TECHNICAL MEMO

MODE AND PATH CHOICE MODELS

TAMPA BAY REGIONAL ACTIVITY BASED MODEL

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PREPARED FOR:
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1.0 INTRODUCTION

The purpose of this document is to explain the mode and path choice model components of the Tampa Bay Regional Activity-Based Model (ABM), based on the DaySim model design and specification for the 2010 Base Year. This first section provides an overview of the mode choice models that have been implemented for the Tampa region. There are two separate mode choice models, tour and trip mode choice. A tour may be defined as a chain of trips that begin and end at the same home or work location. These trips are linked such that travelers, destinations, modes and times are consistent in the context of the tour. The tour mode choice model predicts an overall "main mode" for each tour. Within a given tour, however, travelers may use combinations of modes. The trip mode choice model predicts the modes for each individual trip, constrained by the main mode used for the overall tour.

Sections 3.0 and 4.0 provide details about tour and trip mode choice models, respectively. Appendix A and Appendix B list the estimated parameters for tour and trip mode choice models, respectively.

Section 5.0 describes a feature of DaySim called the "path type model." The "path type model" allows consideration of more than one "best" path for each mode, be it a tour or trip mode. For auto modes, the paths may be distinguished by whether they include a toll. For transit modes, the paths may be distinguished by type of transit service, such as local bus, commuter express bus, light rail, and commuter rail. Alternative path types may be included as well.

2.0 NESTED CHOICE STRUCTURE

Figure 1 below shows the nesting structure of the mode choice models. The structure is labeled as consisting of two parts, "main mode" and "path type." The main mode part of the structure is nearly the same for both tour and trip mode choice models. All main modes are tour mode choices. All main modes except auto access transit are also trip mode choices. A path type is essentially a nest under the main mode choice.

Under the auto nest, there are three modes: single occupancy vehicle (SOV/DA), high occupancy vehicle with two persons (HOV 2/SR2), and high occupancy vehicle with three or more persons (HOV 3+/SR3+). Each of the auto modes has an implicit toll/no-toll choice in the auto path type model. The toll path type is also referred to as the full-network path type in DaySim, since all network links are available for use.

Under the transit nest, the available tour mode choices are walk-access-to-transit (walk-transit/WT) and auto-access-to- transit (drive-transit/DT). The available trip mode choice alternatives do not include DT. DT is available for tour mode choice and not for trip mode choice, because drive access to transit is considered to be a tour-level decision to park-and-ride or kiss-and-ride. At the trip level, the drive segment of a drive-transit trip is apportioned to the highway network and will appear as a DA, SR2 or SR3 trip in highway trip tables, while the transit segment of the drive-transit trip will appear as a walk-transit (e.g. bus) trip in transit trip tables.

For a tour with DT as the chosen tour mode, subsequently modeled trip mode choices may include either driving or transit. For WT, only local bus service/path is currently available in during the base year; however, additional transit sub-modes may be added for future years. For DT, Park-and-Ride (PNR) and Kiss-and-Ride (KNR) to local bus are the available path types in the base year. DaySim is flexible enough to accept any additional transit path types that may be needed to model future scenarios. For this reason, a "future modes" path alternative has been shown both under walk- and drive-transit modes.

Under the non-motorized mode nest, walk and bike are available. In the initial Tampa implementation, both walk and bike modes have one path type which is the full network, excluding freeway links and ramps that are off-limits to bicyclists and pedestrians. It is possible, however, to use separate networks for bicyclists and pedestrians. For example, bicycle path types may be distinguished by inclusion of separated (Class 1) bike facilities. Further details about the path type model implementation may be found in Section 5.0 below.

