips is calculated by multiplying the adjustment factor by the unadjusted trips using the following formula:

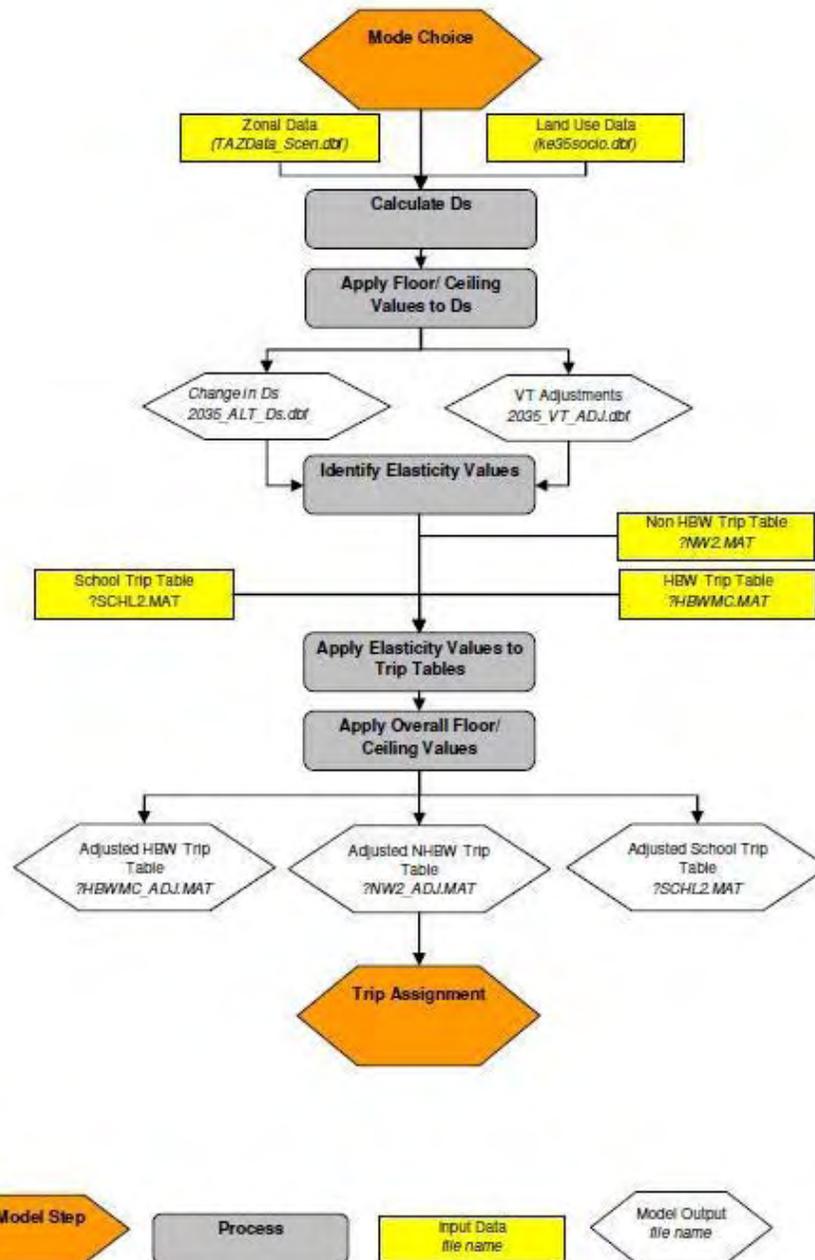
$$\text{Change in Trips} = \text{Unadjusted Trips} \times (\text{Adjustment Factor} - 1)$$

If there is a trip reduction, the change in trips will be a negative. This value is then added to the unadjusted trip value to calculate the number of vehicle trips after D implementation. The product of this step is a set of working matrices that have adjusted trip values for automobile-based trips.

Overall floor and ceiling values are then applied to ensure that the change in overall vehicle trips is reasonable within the context of smart growth principles and research. Earlier in the enhancement process, we defined floor and ceiling values for a single D. But we also want to apply a floor and ceiling value to the overall change. For instance, if a TAZ changes greatly by becoming both very dense and very diverse, we don't want trip reductions to be reduced to an unrealistic level by compounding the adjustments from both Ds. We therefore calculate the adjusted trip volumes relative to the floor and ceiling values. In cases that the adjustments exceed the ceiling value or are below the floor value, the appropriate factor is applied. When the floor or ceiling values are not met, then the initial adjusted trip value is maintained.

The accompanying flow chart (Figure 2) identifies the 4D model enhancement process.

Figure 2 – Enhancement Process



6. POST-D SENSITIVITY TESTS

After implementing the 4D model enhancements, we conducted the same sensitivity tests completed pre-enhancement to test the model's sensitivity to changes in the Ds.

MODEL TEST #1: UNIFORM CHANGES IN DENSITY IN ALL TAZS

The first model test evaluated the model's sensitivity to density by increasing the land use in each category by 10%. Because the model applies floor and ceiling values to areas that have density values below the regional average, we did not anticipate that this sensitivity test would result in a full elasticity reduction.

After running test 1 with the 4D enhancements, we saw the reductions documented in Table 17. As shown in this table, the reduction in vehicle trips with 4D enhancements is closer to reflecting the recommended elasticity reduction of 4%. The reason why this reduction is not completely accounted for, as previously described, is that with uniform density increase, TAZs with densities below the regional average will not receive full 4D adjustments.

With the 4D enhancement, the model is appropriately sensitive to this D variable.

MODEL TEST #2: CHANGES IN DENSITY IN SELECTED TAZS

The second test identified the model's sensitivity to specific changes in density. We identified three TAZs located adjacent to one another and tripled the land use within each TAZ. In the initial sensitivity test, we found that the model was not sensitive to land use changes for a specific TAZ.

The results of Test 2 after applying the 4D enhancements are provided in Table 18-20.

As shown in these tables, the model shows a substantial change to increase in density of select TAZs. In our initial test, the VT per capita *increased* with the addition of density. We adjusted the Ds so that the model's sensitivity to the 4Ds is now in line with the recommended elasticities.

**TABLE 17
TEST #1: UNIFORM DENSITY INCREASE**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7,11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	417,192	1,264,081	56,907	257,143	176,039	27,417	361,968
Test 1 Model	458,947	1,390,516	62,616	282,844	193,684	30,155	398,179
Change (Test 1 Minus Base)	41,755	126,435	5,709	25,701	17,645	2,738	36,211
TRAVEL OUTPUTS							
	Base Model		Test 1 Model		Change (Test 1 Minus Base)		
VT	5,899,842		6,333,526		+433,684 (+7.4%)		
VMT	39,173,435		41,759,746		+2,586,311 (+6.6%)		
VMT / VT (Average Trip Length)	6.64		6.59		-0.05 (-0.7%)		
VT/capita (Elasticity)	4.67		4.55		-0.12 (-2.6%)		
VMT/capita (Elasticity)	30.99		30.03		-0.96 (-3.1%)		
Source: Fehr & Peers, 2009							

TABLE 18
TEST #2A: DENSITY INCREASE IN SELECT ZONES (372, 793, 1329)

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	1,110	3,945	0	206	213	1	1,051
Test 2 Model	3,330	11,835	0	618	639	3	3,153
Change (Test 2 Minus Base)	2,220	7,890	0	412	426	2	2,102
TRAVEL OUTPUTS							
	Base Model	Test 2 Model	Change (Test 2 Minus Base)				
VT	10,945	32,347	+21,402 (+196%)				
VMT	93,042	279,219	+186,177 (+200%)				
VMT / VT (Average Trip Length)	8.5	8.6	+0.1 (+1.2%)				
VT/Capita (Elasticity)	2.77	2.73	-0.04 (-1.4%)				
VMT/Capita (Elasticity)	23.58	23.59	+0.01 (+0.00%)				
Source: Fehr & Peers, 2009							

**TABLE 19
TEST #2B: DENSITY INCREASE IN SELECT ZONES (65)**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	1,208	2,166	0	31	0	5	0
Test 2 Model	3,624	6,498	0	93	0	15	0
Change (Test 2 Minus Base)	2,412	4,332	0	62	0	10	0
TRAVEL OUTPUTS							
	Base Model		Test 2 Model		Change (Test 2 Minus Base)		
VT	7,373		21,151		13,778 (+187%)		
VMT	56,932		167,072		110,140 (+193%)		
VMT / VT (Average Trip Length)	7.72		7.89		0.17 (+2%)		
VT/Capita (Elasticity)	3.40		3.25		-0.15 (-0.04%)		
VMT/DU (Elasticity)	26.28		25.71		-0.57 (-0.02%)		
Source: Fehr & Peers, 2009							

**TABLE 20
TEST #2C: DENSITY INCREASE IN SELECT ZONES (1453)**

LAND USE INPUTS							
	Households (3)	Household Population (5)	Group Quarters (6)	Basic Employment (7, 11)	Retail Employment (8-10)	Other Employment (12)	School Enrollment (13-15)
Base Model	562	1,112	0	0	0	0	0
Test 2 Model	1,686	3,336	0	0	0	0	0
Change (Test 2 Minus Base)	1,124	2,224	0	0	0	0	0
TRAVEL OUTPUTS							
	Base Model	Test 2 Model	Change (Test 2 Minus Base)				
VT	3,403	9,881	6,478 (+190%)				
VMT	31,565	93,568	62,003 (+196%)				
VMT / VT (Average Trip Length)	9.28	9.47	0.19 (+2%)				
VT/Capita (Elasticity)	3.06	2.96	-0.10 (-3%)				
VMT/Capita (Elasticity)	28.39	28.05	-0.34 (-1%)				

Source: Fehr & Peers, 2009

MODEL TEST #3 – OPTIMIZING LAND USE MIX (DIVERSITY) OF A SINGLE TAZ

Our third test evaluated the sensitivity of the model for diversity, by balancing land use within a single TAZ. In our initial test we found that the model showed sensitivity to this D; however, the internal trip capture was less than what research would suggest.