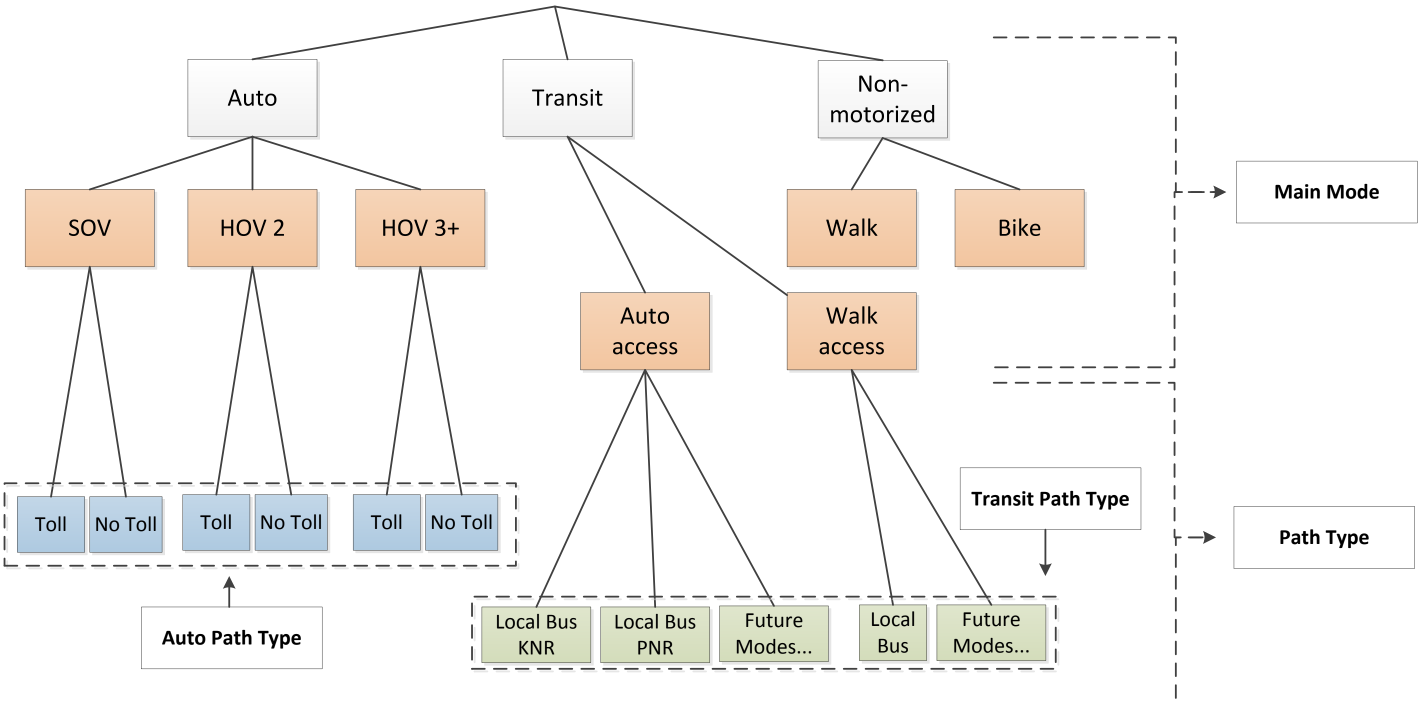

FIGURE 1: TAMPA ABM MODE CHOICE STRUCTURE

3.0 TOUR MODE CHOICE

Tour modes are chosen based on decision-maker bias factors and travel impedances between a tour's beginning point and the primary destination on the tour. A tour's point of origin is always home. DaySim also models work-based sub-tours, which are a tour that begins and ends at a workplace, as a subset of a larger home-based tour. The primary destination on each tour is identified prior to applying the tour mode choice model using one of a set of location/destination choice models, described in separate documentation.

The tour mode choice decision structure is identified as the main mode in Figure 1. It is formulated as a nested logit model with auto, transit, and non-motorized modes in the upper nest. Separate tour mode choice models exist for the following tour purposes:

- Home-based Work
- Home-based School
- Home-based Escort
- Work-based
- Home-based Other

Appendix A lists the variables and estimated coefficients for each of these models. Walk is the base alternative; therefore, all alternative-specific parameters are with reference to walk, which implicitly has a coefficient of zero. It is important to note that the time and cost coefficients in the mode choice models are positive, which may appear counter-intuitive. These time and cost coefficients are multiplicative factors applied to the "actual" tour time and cost coefficients used in the path-type choice models, as described in Section 5.0.

The path-type choice variables enter tour mode choice as "log sums"—the natural log of the sum of the denominator in the path choice. For tour-mode choice, an actual path choice is not simulated. Rather, the composite utility of all possible path choices is represented by these log-sum terms. As described below in Section 4.0, actual path choices are simulated as part of trip-mode choice.

4.0 TRIP MODE CHOICE

The actual mode chosen for each segment of the tour is modeled as the "trip mode." As described above, the trip-mode choice decision structure is nearly the same as that of the tour-mode choice decision structure, as depicted in Figure 1. The only difference is that there is no drive-transit trip mode. At the trip level, what would be a drive-to-transit trip is split between the drive portion, which is allocated to highway trip tables, and the transit portion, which is allocated to transit trip tables.

The trip-mode choice model is not segmented by tour purpose, although tour purpose-specific variables are included in the model. Appendix B includes the variables and estimated coefficients for the trip-mode choice model. A generalized log sum representing the composite utility of all available paths appears in the utility function for the upper-level mode choice models. An actual path choice is made at the lower level for all modes other than bike and walk. Section 5.0 provides additional details regarding the relationship between path-type choice and tour-mode models.