The model enhancements that we provided reduced vehicle trips for this D according to recommended elasticities. This means that the total trips assigned to the network were reduced in line with empirical research. The enhancements do not reassign the internal-external trips to internal, but rather reduce the overall trips. This is based on the assumption that the vehicle trips reduced would instead be non-auto trips that remain within the zone.

Tables 21 identifies the change in vehicle trips related to the change in diversity before and after D enhancements to the model.

TABLE 21 CHANGE IN DIVERSITY VEHICLE TRIPS AFTER D MODEL ENHANCEMENT						
TAZ	Population	Pre-enhancement		Post-enhancement		Change in VT/capita
		VT	VT/Capita	VT	VT/Capita	
3	873	3,504	4.01	3,438	9.94	-0.07 (-1.7%)
268	1,218	6,897	5.66	6,776	5.56	-0.1 (-1.7%)
1006	556	2,790	5.02	2,634	4.74	-0.28 (-5.6%)

Source: Fehr & Peers, 2009

7. ADDITIONAL ENHANCEMENTS MADE TO MODEL

In addition to enhancements developed to improve the model's sensitivity to the 4Ds, we developed two model scripts to improve VMT reporting into EMFAC for SB375 target setting.

VMT IXXI SCRIPT

We developed a VMT script to identify VMT by speed bin for internal-internal (I-I), internal-external (I-X and X-I), external-external (X-X) and RTAC approved land uses. Additionally, the script applied a VMT adjustment according to RTAC recommendations and can be used in SB-375 target setting. RTAC had identified that the COG is not responsible for reductions of half of I-X and X-I trips, all through trips (X-X) and half of military and tribal land use trips.

The VMT script runs separately from the full model script, after the model run is complete. It uses a pre-assignment network and trip assignment matrices to reassign trips to the roadway network by type. After this, the script applies a 50% reduction to I-X, X-I and military land use VMT, and a 100% reduction to X-X trips. The VMT is further disaggregated by speed bin for import into EMFAC. There are two text files that are output from this model – the first identifies the daily VMT by speed bin for each trip purpose and the second identifies the VMT by time of day for each speed bin with SB-375 reductions.

VMT INTRA-ZONAL SCRIPT

We also modified the intrazonal VMT script that Kern COG has developed to extract intrazonal VMT by speed bin. The IXXI script excludes intrazonal trips from its VMT calculations. This script pulls this VMT prior to trip assignment and makes assumptions about the speed and distance of intrazonal scripts. We modified the script to pull VMT after the IXXI script was run, but the results are identical to the original VMT script.

8. FUTURE ENHANCEMENTS FOR MODEL APPLICATION

In conducting the model sensitivity tests and applying enhancements to the Kern COG model, we identified improvements that can be made to the Kern COG model in the future. The following enhancements would be beneficial to Kern COG and could be implemented with additional Proposition 84 funding.

TRIP MATRIX CONSISTENCY

The model's trip tables from the mode choice component have different outputs depending on trip type. For example, home-based work trips have six possible mode choice types, while non-home based trips have four. Non-home based trips are also aggregated for some modes (transit) and disaggregated for others (vehicle). For some purposes, the number of passengers in a vehicle is specified while for others it is not. The inconsistency between mode choice outputs for each trip purpose is the result of this element being updated in pieces, as documented in the model script.

We would recommend that the mode choice component be enhanced in future updates for mode consistency. Each trip purpose would have its own set of trip tables, with the same mode choices available – drive alone, carpool (one or more categories), transit-walk and transit-drive.

REASSIGNMENT OF TRIPS AFTER D REDUCTIONS

The 4D sensitivity enhancements reduce vehicle trips from the model, which is appropriate for SB-375 target setting parameters. However, it is likely that the trips themselves do not entirely disappear, but instead are converted to walk, bike, or transit trips. With additional effort, the 4D post-processor could be further enhanced to remove vehicle trips from the network and reassign them to alternative mode trips based on observed mode share. However, the trip matrix consistency component described above would have to occur first for this feedback to occur appropriately.

BETTER LAND USE INTEGRATION

Our work on this project has indicated that, if possible, a better integrated land use-transportation model could be implemented to assist in the identification of the 4D variables. For this project, we utilized UPlan to obtain the developed acreage information; however, as evidenced by the continued use of Kern COG's spreadsheet methodology, the UPlan component could use further refinements for Kern COG land use planning efforts. With better integration, the model could be set up to self adjust the D factors without external calculations being implemented.

9. COMPARISON OF ALTERNATIVES

ANALYSIS SCENARIOS

We received land use data from Kern COG for the Business as Usual (BAU) alternative and two Better than Usual (BTU) alternatives. Kern COG allocated land use by TAZ for the Better than Usual alternative using two different methods. The first method used is the Spreadsheet Method, which has been frequently used by COG staff for forecasting growth. The second method uses UPlan, which includes land use allocation through spatial analysis. We therefore had two different BTU alternatives that were compared to the BAU alternative.

Because UPlan allocation is completed spatially, it is possible to identify developed acreage from reallocation of land use. We used the spatial output files from the BTU-UPlan scenario to identify new developed acreage and added this to existing developed acreage. We did the same for the BAU scenario. Developed acreage is a necessary component for the 4D enhancements, as density reductions are contingent on increase in land use per developed acre. To assess the BTU-Spreadsheet method, we completed one model run in which we did not make density reductions, since the Spreadsheet method does not produce its own developed acreage outputs. For the second model run we completed to assess this method we assumed that the developed acreage for the BTU-Spreadsheet alternative would resemble that of the BTU-UPlan alternative and used UPlan outputs for comparing developed acreage from BTU to BAU.

We therefore completed the following model runs:

- 2006 (Base Year) Without D Enhancement – Identifies existing VMT in the model area.
- 2035 BAU Scenario Without D Enhancement – Identifies baseline future VMT in the model area.
- 2035 BTU UPlan Scenario Without D Enhancement – Identifies VMT produced by UPlan method without any smart growth reductions.
- 2035 BTU Spreadsheet Scenario Without D Enhancement – Identifies VMT produced by Spreadsheet method without any smart growth reductions.
- 2035 BTU UPlan Scenario With D Enhancement – Identifies VMT produced by UPlan method with reductions based on implementation of smart growth principles.
- 2035 BTU Spreadsheet Scenario With D Enhancement – Identifies VMT produced by Spreadsheet method with reductions based on implementation of smart growth principles. Assumes that developed acreage distribution is identical to that of the UPlan method.
- 2035 BTU Spreadsheet Scenario With Diversity Enhancement – Identifies VMT produced by Spreadsheet method with smart growth reductions, excluding Density.

MODEL POST-PROCESSING

After completing the model runs, we ran the VMT IXXI script that was developed for this project and described in Chapter 8. For SB-375 reduction target setting, Kern COG is not responsible for any through (XX) trips,

and is only responsible for 50% of internal-external (IX, XI) and military base trips. The script accounts for total VMT and IXXI-reduced VMT. We identify VMT per capita based on the model land use assumptions for household population: 745,972 in 2006 and 1,264,081 in 2035 for all scenarios. Results from the model run are identified in Table 22.