The chosen tour ("main") mode constrains the availability of trip modes and has a significant conditioning effect on the choice of trip mode. In the NHTS add-on survey for the Tampa region, the observed trip mode was the same as the tour mode in about 80 percent of the cases. Accordingly, the primary purpose of the trip-level mode choice model is to determine the trip mode for those trips where the trip mode is not the same as the tour mode. On auto tours, most of those cases are changes in car occupancy (DA, SR2, SR3+).

TABLE 1: TRIP MODE AVAILABILITY BY TOUR MODE

Trip Mode Tour Mode	Walk	Bike	DA	SR2	SR3+	Transit Bus	School Bus
Walk	√						
Bike	√	√					
DA	√	√	√				
SR2	√	√	√	√			
SR3+	√	√	√	√	√		
Walk-Transit	√	√	√	√	√	√	
Drive-Transit	√	√	√	√		√	
School Bus	√	√	√	√	√	√	√

Table 1 shows the available trip mode alternatives for each tour mode. Tour modes are listed as rows, and available trip modes are identified in the columns. Tour modes were defined in this manner, based on observations in household survey data. For example, a bicycle tour allows only bicycle and walk trip modes, and is therefore more restrictive than other tour-mode types listed below it. Bicycle is also available on drive and transit tours; however, these are relatively low probability trip-mode choices, as revealed through the household survey data.

5.0 PATH TYPE MODEL

This section describes how the path-type model works in DaySim. The objective is to provide a detailed framework for how the base-year model is currently set up as well as what is possible for setting up alternative, future scenarios. The path type model is primarily used to more consistently model roadway pricing scenarios and transit sub-mode alternatives. It allows the consideration of more than one "best" path for each mode. For auto, paths can be distinguished by whether they include a toll. For transit, paths can be distinguished by type of transit service, such as local bus, express bus, light rail, and commuter rail. For bike, path types can be distinguished by inclusion of separated (Class 1) bike facilities, if such networks are available. The path type models provide a consistent framework for generating multimodal accessibilities (log sums) used by other Daysim model components, and provide the ability to select discrete path alternatives during trip mode choice. Figure 2 shows how the various data inputs and path type models interact with other choice models in DaySim.

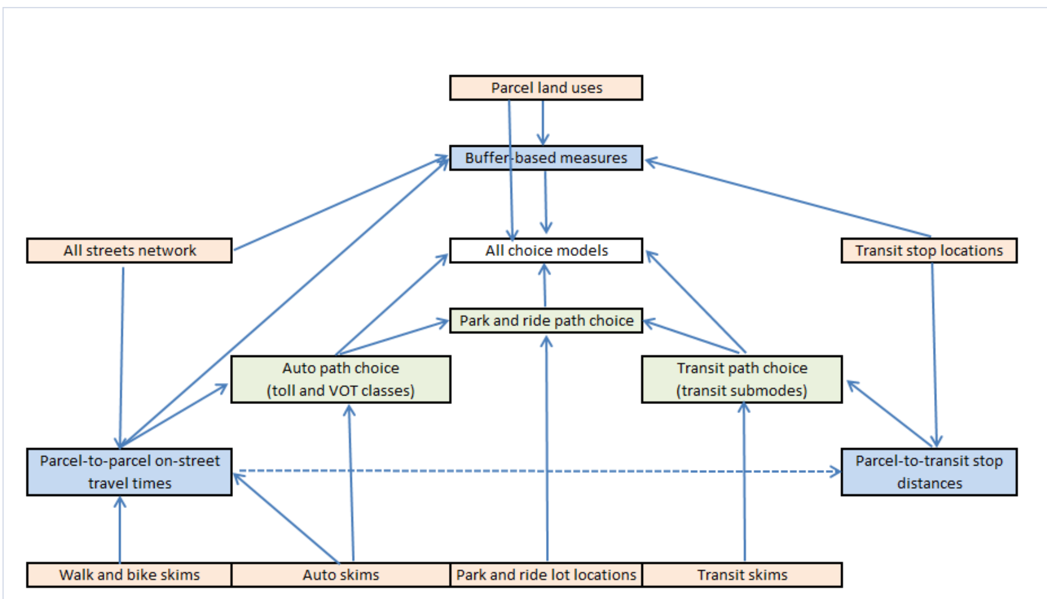

FIGURE 2: STRUCTURE OF THE USE OF PATH TYPE MODELS IN DAYSIM ABM

If finding the "best" path through a network simply involves finding the shortest time path, then it may be satisfactory to do all path building and assignment outside of DaySim in a more aggregate environment. This may not be the case, however, when toll cost, operating or transit sub-modal availability costs become key considerations in choosing a route. Each traveler may have different trade-offs between travel time and cost—their value of time (VOT) or willingness to pay (WTP) to save travel time. For example, suppose the two best paths for a given origin-destination pair have a travel time of 40 minutes with no toll, or a travel time of 30 minutes with a $2.50 toll (and no difference in distance or operating cost). Then any traveler willing to pay $2.50 for a 10-minute savings (VOT higher than $15/hour) has a higher probability of choosing the tolled path, and any traveler with VOT lower than $15/hour would choose the free path.

In DaySim, the path type model returns:

(a) a generalized time log sum across all available path types, and

(b) at the trip level, a single chosen path type and the travel time, cost and distance via that mode.

It is important to note that the path-type choice model calculates and returns a utility log sum across all the available path types for a mode. The utility log sum value is divided by the time coefficient to produce a generalized time value. Upper-level models, such as trip- and tour-mode choice models, use generalized time as a variable representing travel impedance.

While running the trip-mode choice model, the path-choice model also simulates the selection of an actual path type based on a Monte Carlo simulation, using the path type utilities and probabilities. This means that when an auto trip mode is chosen (DA/SR2/SR3+), a toll (full network) or no-toll path is also chosen. When a transit trip mode is chosen, a service path type (local bus, light rail, etc.) is also predicted. Note that if only one path type is used for a given mode (e.g., only local bus is used for transit), then the path-type-utility log sum is simply the utility of that single path type.

5.1 | AUTO PATH TYPE

Conceptually, the toll vs. no-toll auto path type choice model can be thought of as a binary choice beneath each of the auto alternatives (DA, SR2, SR3+) in the DaySim mode choice model, as depicted in Figure 1. Whenever auto time and cost for DA, SR2, SR3+ modes are referenced in the DaySim models, they are replaced by the composite utility from both the tolled and non-tolled paths under each of those modes, just as they would be in a fully-nested model. This composite utility is a "generalized auto time" log-sum, calculated as

$$V(n,i) = s*b(i) * Time(n,i) + s*c(i) * Distance(n,i) * opcost$$

$$V(t,i) = s*a(i) + s*b(i) * Time(t,i) + s*c(i) * (Toll(t,i) + Distance(t,i) * opcost)$$

$$P(t,i) = 1 – P(n,i) = exp[V(t,i)] / (exp[V(t,i)] + exp[V(n,i)]]$$

$$GT(i) = LN [(exp[V(t,i)] + exp[V(n,i)]] / (s*b(i))$$

where:

V(n,i) and *V(t,i)* are the systematic logit utilities for the non-tolled and tolled paths, respectively, for individual traveler *i*, and *P(t,i)* and *P(n,i)* are the corresponding binary logit probabilities.

Time(n,i), Time(t,i), Distance(n,i), Distance(t,i) are the travel time and distance along the best non-tolled and tolled paths, respectively, for traveler *i*, depending on the traveler/trip's origin, destination, time of day, and value of time (VOT) class.

Toll(t,i) is the toll along the best tolled path for traveler *i*, depending on the traveler/trip's origin, destination, time of day, and value of time (VOT) class.

a(i) is an alternative-specific constant for the tolled path for traveler i

b(i) is the travel time coefficient for traveler i

c(i) is the travel cost coefficient for traveler i

s is a scale factor applied to all coefficients, denoting the scale of this model relative to mode choice

opcost is the auto operating cost per mile.

Generalized time *GT(i)* is the log sum across the two alternatives, divided by the scaled travel time coefficient, *s*b(i))* , resulting in equivalent minutes of travel time. Note that the generalized time includes the effects of toll and operating cost as well as travel time. If the two paths are identical in terms of time, distance and toll, then the non-tolled path is selected as the chosen route type without applying the model. Also note that operating cost per mile is treated as a constant, which can be varied by the user to represent future fuel cost assumptions. If DaySim is enhanced in the future to include a model of vehicle type choice (economy, SUV, hybrid, etc.), then operating cost may be treated as traveler-specific.

An important feature of Daysim is that it provides users with the ability to use traveler- and tour-specific coefficients for the model. These coefficients are specified in the **Configuration.xml** file. This allows different tours and trips to use different implied values of time based on household income, vehicle occupancy and purpose. In the initial Tampa Bay Regional ABM setup, the following calculations were used to develop the cost coefficients for work and non-work tours:

Work tours

*c(i) = -0.15/$ / [((income(i) / 30,000) ^ 0.6) * (occupancy(i) ^ 0.8)]*

b(i) = -0.030/min * random draw (log-normal distribution, mean 1.0 and std. deviation 0.8)

a(i) = -1.00

s = 1.5

Non-work tours

*c(i) = -0.15/$ / [((income(i) / 30,000) ^ 0.5) * (occupancy(i) ^ 0.7)]*

b(i) = -0.015/min * random draw (log-normal distribution, mean 1.0 and std. deviation 1.0)

a(i) = -1.00

s = 1.5

The cost coefficient *c* is set at -0.15/$ for both work and non-work tours. It is adjusted according to the household income of the traveler, using a power function with a somewhat higher exponent for work tours (0.6) than for non-work tours (0.5). When applied to specific car occupancy levels, the cost coefficient is also adjusted downwards for cost-sharing, again using a power function with a somewhat higher coefficient for work tours (0.8) than for non-work tours (0.7).