TABLE 22				
VMT OUTPUTS				
Scenario	Full Model VMT		VMT with IXXI Reduction	
	VMT	VMT/Capita	VMT	VMT/Capita
2006 Base Year Model	22,759,055	30.51	15,106,071	20.25
2035 BAU	41,808,553	33.07	28,348,914	22.43
2035 BTU - UPlan (No D Reductions)	37,490,506	29.66	24,041,270	19.02
2035 BTU – Spreadsheet (No D Reductions)	41,657,289	32.95	28,194,618	22.30
2035 BTU – UPlan (With D Reductions)	36,419,197	28.81	23,525,094	18.61
2035 BTU – Spreadsheet (With D Reductions)	40,743,566	32.23	27,773,089	21.97
2035 BTU – Spreadsheet (With Diversity Reduction Only)	40,826,326	32.30	27,854,967	22.04
Source: Fehr & Peers, 2010				

As shown in the table above, the BAU scenario produces a higher VMT per-capita than baseline conditions, as does BTU Spreadsheet scenario both with and without the Ds. However, the BTU UPlan scenario produces lower VMT than the base scenario both with and without D enhancements.

10. GREENHOUSE GAS AND EMISSIONS REDUCTIONS

APPROACH

After finishing the model runs for each scenario, we ran a VMT post-processor to assign VMT by speed bin, based on congested speeds on the model's roadway network. This information can be used as inputs into EMFAC to calculate Greenhouse Gas emissions estimate for submittal to CARB.

REDUCTIONS

Greenhouse Gas Emissions per capita are calculated based on VMT by speed bin. Different speeds produce different levels of GhGs, since vehicles idling or driving at very high speeds generally produce higher emissions than vehicles driving at freeflow speeds around 40 miles per hour.

Based on our analysis, we expect to see a reduction in GhG between the BTU scenarios and 2035 BAU. We would anticipate that the GhG per capita for the BTU Spreadsheet scenario would be higher than existing levels.

11. RECOMMENDATIONS

As previously discussed, the UPlan scenario is the only scenario in which VMT per capita is lower than existing conditions. However, the BTU Spreadsheet scenario produces VMT below business as usual with and without D reductions. Since the Spreadsheet scenario provides the most accurate land use forecasts developed by Kern COG, we recommend that Kern COG consider the following approaches to further reduce VMT and GhG emissions generated by the BTU Spreadsheet scenario.

ENHANCEMENT TO SPREADSHEET METHOD

The spreadsheet method has been regularly used by Kern COG for land use forecasting. As mentioned in Chapter 10, the existing spreadsheet method does not identify the amount of land that would be developed by future growth. Lacking this, we completed a model run assuming that the Spreadsheet method would have the same amount of developed acreage as the UPlan method. Enhancing the Spreadsheet method to include a component by which developed acreage associated with growth can be identified. This will produce a more accurate method of measuring changes in density and may further reduce VMT as a result of density increases.

USE OF SPATIALLY-BASED LAND USE ALLOCATION TOOL

Kern COG can consider using UPlan or another spatially-based land use allocation tool to develop land use forecasts. Our model runs indicated that the forecasts developed using UPlan generated lower VMT than any other scenario. UPlan, and similar tools, allow users to identify at a parcel level the locations of future development and can be of benefit for use by Kern COG.

CONSIDERATION OF TRAVEL DEMAND MANAGEMENT PROGRAMS

Kern COG may consider the implementation of Travel Demand Management programs for future development. In some jurisdictions, new development is required to develop a TDM program to reduce vehicle trips, and in turn VMT, to the project site. The Kern COG Travel Demand Forecasting Model can be further enhanced to identify reductions in VMT and GhG with the implementation of Travel Demand Management measures on a site-specific basis. This may further reduce VMT in the model area.

TECHNICAL APPENDIX A USER GUIDE



TECHNICAL MEMORANDUM

Date: February 24, 2010

To: Troy Hightower, Kern COG

From: Jason Pack, P.E., Senior Associate
Richard Lee, PhD, Associate
Tamar Fuhrer, Transportation Planner

Subject: 4D Enhancement User Guide

IE09-0031

This memorandum provides guidance to Kern COG staff in understanding and applying the updated Kern COG TDF model script with 4D enhancements. This memorandum is broken into four sections. First, we describe the overall approach to applying 4D model enhancements. Next, document new inputs and data needed for applying adjustments. We then go through the 4D portion of the script step-by-step to provide insight as to how this enhancement functions. Finally, we provide instruction on how to make adjustments to the script.

OVERALL APPROACH TO 4D MODEL ENHANCEMENTS

The Kern COG Travel Demand Forecasting model is a four step model; there are trip generation, trip distribution, mode choice, and trip assignment steps embedded in the model script. In the trip generation step, trip rates are applied to each land use within a Traffic Analysis Zone (TAZ). The model is socioeconomic based, so trip generation rates for each land use type are partially dependent on the median income group for a given TAZ. An output of the trip generation step is the number of person trips for each TAZ by trip purpose, such as home-based work or home-based shopping. After this step, trips are distributed throughout the model. Friction factors are taken into account with this step, so that a production is not automatically assigned to the nearest attraction but instead mimics observed regional travel characteristics. The third model step is the mode-choice component. In this step, person trips are assigned to walk, bike, transit, and automobile trips. For some trip purposes, automobile trips are further divided into drive alone and shared-ride trips (e.g. home-based work, which has drive alone, 2-person carpool, 3-person carpool, and 4-person carpool trips). At the end of this step, there are three trip matrices for person trips by automobile or transit: home-based work, school, and non-home trips. The final step is trip assignment. In this step, person trips are converted into vehicle trips using shared-ride factors. Vehicle trips are then assigned to the roadway network based on the distribution exercise performed in step two of the model. Table 1 identifies each step of the model and the trip outputs.

Based on the model structure, it is most appropriate to apply the 4D adjustment step after the mode choice and before the trip assignment steps. In the mode choice step, vehicle trips are separated from transit trips (walk and bicycle trips have already been separated from motorized trips in the trip distribution step). Since 4D trip reductions are targeted specifically at vehicle trips, adjustments can be made to the output matrices from the mode choice component. Additionally, we would like to make adjustments to person trips, not vehicle trips, which is feasible after the mode choice step.

TABLE 1	
MODEL TRIP OUTPUTS	
Step	Output
Trip Generation	Total Person Trips Generated by TAZ
Trip Distribution	Total Person Trip Matrices with origin and destination TAZs; non-motorized trips in separate matrices from motorized trips
Mode Choice	Total Person Trip Matrices with origin and destination TAZs for motorized trips
Assignment	Assignment network with vehicle trips loaded onto model roadways
Source: <i>Fehr & Peers, 2009</i>	

We applied 4D enhancements to the model based on results of the existing model's sensitivity tests and a synthesis of 4D data from regional and national empirical research. The four Ds associated with smart growth are: density, diversity, design, and destination. The model structure did not lend itself towards testing for the design D; enhancements to this D will need to take place at least partially off-model. Another D, destination, was found to be very sensitive based on model testing so no further enhancements to this element are necessary. Thus, the application of 4D enhancements to the model is currently limited to density and diversity.

As previously noted, we synthesized the results of empirical studies documenting the change in travel behavior related to the application of smart growth principles. These sources included national evaluations of smart growth principles (such as Index 4D) and more regional sources, such as the SACOG evaluation. We selected elasticities that would be most representative of smart growth application in the Central Valley. The elasticity values were based on the Index 4D research and further refined for the San Joaquin COG model enhancements.

The model is already sensitive to changes in access to regional destination, so trip adjustments to this D have not been applied. Additionally, we are still developing a level of enhancements to the fourth D, pedestrian design, and have not applied adjustments to the model. Therefore, model enhancements are limited to changes in density and diversity. Table 2 identifies the selected elasticities and whether they were embedded into the model script.

TABLE 2		
4D ELASTICITIES		
D Variable	Selected Elasticity (VT)	Embedded in Script?
Density	-0.04	Yes
Diversity	-0.06	Yes
Design	-0.02	No – will be applied off-model
Destination	-0.04	No – model already sensitive
Source: <i>Fehr & Peers, 2009.</i>		

NEW INPUTS

The model enhancements are predominantly based off of existing model outputs from the mode choice component and model land use data. However, additional inputs files were developed to further assist in enhancing the model so that it is sensitive to the Ds. The following files are new additions to the existing model:

- Land Use
 - ?socio.dbf is the existing land use file. This is one of the inputs in the trip generation step of the model, and this .dbf file is not included in the full model run
 - In the enhanced model, the test land use file (for example, the ke35socio.dbf file for the Better than Usual land use) should be saved to the “BTU” folder within the full model run after completing the Trip Generation model run. The base land use file (the existing ke35socio.dbf file) is saved to the “BAU” folder and should not be modified.
- Zonal Data (non-Land Use)
 - We created two zonal data files, TAZData_BASE.dbf and TAZData_TEST.dbf. These files should remain within the full model run directory. They contain information on developed acreage by TAZ and roadway miles by TAZ.
 - Developed acreage was calculated the Kern COG UPlan outputs. This information is then used to calculate the density of developed land within each TAZ.
 - Roadway mileage by TAZ was calculated using ArcGIS. Kern COG supplied the existing roadway centerline file. This file was then unioned with the model’s future year roadway network to account for any future roadways accounted for by the model. The resulting file was then dissolved by TAZ and the roadway mile distance for each TAZ was populated into the zonal data files.
- New Scripting
 - Additional scripting was embedded into the full model run, which will be discussed in the following section of this report.