The base scenario travel time coefficient is set at -0.030 per minute for work tours and -.015 per minute for non-work tours. For an SOV trip for a traveler with an income of $30,000, this corresponds to a VOT ratio of 60* -0.030 / -0.15, or $12 per hour for work tours, and 60 * -0.015 / -0.15, or $6 per hour for non-work tours.

As discussed above, the time and cost utility logsum coefficients are positive in the mode specifications presented in the appendices. The time and cost coefficients in the tables in appendices are multiplied by *b(i)* and *c(i)* (tour- and person-specific coefficients, respectively) before calculating the utilities of available alternatives in both tour and trip mode choice models. Thus the time and cost coefficients in the mode choice tables appearing in the appendices are "factors" that are applied to "actual" traveler-specific coefficients *b(i)* and *c(i)*.

The alternative-specific constant for the tolled route is set at -1.0 for both work and non-work tours, as evidence shows some aversion to paying tolls, all else equal. Note that it would be possible to also simulate normal or log-normal taste variation around this coefficient for each individual.

The final parameter in the equations above is *s*, the model scale relative to mode choice. If the binary toll/non-toll path type model is imagined as a nest of mode alternatives under each of the auto alternatives in a mode choice model, then the unscaled time and cost coefficients b and c are those used in the mode choice model, while the scaled coefficients *s*b* and *s*c* are those used in the lower level route type choice nest when the logsum parameter for the nest is *1/s*.

Some advantages of including path type choice in the ABM, rather than just the network assignment model are:

- path choice is sensitive to small variations in VOT (more disaggregation);
- the model can provide expected utilities (log sums) over multiple paths, which is more consistent with choice theory; and
- fewer required VOT classes are needed for stratifying skim matrices, which can be tailored to the complexity of the pricing scenario and is more memory-efficient and flexible.

In the initial Tampa Bay Regional ABM implementation, there is no stratification of roadway skims by VOT class. If a significant number of alternatives is anticipated for a tolling analysis, extension of the number of tolling classes used in assignment should be considered.

5.2 | FEEDBACK OF DAYSIM RESULTS TO CUBE

The DaySim model system produces a list of person-trips for a single day for the entire regional population. The trip list includes two variables to the DaySim trip-level output file:

- predicted chosen path type (full network or non-tolled network), and
- trip-specific value of time (VOT)

Cube highway assignment processes can use this information to select whether to exclude tolled links from possible paths when assigning the trip to the network and to determine what range of VOT to use when assigning trips to different VOT-related user classes for multi-class assignment. This information helps to ensure that the choice behavior being predicted by DaySim is consistent with the route choices and traffic flows being predicted by Cube through highway assignment.

5.3 | TRANSIT PATH TYPE

The transit path-type model can choose between any number of transit sub-modes specified by the user. It also works with just a single path type. As with the auto path-type model, the transit path type model calculates a generalized time logsum across the available path types, and that logsum is then used in other models such as mode choice and the calculation of accessibility logsums. It predicts a single chosen path type at the trip level, so that each simulated transit trip can be assigned to a specific service type for transit assignment.

The transit utility depends on a variety of different user configuration inputs, several of which are path type-specific. As shown below, Table 2 list the transit path-finding weights used in the calculations of path utilities. The values are set in DaySim's **Configuration.xml** file and should be consistent with the path-finding weights used in Cube's transit assignment model. Transit path utilities are calculated as

$$Transit\ Utility = c(i)*f + b(i)*wtd\_imp + IVT(p)*(wt(p) + pc(p))$$

Where,

c(i) = Cost coefficient for traveler i

f = Full fare *(1 – fare discount); See Table 2 for fare discount fractions.

b(i) = Time coefficient for traveler *i*

wtd_imp = Weighted sum of transit impedance variables shown in Table 2

IVT(p) = In-vehicle time of path type *p*

wt(p) = Additive in-vehicle time weight for path type *p*; currently set to 0

pc(p) = Path constant for path type *p*; currently set to 0

TABLE 2: TRANSIT PATH TYPE UTILITY PARAMETERS

Variable	Parameter
Transit Impedance	
Total in-vehicle time weight	1
First wait time weight	2.25
Transfer wait time weight	2.25
Number of boardings weight	2.5
Walk access time weight (access and egress)	2.25
Drive access time weight	1
Fare Discount	
Child under 5 years	0.8
Child 5 to 5 years	0.5
High school student	0.5
University student	0.5
Adult age 65+ years	0.5

The walk access and egress times for transit paths are calculated as the distance from the parcel to the nearest stop using the all-streets network. For drive-access to transit, auto access times are determined from the park-and-ride path type model, described below.