HOW THE ENHANCEMENTS WORK

The model enhancements are embedded into the full model run script after the final Mode Choice step (MC20) and before the Assignment step (AAO1). The addition to this model script is as follows:

PART A – Defining Inputs, Calculating Ds, and Calculating Trip Adjustments

User Specifications and Definition of D Parameters

Before any calculations are made in the model, the user can specify parameters for the 4D enhancement. The maximum zone number is specified in this section. Currently, it is coded as 1984 to represent the largest TAZ number, but if additional TAZs are added then this may need to be adjusted.

In this step the comparison scenarios are also identified. In this case, we have identified “RTP” (Regional Transportation Plan) as the base scenario and “COMP” (Compass Blueprint) as the test scenario. We have since updated this part of the script to identify BAU as the base scenario and BTU as the test scenario. We identify the file paths to where the base case files and test case files are located in addition to the variable names.

```
=====
; USER SPECIFY (THESE ALL GO AT THE BEGINNING OF THE OVERALL SCRIPT)
LOOP YI=1,1 ;loop to run a specific year or scenario

; Number of Zones
MAX_ZONE_NUM=1984

; DEFINE D PARAMETERS
; Variables that define file paths. Set both to current scenario to turn off D calculations
BaseScen='C:\Models\KernCOG\RTP' ; Path to base case files (existing 2035)
TestScen='C:\Models\KernCOG\COMP' ; Path to test case files (compass blueprint)

; Variables that define file names. Set both to same scenario to turn off D calculations
BaseSE='?socio.dbf' ; Base case for determining change in D variable
TestSE='?socio.dbf' ; Test case for determining change in D variable
```

Specify maximum zone number

Denote base and test case scenario

Denote land use file name

Define Inputs and Outputs

We identify all of the files that will be used to make the 4D adjustments and the outputs for Part A of the model script. First, we identify the two land use files (ke35socio.dbf) and read in this file. Next, we identify and read in the zonal data files that were previously described (TAZData_Base.dbf and TAZData_Test.dbf). Input files noted as “ZDATI” refer to input data files.

For the first set of calculations, we output two files: in one file we calculate the difference between the base Ds and future Ds (2035_ALT_Ds.dbf), and in the second file we apply the adjustments to each trip purpose (2035_VT_ADJ.dbf). The readout files are defined by the term “RECO.” Please note that at this point in the script we have not done any calculations; rather, we are defining these for later use.

```
; DEFINE INPUTS AND OUTPUTS

RUN PGM=MATRIX

; Read in master land use\socio-economic data
; USER SPECIFY FILE PATH AND NAME
FILEI ZDATI[1]="@BaseScen@\@BaseSE@" ; Base Scenario Land Use\Socio-Economic file
FILEI ZDATI[2]="@TestScen@\@TestSE@" ; Test Scenario Land Use\Socio-Economic file

; Read in text file with list of zones which one desires to modify
; (For example, some county models have detail within that county,
; but include other areas - you may want to leave the other areas alone)
; FILEI ZDATI[3]="TAZSINCLUDED.txt", Z=#1, ZONE=#1 ; make this file

; Read in zonal data files (base and future)
; USER SPECIFY FILE PATH AND NAME
FILEI ZDATI[3]="TAZData_BASE.DBF" ; create file
FILEI ZDATI[4]="TAZData_TEST.DBF" ; create file

; Write out D summary spreadsheet
; (this is documentation / QA for viewing the percent changes in the D values
; but it is not used anywhere subsequently)
FILEO RECO[1] ="2035_ALT_Ds.DBF",
      FIELDS=Z,BASE_HH(6.0),BASE_POP(6.0),BASE_EMP(6.0),BASE_ACRES(6.4),BASE_DEN(6.4),BASE_DIV(6.4),BASE_DES(6.4)
      SCEN_HH(6.0),SCEN_POP(6.0),SCEN_EMP(6.0),SCEN_ACRES(6.4),SCEN_DEN(6.4),SCEN_DIV(6.4),SCEN_DES(6.4)
      DIF_DEN(6.4),DIF_JOBHH(6.4),DIF_DES(6.4)

; Write out D adjustment factors
; This is used as input to the latter half of this script, in the MATRIX program
FILEO RECO[2] = "2035_VT_ADJ.DBF",
      FIELDS=Z,ADJ_HBW(6.4),ADJ_HBSH(6.4),ADJ_HBO(6.4),ADJ_NHB(6.4),ADJ_HBSCH(6.4)
```

We also specify the maximum zone number (1984) at this point and regional averages for the various Ds. We used the model land use file to calculate the job-to-population ratio. Density was calculated by dividing the overall number of jobs and population by the acreage. We used an off-model spreadsheet to make these calculations, however all data came from the land use files and UPlan outputs. For diversity, we used the following formula to calculate the average job:population diversity of the zones. At this time we have not calculated average design. These averages will be applied to the trip adjustments; TAZs that have Ds below the regional average will not receive trip reductions.

We then initialize the variables by setting all variables to zero. We do this to ensure that zones that are not included within the network or test scenario are not assigned land use or trip reduction values. We also have created an input in which the D calculations and adjustments can be applied to a select group of TAZs rather than the entire network. This portion of the script can be updated to account for the districts that the D calculations would be applied to.

```
; USER SPECIFY HIGHEST ZONE NUMBER (could be done earlier in the script)
ZONES=1984

; USER SPECIFY AVERAGE HH SIZE FOR SFDU AND MFDU AND NOTE THE SOURCE
; CAN USE CENSUS 2000 DATA
; Exclude because we have household size within each TAZ
; SFHHSIZE=3.11      ; User Note source
; MFHHSIZE=3.11      ; User Note source

; USER SPECIFY THE FOLLOWING QUANTITIES BY CALCULATING FROM MODEL LAND USE DATA
; Note: one should only include the zones for which one is making "D"
; adjustments in these calculations
JOBPOPRATIO=0.36 ; overall jobs / population ratio calc using 4D spreadsheet
AVGDEN=1.4 ; overall Jobs + Pop per acre calc using 4D spreadsheet
AVGDIV=0.33 ; average Jobs / Pop diversity (not weighted) of the zones
              ; with the above JOBPOPRATIO used as the benchmark
              ; calculated by using 4D spreadsheet
AVGDES=0.50 ; average design (filler)

; Initialize variables
BASE_HH = 0
BASE_POP = 0
BASE_EMP = 0
BASE_ACRES= 0
BASE_DEN = 0
BASE_DIV = 0
SCEN_HH = 0
SCEN_POP = 0
SCEN_EMP = 0
SCEN_ACRES= 0
SCEN_DEN = 0
SCEN_DIV = 0

; IF (ZI.4.DISTRICT=1) ; Calculate and apply Ds only to zones being modified
```

Specify regional averages for Ds (note: these values will change upon receiving updated land use data from the COG)

Initialize variables so zones not included will not receive values

Identify districts being modified if limiting D adjustments to select areas

Step 1 - Calculate Input and D Variables

This is the first of model calculations. In this step, we calculate the base and test scenario Ds. First, the base scenario values are calculated. As noted in the previous step, ZI.1 refers to the base scenario land use (ke35socio.dbf) file. From this file, the script reads in the households column to calculate the number of households in the model, the household population for population, and the employment columns to calculate employment. The acres are read in from the second zonal data file (TAZData_BASE.dbf), as referenced by ZI.3.