5.4 | PARK-AND-RIDE LOT CHOICE

The park-and-ride path (PNR) type model applies elements of both the auto path type choice model and the transit path type choice model. As such, it predicts the transit sub-mode type for the transit portion of the park-and-ride path as well as the auto-path type for the auto-access path, and puts both elements together in calculating the generalized time logsum across the available path types. In addition, the path-type model includes some extra features:

- In addition to selecting the path types, the park-and-ride path type model also selects the specific PNR lot location that minimizes the generalized time for the combined, round-trip auto plus round-trip transit path.
- This model is applied at the tour level only, because persons must return to the same park-and-ride lot to collect their vehicles before returning home. Trip modes for the tour are constrained by the tour mode and the trip sequence in each half tour, relative to the stop at the PNR lot. In addition, DaySim may simulate the insertion of intermediate stops on the auto portions of the tour between home and the park-and-ride lot, in either direction.
- The PNR lot choice model uses data on all available park-and-ride lots, including the location, parking price (if any), and capacity of each lot.

- The model can be applied with "shadow pricing" across global iterations, so that if a specific park-and-ride lot is simulated to "overfill" (occupancy exceeds parking capacity) during specific hours of the day, those lots are given an artificially higher price during those same periods during the next global iteration to move the demand closer to the capacity.

In the Tampa Bay Regional ABM, the park-and-ride lot choice model was customized to include kiss-and-ride (KNR) path type in addition to PNR path type. This works in a very similar fashion and needs a separate list of KNR locations/stations, but without shadow pricing. Note that if the user does not provide a park-and-ride node file, DaySim will assume that park-and-ride is not relevant for the region and the park-and-ride mode alternative is never available.

5.5 | WALK AND BIKE PATH TYPE

Currently, there is only one path type used for Walk (full network, excluding freeways and ramps where pedestrians are prohibited). The utility is simply a function of time:

*Walk_Utility = b(i)*wk_time*wt_weight*

where:

b(i) = Time coefficient for traveler *i*

wk_time = Walk time

wt_weight = Walk time weight, currently set to 2.25

It would be possible to add detail to this model if more data were available (availabiliy of sidewalks, slope, etc.). A similar utility equation is applied for bike path since currently only one path type used for Bike (full network). Bike time weight is also set to 2.25. In the future, it would be possible to use the path type model to allow different types of bike paths according to the types of links they use: for example a full-network vs. a network that does not use Class 1 bike paths.

APPENDIX A. TOUR MODE CHOICE PARAMETERS

TABLE 3: HOME-BASED WORK TOUR MODE CHOICE MODEL

Modes	Variable	Coefficient
	Level of Service	
DA, SR2, SR3+, DT, WT	Path type utility log sum	0.559
DA, SR2, SR3+	Parking cost utility	0.529
	Mode-specific	
DT	Constant	-2.772
DT	No cars in HH	-2.000
DT	HH fewer cars than workers	-1.011
WT	Constant	-1.589
WT	Mixed use density at origin	2.002
WT, DT	Intersection density at destination	0.011
WT, DT	Total employment density at destination	0.000
SR3+	Constant	-1.083
SR3+	One person HH	-0.618
SR3+	Two person HH	-1.245
SR2	Constant	-0.390
SR2	One person HH	-0.393
SR2, SR3+	HH # children under age 5	0.323
SR2, SR3+	HH # children age 5-15	0.279
SR2, SR3+	Log of auto distance (miles)	-0.136
SR2, SR3+	No cars in HH	-3.106
SR2, SR3+	HH fewer cars than drivers	0.433
SR2, SR3+	Escort stop purpose / # tours in day	3.703
SR2, SR3+	Other stop purposes / # tours in day	0.243
DA	Constant	2.066
DA	HH fewer cars than workers	-1.277
DA	HH income under $25K	-0.174
DA	Escort stop purpose / # tours in day	-2.217
DA	Other stop purposes / # tours in day	-0.032
Bike	Constant	-15.930
Bike	Male	0.766
Bike	Age over 50	-0.662
Bike	Class 2 distance	0.480
Bike	Mixed use density at origin	2.410
Bike	Total employment density at destination	0.000
Bike	Mixed use density at destination	7.171
Walk	Male	-0.660

Modes	Variable	Coefficient
Walk	Mixed use density at destination	0.925
All	Mode nesting parameter	0.960