Using these calculations, we can calculate the base scenario Ds. To ensure that we have no undefined values, we only calculate the base scenario Ds when each input does not equal zero.

```
; Step 1 - Calculate Input and D variables for each zone by scenario

; BASE SCENARIO

; USER SPECIFY FIELDS FOR TOTAL HH, TOTAL POP, TOTAL EMP,
; AND TOTAL DEVELOPED ACRES
; Note: can use the HH sizes defined above to get pop from HH as shown
; or can read total pop in directly if it's in the data
BASE_HH   =ZI.1.HOUSEHOLDS
BASE_POP  =ZI.1.HHPOP ;Omitted group quarters
BASE_EMP  =ZI.1.BASIC_EMP+ZI.1.RHRET_EMP+ZI.1.RMRET_EMP+ZI.1.SCSER_EMP+ZI.1.SOSER_EMP+ZI.1.BWOTH_EMP
BASE_ACRES=(ZI.3.ACRES) ; create this in file

IF ((BASE_POP>0 | BASE_EMP>0) & (BASE_ACRES>0))
BASE_DEN  =MAX((BASE_EMP+BASE_POP)/BASE_ACRES,AVGDEN)
BASE_DIV  =MAX(1-ABS((JOBPOPRATIO*BASE_POP)-BASE_EMP)/((JOBPOPRATIO*BASE_POP)+BASE_EMP),AVGDIV)

; USER SPECIFY FIELDS FOR ROADWAY MILES AND TOTAL GROSS ACRES
BASE_DES  =ZI.3.ROAD_MILES/ZI.3.ACRES
ELSE
BASE_DEN  = 0
BASE_DIV  = 0
BASE_DES  = 0
ENDIF
```

Calculate number of households, population, employment, and developed acreage

Calculate base scenario Ds

We then follow the same step for the test scenario.

```
; TEST SCENARIO

; USER SPECIFY FIELD NAMES FOR TOTAL HH, TOTAL POP, TOTAL EMP,
; AND TOTAL DEVELOPED ACRES
; Note: can use the HH sizes defined above to get pop from HH as shown
; or can read total pop in directly if it's in the data
SCEN_HH   =ZI.2.HOUSEHOLDS
SCEN_POP  =ZI.2.HHPOP
SCEN_EMP  =ZI.2.BASIC_EMP+ZI.2.RHRET_EMP+ZI.2.RMRET_EMP+ZI.2.SCSER_EMP+ZI.2.SOSER_EMP+ZI.2.BWOTH_EMP
SCEN_ACRES=(ZI.4.ACRES)

IF ((SCEN_POP>0 | SCEN_EMP>0) & (SCEN_ACRES>0))
SCEN_DEN  =MAX((SCEN_EMP+SCEN_POP)/SCEN_ACRES,AVGDEN)
SCEN_DIV  =MAX(1-ABS((JOBPOPRATIO*SCEN_POP)-SCEN_EMP)/((JOBPOPRATIO*SCEN_POP)+SCEN_EMP),AVGDIV)

; USER SPECIFY FIELDS FOR ROADWAY MILES AND TOTAL GROSS ACRES
SCEN_DES  =ZI.4.ROAD_MILES/ZI.4.ACRES
ELSE
SCEN_DEN  = 0
SCEN_DIV  = 0
SCEN_DES  = 0
ENDIF
```

Calculate number of households, population, employment, and developed acreage

Calculate test scenario Ds

Step 2 - Initialize Land Use Totals and Define Parameters

In this step of the 4D enhancement, we identify the elasticity values for each of the Ds that we are applying. This information was based on a synthesis of 4D data from empirical studies and the selected elasticities are identified in Table 2. We identify the elasticity by trip purpose, however, at this time we believe that it is appropriate to apply the Ds uniformly to all trip purposes.

In this step we also define floor and ceiling values for both a single D and the overall scenario; these values cap the adjustment for each TAZ. This is done to ensure that there are realistic adjustments to the Ds in locations where there are substantial land use changes.

```
; Step 2 - Initialize LU totals and define parameters
; 3D PARAMETERS from National Index4Ds - MPW 04.21.09
; DENSITY ELASTICITIES FOR VT BY TRIP PURPOSE
  E_RES_DEN_HBW = -0.040 ; Ps & As
  E_RES_DEN_HBSH = -0.040 ; Ps & As
  E_RES_DEN_HBO = -0.040 ; Ps & As
  E_RES_DEN_NHB = -0.040 ; Ps & As
  E_RES_DEN_HBSCH = -0.040 ; Ps & As
;
; JOBMIX DIVERSITY ELASTICITIES FOR VT BY TRIP PURPOSE
; E_VT_JOBMIX_HBW = 0.0 ; Not included in national 4Ds
; E_VT_JOBMIX_HBSH = 0.0 ; Not included in national 4Ds
; E_VT_JOBMIX_HBO = 0.0 ; Not included in national 4Ds
; E_VT_JOBMIX_NHB = 0.0 ; Not included in national 4Ds
; E_VT_JOBMIX_HBSCH = 0.0 ; Not included in national 4Ds
;
; JOBBH DIVERSITY ELASTICITIES FOR VT BY TRIP PURPOSE
  E_JOBHH_HBW = -0.060 ; Ps & As
  E_JOBHH_HBSH = -0.060 ; Ps & As
  E_JOBHH_HBO = -0.060 ; Ps & As
  E_JOBHH_NHB = -0.060 ; Ps & As
  E_JOBHH_HBSCH = -0.060 ; Ps & As
;
; DESIGN ELASTICITIES FOR VT BY TRIP PURPOSE
  E_DES_HBW = -0.020 ; Ps & As
  E_DES_HBSH = -0.020 ; Ps & As
  E_DES_HBO = -0.020 ; Ps & As
  E_DES_NHB = -0.020 ; Ps & As
  E_DES_HBSCH = -0.020 ; Ps & As
;
; CEILING AND FLOOR VALUES -- MAXIMUM OVERALL SCENARIO ADJUSTMENT
  C_SCEN = 5.0 ; 500%
  F_SCEN = -0.8 ; -80%
;
; CEILING AND FLOOR VALUES -- MAXIMUM ADJUSTMENT FOR A SINGLE D FOR
; A SINGLE TRIP PURPOSE
  C_PERD = 0.30 ; 30%
  F_PERD = -0.30 ; -30%
```

Identify elasticity values for each D, by trip purpose

Identify floor and ceiling values

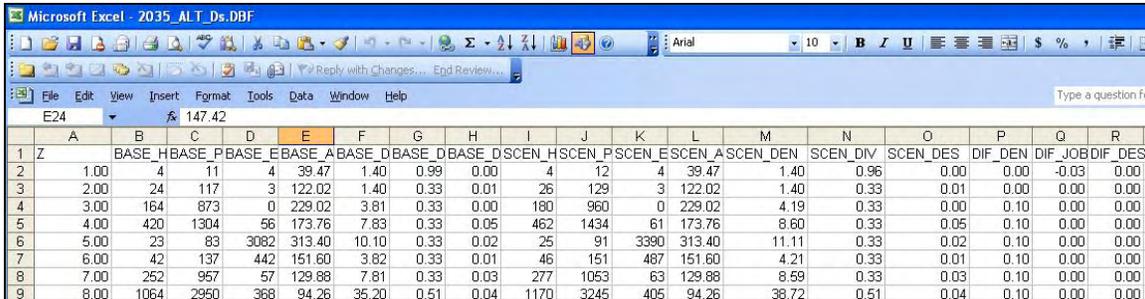
Step 3 - Calculate Changes to the Ds

At this point in the model, we have calculated the base and test scenario Ds. We have also defined the elasticity values for the Ds and the floor and ceiling values. Because the elasticity values are applied to the change in the Ds, we now need to calculate the change. The model assesses the change using four conditions:

- If there is no change, the difference in that D is set to zero
- If the change is greater than the ceiling value, the difference is set to the ceiling value
- If the change is less than the floor value, the difference is set to the floor value
- If none of these conditions apply, then the difference is the result of the calculation

The first recorded output that we defined in the beginning of the model (denoted by RECO[1]) is the Alt_Ds.dbf table. This table populates columns for each scenarios land use inputs and D

calculations in addition to the changes to the Ds. This table can be used as an intermediary step to check that the land use inputs provide logical outputs.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R							
1	Z	BASE_H	BASE_P	BASE_E	BASE_A	BASE_D	BASE_D	SCEN	HSCEN	P	SCEN	ESCEN	A	SCEN	DEN	SCEN	DIV	SCEN	DES	DIF	DEN	DIF	JOB	DIF	DES
2		1.00	4	11	4	39.47	1.40	0.99	0.00	4	12	4	39.47	1.40	0.96	0.00	0.00	-0.03	0.00						
3		2.00	24	117	3	122.02	1.40	0.33	0.01	26	129	3	122.02	1.40	0.33	0.01	0.00	0.00	0.00						
4		3.00	164	873	0	229.02	3.81	0.33	0.00	180	960	0	229.02	4.19	0.33	0.00	0.10	0.00	0.00						
5		4.00	420	1304	56	173.76	7.83	0.33	0.05	462	1434	61	173.76	8.60	0.33	0.05	0.10	0.00	0.00						
6		5.00	23	83	3082	313.40	10.10	0.33	0.02	25	91	3390	313.40	11.11	0.33	0.02	0.10	0.00	0.00						
7		6.00	42	137	442	151.60	3.82	0.33	0.01	46	151	487	151.60	4.21	0.33	0.01	0.10	0.00	0.00						
8		7.00	252	957	57	129.88	7.81	0.33	0.03	277	1053	63	129.88	8.59	0.33	0.03	0.10	0.00	0.00						
9		8.00	1064	2950	368	94.26	35.20	0.51	0.04	1170	3245	405	94.26	38.72	0.51	0.04	0.10	0.00	0.00						

Output table columns

Step 4 - Calculate Changes to Vehicle Trips

Now that we know the change for each D, we want to calculate the change to the vehicle trips. We do this by multiplying the change for each D by that Ds' elasticity value. Again, these calculations are conditional; when floor or ceiling values are met, then the appropriate value is assigned. These calculations are made by each trip purpose.

```

; Step 4 - Calculate VT change
; HBW Adjustment

IF (DIF_DEN * E_RES_DEN_HBW > C_PERD)
    ADJ_HBW_VT_DEN=C_PERD
ELSEIF (DIF_DEN * E_RES_DEN_HBW < F_PERD)
    ADJ_HBW_VT_DEN=F_PERD
ELSE
    ADJ_HBW_VT_DEN=DIF_DEN * E_RES_DEN_HBW
ENDIF

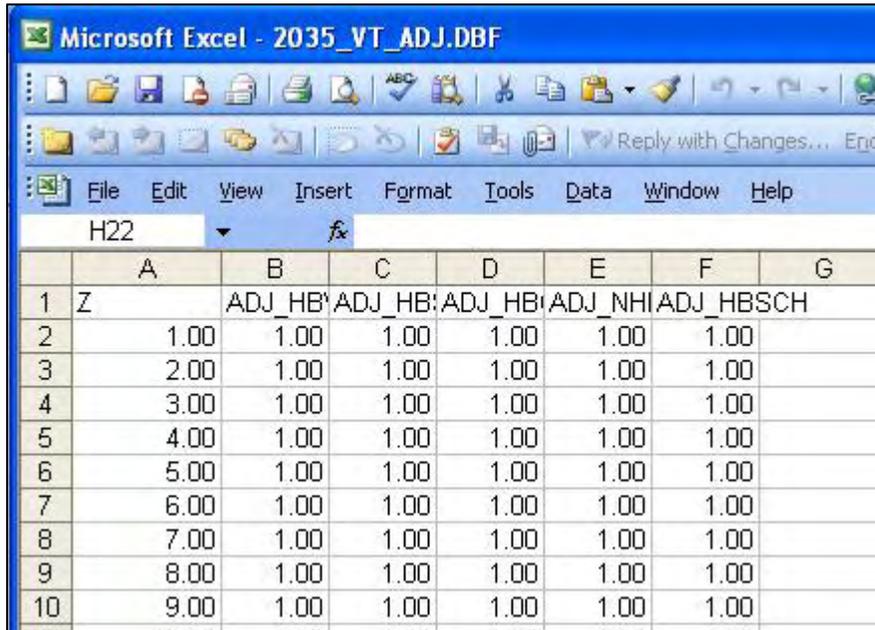
IF (DIF_JOBHH * E_JOBHH_HBW > C_PERD)
    ADJ_HBW_VT_JOBHH=C_PERD
ELSEIF (DIF_JOBHH * E_JOBHH_HBW < F_PERD)
    ADJ_HBW_VT_JOBHH=F_PERD
ELSE
    ADJ_HBW_VT_JOBHH=DIF_JOBHH * E_JOBHH_HBW
ENDIF

IF (DIF_DES * E_DES_HBW > C_PERD)
    ADJ_HBW_VT_DES=C_PERD
ELSEIF (DIF_DES * E_DES_HBW < F_PERD)
    ADJ_HBW_VT_DES=F_PERD
ELSE
    ADJ_HBW_VT_DES=DIF_DES * E_DES_HBW
ENDIF

ADJ_HBW_VT = (1+ADJ_HBW_VT_DEN) * (1+ADJ_HBW_VT_JOBHH) * (1+ADJ_HBW_VT_DES)
    
```

Calculate adjustment factors for auto person trips for each D

The calculations completed in this step are then written to the second recorded output file (RECO[2]) which is the vehicle trip adjustment factor table.



	A	B	C	D	E	F	G
1	Z	ADJ_HB	ADJ_HB	ADJ_HB	ADJ_NHI	ADJ_HBSCH	
2	1.00	1.00	1.00	1.00	1.00	1.00	
3	2.00	1.00	1.00	1.00	1.00	1.00	
4	3.00	1.00	1.00	1.00	1.00	1.00	
5	4.00	1.00	1.00	1.00	1.00	1.00	
6	5.00	1.00	1.00	1.00	1.00	1.00	
7	6.00	1.00	1.00	1.00	1.00	1.00	
8	7.00	1.00	1.00	1.00	1.00	1.00	
9	8.00	1.00	1.00	1.00	1.00	1.00	
10	9.00	1.00	1.00	1.00	1.00	1.00	

Trip Adjustment Factors by TAZ (Z=TAZ)

For cells in columns B-F where values are below 1.0, a vehicle trip reduction factor is applied. When values are equal to 1.0, no vehicle trip adjustments are applied. When values are greater than 1.0, then vehicle trips are added to the cells.

Part B – Applying Trip Adjustments to Trip Tables

After Part A, we have identified the vehicle trip adjustment factors for each TAZ by trip purpose. In Part B, we apply these adjustments to the trip tables that were created in the Mode Choice step of the full model run.

Identify Inputs, Outputs, and Floor/Ceiling Values

Before we apply the trip adjustments, we need to identify all of the inputs for this step, which will be used for calculating adjusted vehicle trips. There are two major input components: trip tables and adjustment tables. The trip tables are matrices that were developed in the Mode Choice component; each row represents the TAZ where trips originate and each column represents the TAZ where the trips terminate. The adjustment table, created in Part A of the enhancement script, defines the adjustment factor for each trip purpose.

First, we read in the trip matrix files. There are three files that are read in:

- The matrix file “?NW2.MAT” contains six non-home-based work, non-school trip tables. The first four trip tables in this file are for vehicle trips (home based shopping, home based other, non home based work, and non home based other). The final two trip tables are for transit trips.
- The matrix file “?HBWMC.MAT” contains eight home-based work trip tables. The first four tables represent trips occurring by automobile (drive alone or shared ride). The latter four tables represent trips occurring by transit.

- The matrix file “?SCHL2.MAT” contains twelve school trip tables. The first six trip tables represent trips occurring by automobile (drive alone or shared ride). The latter six tables represent trips occurring by transit.

We then read in the D adjustment factors from Part A of the enhancement model.

In this portion of the script, we also want to identify the outputs for Part B. Because these outputs are going to be read back into the model during the assignment step, they must have the same file structure as the inputs; in this case, they will be maintained as matrix files. We therefore rename the matrix output files (specified as MATO) to be the same as the input files but with a suffix of “_ADJ,” as shown below:

- ?NW2_ADJ.MAT – Non-home-based work trips
- ?HBWMC_ADJ.MAT – Home-based work trips
- ?SCHL2_ADJ.MAT – School trips