TABLE 4: HOME-BASED SCHOOL TOUR MODE CHOICE MODEL

Modes	Variable	Coefficient
	Level of Service	
DA, SR2, SR3+, WT	Path type utility log sum	1.022
DA, SR2, SR3+	Parking cost utility	0.083
	Mode-specific	
SchBus	Constant	0.260
SchBus	Child under age 5	-0.374
SchBus	Adult age 18+	-2.155
WT	Constant	-5.442
WT	No cars in HH	1.029
WT	HH fewer cars than drivers	0.285
WT	Child under age 5	-5.000
WT	Adult age 18+	1.619
WT	Child age 16-17	1.442
WT	Log of transit stops buffer variable 1 at origin	0.419
WT	Mixed use density at destination	2.589
SR3+	Constant	0.261
SR3+	Two person HH	-1.171
SR2	Constant	-0.685
SR2	One person HH	-0.500
SR2, SR3+	No cars in HH	-1.745
SR2, SR3+	Escort stop purpose / # tours in day	1.288
SR2, SR3+	Other stop purposes / # tours in day	0.221
SR2, SR3+	HH income under $25K	-0.264
SR2, SR3+	HH income $25-50K	-0.263
SR2, SR3+	Child under age 5	1.376
DA	Constant	2.812
DA	HH fewer cars than drivers	-1.019
DA	HH income under $25K	-0.783
DA	HH income over $75K	0.308
DA	Child age 16-17	-1.565
DA	Escort stop purpose / # tours in day	-1.784
DA	Other stop purposes / # tours in day	0.220
Bike	Constant	-2.559
Bike	Male	0.161
Bike	Adult age 18+	0.515

Modes	Variable	Coefficient
Bike	Class 1 distance	1.078
Bike	Class 2 distance	0.882
Bike	Worst distance	-1.153
Bike	Mixed use density at origin	0.936
Bike	Total employment density at destination	0.000
Bike	Mixed use density at destination	0.212
Walk	Mixed use density at destination	0.187
Walk	Adult age 18+	-0.007
All	Mode nesting parameter	1.000

TABLE 5: HOME-BASED ESCORT TOUR MODE CHOICE MODEL

Modes	Variable	Coefficient
	Level of Service	
DA, SR2, SR3+	Path type utility log sum	3.342
	Mode-specific	
SR3+	Constant	-4.320
SR3+	HH # children under age 5	1.167
SR3+	HH # children age 5-15	0.482
SR3+	HH # students age 16-17	0.078
SR2	Constant	-3.580
SR2, SR3+	No cars in HH	-5.914
SR2, SR3+	HH fewer cars than drivers	-0.033
DA	Constant	-10.000
Bike	Constant	-14.997
Walk	Age over 50	-2.381
Walk	Intersection density at destination	0.002
Walk	HH # children under age 5	0.915
Walk	HH # children age 5-15	-0.027
Walk	HH # students age 16-17	-1.415

TABLE 6: HOME-BASED OTHER TOUR MODE CHOICE MODEL

Modes	Variable	Coefficient
	Level of Service	
DA, SR2, SR3+, WT	Path type utility log sum	2.019
DA, SR2, SR3+	Parking cost utility	0.379
	Mode-specific	

Modes	Variable	Coefficient
WT	Constant	-8.304
WT	No cars in HH	4.946
WT	Shopping tour	-1.374
WT	Mixed use density at origin	1.985
WT	Total employment density at destination	0.000
SR3+	Constant	-5.486
SR3+	One person HH	-3.645
SR3+	Two person HH	-2.046
SR2	Constant	-5.746
SR2	One person HH	-2.124
SR2, SR3+	HH # children under age 5	0.598
SR2, SR3+	HH # children age 5-15	0.126
SR2, SR3+	HH # non-working adults 18+	0.182
SR2, SR3+	Log of auto distance (miles)	0.225
SR2, SR3+	No cars in HH	-0.929
SR2, SR3+	HH fewer cars than workers	-0.116
SR2, SR3+	Escort stop purpose / # tours in day	-0.449
SR2, SR3+	Other stop purposes / # tours in day	0.337
SR2, SR3+	Shopping tour	0.073
SR2, SR3+	Meal tour	2.174
SR2, SR3+	Social/recreation tour	0.549
DA	Constant	-3.725
DA	HH fewer cars than drivers	-0.877
DA	HH income under $25K	0.115
DA	Escort stop purpose / # tours in day	-0.489
DA	Other stop purposes / # tours in day	0.232
Bike	Constant	-8.069
Bike	Male	1.036
Bike	Age over 50	-0.767
Bike	Class 1 distance	0.731
Bike	Class 2 distance	0.919
Bike	Worst distance	-0.883
Bike	Social/recreation tour	0.976
Bike	Mixed use density at origin	2.869
Bike	Household density at origin	0.001
Bike	Total employment density at destination	0.000
Bike	Mixed use density at destination	1.043
Walk	Meal tour	1.238
Walk	Social/recreation tour	3.088
Walk	Household density at origin	0.001
Walk	Household density at destination	0.000