We also define the overall floor and ceiling values. In addition to considering the floor and ceiling adjustments for each D, we want to ensure that the cumulative adjustment remains realistic with implementation of the Ds. We have defined the floor value to be -0.25 and the ceiling value to be 0.25.

```
; Input files

; Read in Future Year Vehicle Trip Matrix File
; USER SPECIFY PATH AND FILE NAME
FILEI MATI[1]="?NW2.MAT"
FILEI MATI[2]="?HBWMC.MAT"
FILEI MATI[3]="?SCHL2.MAT"

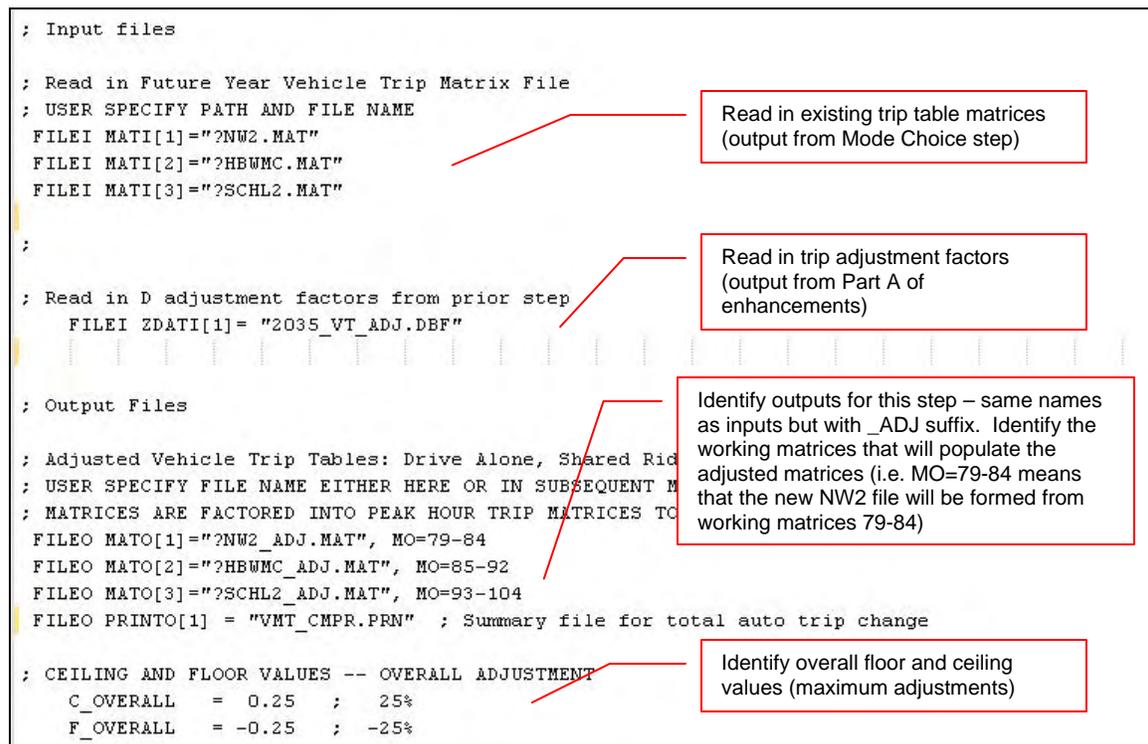
;

; Read in D adjustment factors from prior step
FILEI ZDATI[1]= "2035_VT_ADJ.DBF"

; Output Files

; Adjusted Vehicle Trip Tables: Drive Alone, Shared Ride
; USER SPECIFY FILE NAME EITHER HERE OR IN SUBSEQUENT M
; MATRICES ARE FACTORED INTO PEAK HOUR TRIP MATRICES TO
FILEO MATO[1]="?NW2_ADJ.MAT", MO=79-84
FILEO MATO[2]="?HBWMC_ADJ.MAT", MO=85-92
FILEO MATO[3]="?SCHL2_ADJ.MAT", MO=93-104
FILEO PRINTO[1] = "VMT_CMPR.PRN" ; Summary file for total auto trip change

; CEILING AND FLOOR VALUES -- OVERALL ADJUSTMENT
C_OVERALL = 0.25 ; 25%
F_OVERALL = -0.25 ; -25%
```



Read in existing trip table matrices (output from Mode Choice step)

Read in trip adjustment factors (output from Part A of enhancements)

Identify outputs for this step – same names as inputs but with _ADJ suffix. Identify the working matrices that will populate the adjusted matrices (i.e. MO=79-84 means that the new NW2 file will be formed from working matrices 79-84)

Identify overall floor and ceiling values (maximum adjustments)

Working Matrices Numbering

Before we apply the trip adjustment factors to the trip table matrices, we want to ensure that we can keep track of all trip tables at each stage of the adjustment. There are 26 total trip tables within the three matrices: six non-home based work tables, eight home-based work tables, and 12 school tables. We therefore assign each trip table its own working matrix number from 1-26 to better follow adjustments. We follow the same numbering system for denoting the changes in

trips due to the Ds, adjusted trips before floor and ceiling assessment, and adjusted trips after floor and ceiling assessment. The numbering system is as follows:

- 1-26: Unadjusted trips
- 27-52: Change in trips due to Ds
- 53-78: Adjusted trips before floor/ceiling evaluation
- 79-104: Adjusted trips after floor/ceiling evaluation

For example, working matrix 2 would also be represented in working matrices 28, 54, and 80 during each stage of the D adjustments. After defining the numbering system, we read in the trip tables to the working matrix according to the numbering system.

```
WORKING MATRICES NUMBERING SYSTEM

1-26 Unadjusted Trips (each purpose person trips)
27-52 Change in trips due to "D"s (each purpose person trips)
53-78 Adjusted Trips (each purpose person trips) before floor / ceiling
79-104 Adjusted Trips (each purpose person trips) after floor / ceiling

READ IN TRIP TABLES TO WORKING MATRIX
FILLMW MW[1] =MI.1.1, 2, 3, 4, 5, 6
  FILLMW MW[7] =MI.2.1, 2, 3, 4, 5, 6, 7, 8
  FILLMW MW[15] =MI.3.1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
```

Identify numbering pattern. For example, ?NW2.MAT's six matrices are now MW1-6, while ?HBWMC.MAT occupies trip tables 7-14

Apply Trip Reductions to Automobile Person Trips

This is the first step of model calculation for part B of the 4D enhancements. Now, we want to apply the adjustments to automobile trips earlier. As mentioned before, some of the trip tables represent transit trips, which will not receive vehicle trip reductions. For these tables, the change in trips is hard-coded to zero. Table 3 identifies the trip types for each matrix.

TABLE 3			
MATRIX TRIP TABLES			
Table Number	?NW2.MAT	?HBWMC.MAT	?SCHL2.MAT
1	Home-Based Shop Auto	Drive Alone	Elementary School Auto
2	Home-Based Other Auto	2 Passenger Carpool	High School Auto
3	Non-Home-Based Work Auto	3 Passenger Carpool	College Drive Alone
4	Non-Home-Based Other Auto	4+ Passenger Carpool	College 2 Passenger Carpool
5	Walk to Transit	Walk to Transit (local)	College 3 Passenger Carpool
6	Drive to Transit	Walk to Transit (premium)	College 4+ Passenger Carpool
7		Drive to Transit (informal)	El-Hi Walk to Transit
8		Drive to Transit (formal)	El-Hi Drive to Transit
9			College Walk to Transit (local)
10			College Walk to Transit (premium)
11			College Drive to Transit (informal)
12			College Drive to Transit (formal)
Note: bold denotes trip adjustments applied Source: Fehr & Peers, 2009			

First, we calculate the change in auto trips, multiplying the change in trips by the product of the adjustment factor subtracted from 1. For example, if the adjustment factor is 0.99, then the change in auto trips would be as follows:

$$\text{Change in Trips} = \text{Unadjusted Trips} \times (0.99 - 1) = \text{Unadjusted Trips} \times -0.01, \text{ or a 1\% reduction}$$

Next we add the change in auto trips to the unadjusted trips to calculate the adjusted trip value.

```
; Apply trip reductions to Auto trips
; HBS Auto Person Trips
MW[27] = MW[1]*(ADJ_HBSH[I]-1) ; CHANGE IN AUTO TRIPS
MW[53] = MW[1]+MW[27] ; ADJUSTED AUTO TRIPS

;HBO Auto Person Trips
MW[28] = MW[2]*(ADJ_HBO[I]-1)
MW[54] = MW[2]+MW[28] ; ADJUSTED AUTO TRIPS

;NHBW Auto Person Trips
MW[29] = MW[3]*(ADJ_NHB[I]-1) ; CHANGE IN AUTO TRIPS
MW[55] = MW[3]+MW[29] ; ADJUSTED AUTO TRIPS

;NHBO Auto Person Trips
MW[30] = MW[4]*(ADJ_NHB[I]-1) ; CHANGE IN AUTO TRIPS
MW[56] = MW[4]+MW[30] ; ADJUSTED AUTO TRIPS

;NWNS Trans Walk
MW[31] = 0 ; CHANGE IN AUTO TRIPS
MW[57] = MW[5]+MW[31] ; ADJUSTED AUTO TRIPS
```

Calculate change in number of auto person trips by multiplying the adjustment factor (from Step A output) by the unadjusted auto person trips for each TAZ. Add the unadjusted auto person trips to the change to calculate the adjusted auto person trip value.

The product of this step is a set of working matrices that have adjusted trip values for automobile-based trips.