Modes	Variable	Coefficient
Walk	Age over 50	-0.367
All	Mode nesting parameter	0.784

TABLE 7: WORK-BASED TOUR MODE CHOICE MODEL

Modes	Variable	Coefficient
	Level of Service	
DA, SR2, SR3+, WT	Path type utility log sum	1.304
DA, SR2, SR3+	Parking cost utility	1.451
	Mode-specific	
WT	Constant	-4.870
SR3+	Constant	-5.302
SR2	Constant	-5.347
SR2, SR3+	Drive alone to work tour	-0.239
SR2, SR3+	Shared ride to work tour	1.319
DA	Constant	-4.060
DA	HH income under $25K	-0.136
DA	HH income $25-50K	-0.132
DA	Drive alone to work tour	2.967
DA	Shared ride to work tour	0.347
Bike	Constant	-6.738
Bike	Male	-0.076
Bike	Bike to work tour	4.254
Walk	Walk to work tour	5.000
All	Mode nesting parameter	0.967

APPENDIX B. TRIP MODE CHOICE PARAMETERS

TABLE 8: TRIP MODE CHOICE MODEL

Modes	Variable	Coefficient
	Level of Service	
DA, SR2, SR3+, WT, SchBus	Path type utility log sum	2.456
DA, SR2, SR3+	Parking cost utility	0.954
DA, SR2, SR3+, WT, SchBus	Same as tour mode	4.715
DA, SR2, SR3+, WT, SchBus	Same as tour mode – only outbound trip	0.723
DA, SR2, SR3+, WT, SchBus	Same as tour mode – only return trip	0.583
DA, SR2, SR3+, WT, SchBus	Same as tour mode – first of 2+ outbound trips	-0.166
DA, SR2, SR3+, WT, SchBus	Same as tour mode – first of 2+ return trips	0.134
DA, SR2, SR3+, WT, SchBus	Same as tour mode – last of 2+ outbound trips	-0.037
DA, SR2, SR3+, WT, SchBus	Same as tour mode – last of 2+ return trips	-0.320
	Mode-specific	
WT	Constant	2.234
WT	HH fewer cars than drivers	-0.351
SR3+	Constant	3.836
SR3+	One person HH	-1.313
SR3+	Two person HH	-0.418
SR3+	Walk transit tour	-3.128
SR3+	School bus tour	2.377
SR2	Constant	2.415
SR2	One person HH	-0.950
SR2	Walk transit tour	-0.999
SR2	School bus tour	3.310
SR2	SR3+ tour	4.570
SR2, SR3+	HH # children age 5-15	-0.224
SR2, SR3+	No cars in HH	-2.763
SR2, SR3+	HH # non-working adults 18+	-0.009
SR2, SR3+	Work tour	-3.391
SR2, SR3+	School tour	-2.680
SR2, SR3+	Escort tour	-2.828
SR2, SR3+	Shopping tour	2.241
SR2, SR3+	Meal tour	1.104
SR2, SR3+	Social/rec tour	-0.019
SR2, SR3+	Escort to work trip , AM period (6-10 AM)	-3.284
SR2, SR3+	Work to escort trip , PM period (3-7 PM)	-2.814
SR2, SR3+	Home to escort trip , AM period (6-10 AM)	3.240

Modes	Variable	Coefficient
SR2, SR3+	Home to escort trip , MD period (10-3 PM)	-2.006
SR2, SR3+	Home to escort trip , PM period (3-7 PM)	-1.808
SR2, SR3+	Home to escort trip , EV period (after 7 PM)	-1.912
SR2, SR3+	Escort to home trip , AM period (6-10 AM)	-3.950
SR2, SR3+	Escort to home trip , MD period (10-3 PM)	-0.713
SR2, SR3+	Escort to home trip , PM period (3-7 PM)	0.234
SR2, SR3+	Escort to home trip , EV period (after 7 PM)	-1.738
DA	Constant	1.389
DA	HH fewer cars than drivers	-0.741
DA	HH income under $25K	-0.387
DA	HH income $25-45K	-0.131
DA	Child age 16-17	-0.986
DA	Drive transit tour	-1.666
DA	Walk transit tour	-4.472
DA	SR3+ tour	2.050
DA	SR2 tour	2.500
Bike	Constant	-4.148
Bike	Male	0.721
Bike	Age under 35	1.587
Bike	Intersection density at origin	0.024
Bike	Walk transit tour	-0.591
Bike	School bus tour	0.000
Bike	SR2 tour	-0.011
Bike	Drive alone tour	-1.158
Bike	Work-based tour	-0.392
Walk	Age under 35	0.790
Walk	Intersection density at origin	0.025
Walk	Mixed use density at destination	0.309
Walk	Work tour	1.598
Walk	School tour	1.313