Apply Floor/Ceiling Values for Overall Adjusted Trips

We want to ensure that the change in overall vehicle trips is reasonable within the context of smart growth principles and research. Earlier in the enhancement process, we defined floor and ceiling values for a single D. But we also want to apply a floor and ceiling value to the overall change. For instance, if a TAZ changes greatly by becoming both very dense and very diverse, we don't want trip reductions to be reduced to an unrealistic level by compounding the adjustments from both Ds. We therefore calculate the adjusted trip volumes relative to the floor and ceiling values. In cases that the adjustments exceed the ceiling value or are below the floor value, the appropriate factor is applied.

```
; APPLY FLOOR/CEILING FOR OVERALL ADJUSTED TRIPS

INIT_TRIPS=MI.1.1+MI.1.2+MI.1.3+MI.1.4+MI.1.5+MI.1.6+MI.2.1+MI.2.2+MI.2.3+MI.2.4+MI.2.5+MI.2.6+MI.2.7+MI.2.8
ADJ_TRIPS_TOT=MW[53]+MW[54]+MW[55]+MW[56]+MW[57]+MW[58]+MW[59]+MW[60]+MW[61]+MW[62]+MW[63]+MW[64]+MW[65]+MW[66]
IF (INIT_TRIPS <> 0)
  IF (ADJ_TRIPS_TOT/INIT_TRIPS > C_OVERALL)
    FACTOR=1-C_OVERALL*INIT_TRIPS/ADJ_TRIPS_TOT
    MW[79]=MW[53]-FACTOR*MW[27]
    MW[80]=MW[54]-FACTOR*MW[28]
    MW[81]=MW[55]-FACTOR*MW[29]
    MW[82]=MW[56]-FACTOR*MW[30]
    MW[83]=MW[57]-FACTOR*MW[31]
    MW[84]=MW[58]-FACTOR*MW[32]
    MW[85]=MW[59]-FACTOR*MW[33]
    MW[86]=MW[60]-FACTOR*MW[34]
```

Apply ceiling values when the ratio of adjusted trips:initial trips exceeds the overall ceiling

```
ELSEIF (ADJ_TRIPS_TOT/INIT_TRIPS < F_OVERALL)
  FACTOR=1-F_OVERALL*INIT_TRIPS/ADJ_TRIPS_TOT
  MW[79]=MW[53]-FACTOR*MW[27]
  MW[80]=MW[54]-FACTOR*MW[28]
  MW[81]=MW[55]-FACTOR*MW[29]
  MW[82]=MW[56]-FACTOR*MW[30]
  MW[83]=MW[57]-FACTOR*MW[31]
  MW[84]=MW[58]-FACTOR*MW[32]
  MW[85]=MW[59]-FACTOR*MW[33]
  MW[86]=MW[60]-FACTOR*MW[34]
```

Apply floor value when the ratio of adjusted trips to initial trips is below the floor value

When the floor or ceiling values are not met, then the initial adjusted trip value is maintained.

```
ELSE
  MW[79]=MW[53]
  MW[80]=MW[54]
  MW[81]=MW[55]
  MW[82]=MW[56]
  MW[83]=MW[57]
  MW[84]=MW[58]
  MW[85]=MW[59]
  MW[86]=MW[60]
  MW[87]=MW[61]
  MW[88]=MW[62]
  MW[89]=MW[63]
```

If neither the floor nor ceiling values are met, the adjusted auto person trips are fine as is

The working matrices of adjusted trip tables (after floor/ceiling values are applied) are then output into the adjusted trip matrices. This means that the matrix outputs are based on the working matrices numbered 79-104.

Overall Summary Reports

As a final check for this step, we have created an overall summary report, that reports the base and adjusted automobile trips, the change in trips, and changes in trips per capita.

```
; Report Overall Summary
IF (I=ZONES)
  PRINT FORM=12C,
  LIST="**** Total Auto Reductions",
  "\nBase Auto = ",TOT_BASE/100,
  "\nTest Auto = ",TOT_ADJ/100,
  "\nAuto Diff = ",(TOT_ADJ-TOT_BASE)/100,
  "\nAuto Diff % = ",(((TOT_ADJ-TOT_BASE)/100)*100/(TOT_BASE/100))(10.3),"%",
  "\n\n**** VT per Capita Reductions",
  "\nBase VT per Capita = ",((TOT_BASE/@Matrix._BasePopT8)/100)(10.3),
  "\nTest VT per Capita = ",((TOT_ADJ/@Matrix._ScenPopT8)/100)(10.3),
  "\nVT per Capita Diff = ",(((TOT_ADJ/@Matrix._ScenPopT8)-(TOT_BASE/@Matrix._BasePopT8))/100)(10.3),
  "\nVT per Capita %Change = ",(((TOT_ADJ/@Matrix._ScenPopT8)-(TOT_BASE/@Matrix._BasePopT8))/(TOT_BASE/@Matrix._BasePopT8))(10.3)
PRINTO=1
```

You can read out a summary report to check for reasonableness

Adjustments to Other Components of the Model Script

Prior to the model enhancements, the trip tables (i.e. "?NW2.mat) were created in the mode choice component and then read back into the model during trip assignment. Because this file is modified in the 4D enhancement step of the model, we now need to change the trip table inputs in the assignment script. This occurs in steps AAO1, AAO2, and AAO3. The MATI (matrix input) files for these three have been modified to have the _ADJ suffix so that adjusted trip tables are used for the assignment process.

HOW TO USE THE ENHANCEMENTS

The previous steps provide a detailed explanation of how each portion of the enhancement script works. Because this script was designed for use in the Kern COG model, only small changes need to be made to modify parameters and analysis scenarios. These characteristics are defined at the beginning of parts A and B of the model script, making changes more straightforward.

Instructions for modifying the script are described in the scenarios below:

1. Turning off the 4D Enhancement Step

The 4D adjustments are not always applicable when conducting model runs. For example, conducting a "cold start" to the base year model would not require 4D enhancements. Thus, there may be instances when users would not want this portion of the model script to run. A user can turn off the 4D Enhancement step by making changes to the User Defined D Parameters at the beginning of this step.

```
; DEFINE D PARAMETERS
; Variables that define file paths. Set both to current scenario to turn off D calculations
BaseScen='C:\Models\KernCOG\RTP' ; Path to base case files (existing 2035)
TestScen='C:\Models\KernCOG\RTP' ; Path to test case files
; Variables that define file names. Set both to same scenario
BaseSE='?socio.dbf' ; Base case for determining change in D variable
TestSE='?socio.dbf' ; Test case for determining change in D variable
```

Set BaseScen and TestScen to same values to turn off D calculations

By setting the Base Scenario and Test Scenario to the current scenario (in this case RTP), D adjustments will not be calculated.

2. Change Base and Test Scenarios

The two scenarios compared may not be BAU and BTU, so the user may wish to rename these two folders in the directory to other names. For the model to correctly read in the files if they are in renamed folders, update the naming conventions in the file path to reflect the new folder names.

```
; DEFINE D PARAMETERS
; Variables that define file paths. Set both to current scenario to turn off D calculations
BaseScen='C:\Models\KernCOG\RTP' ; Path to base case files (existing 2035)
TestScen='C:\Models\KernCOG\RTP' ; Path to test case files
; Variables that define file names. Set both to same scenario
BaseSE='?socio.dbf' ; Base case for determining change in D variable
TestSE='?socio.dbf' ; Test case for determining change in D variable
```

You can rename the folders and define the new path. For example, if the Base Scenario is renamed "Base" (instead of RTP), change this path to read 'C:\Models\KernCOG\Base.'

3. Change File Paths

The user inputs in the script assume that the Model Run is being stored on the C drive of one's computer under a modeling folder and a Kern COG subfolder. The drive in which the model is running may differ from user to user. The user should therefore specify the file paths within the user defined parameters. Most of the files will be maintained in the full run folder. The file paths are primarily intended to identify where the land use files for comparison are located.

<pre> ; DEFINE D PARAMETERS ; Variables that define file paths. Set both to current scenario to turn off D calculations BaseScen='C:\Models\KernCOG\RTP' ; Path to base case scenario TestScen='C:\Models\KernCOG\RTP' ; Path to test scenario ; Variables that define file names. Set both to current scenario to turn off D calculations BaseSE='?socio.dbf' ; Base case for determining change in variables TestSE='?socio.dbf' ; Test case for determining change in variables </pre>	<p>If these files are located in another drive on the computer, specify where they are located. For example, if they are moved to the D drive under a folder called "D_ADJ", the file path should read 'D:\D_ADJ\RTP' and 'D:\D_ADJ\COMP.'</p>
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4. Number of TAZs exceed 1984

Currently, the largest TAZ number is 1984. However, if new TAZs exceed this number, the script will need to be modified so that new TAZs with numbers above 1984 are not excluded from calculations. Under "User Specify Highest Zone Number," change the Zone Number to the highest one in the model network. Please note that the maximum number has been coded elsewhere in the Kern COG model so additional modifications would need to be applied to the model in this scenario.

5. Calculate D Adjustments for Limited Area

There may be instances in which D adjustments are only requested to be applied to specific areas, such as Bakersfield. The model has been broken into districts, which is embedded within the land use file. If calculations should be limited to one district, simply denote that district after "IF (ZI.4.DISTRICT=X)." When the D adjustments should be applied to all TAZs, turn this off by placing a semi-colon right before the word "IF."

<pre> IF (ZI.4.DISTRICT=1) ; Calculate and apply D adjustments to selected districts ; Step 1 - Calculate Input and D variables for each TAZ </pre>	<p>Remove semicolon and identify selected adjustment districts if D adjustments are limited to specific area</p>
------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------

<pre> ; IF (ZI.4.DISTRICT=1) ; Calculate and apply D adjustments to selected districts ; Step 1 - Calculate Input and D variables for each TAZ </pre>	<p>Place semicolon in front of IF statement to apply D values to full model area</p>
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------