TECHNICAL REPORT
FSUTMS Transit Model Development Guide
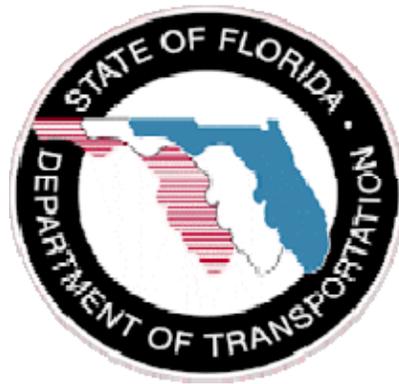
Submitted to:
Florida Department of Transportation

Submitted by:
AECOM Consult, Inc.
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Introduction

In 2006, the Florida Department of Transportation updated the transit modeling standards for the State of Florida. As part of that effort, a CUBE Voyager transit model application is being developed incorporating the updated transit modeling standards. This document provides background and describes the methodology. Details regarding the location of the application and installation procedure can be found in the *FSUTMS Transit Model Application Guide* located at http://www.fsutmsonline.net/images/uploads/mtf-files/TM_ApplicationGuide.pdf.

The transit model application is designed to be executed after trip distribution and before highway assignment. The transit model prepares the transit network, generates transit access connectors, builds transit paths and skims, performs the mode choice analysis, assigns the transit trips and produces transit assignment reports.

Chapter 1 of this document describes the elements of the transit network, including the transit lines, modes, operators, fares, speeds, and access connectors. The transit paths are described in Chapter 2. Chapter 3 reviews at the mode choice model used and explains the structure and utility equations. The transit assignment process is summarized along with the transit assignment reports in Chapter 4.

Chapter 1: Transit Network

There can be a number of different public transportation services available to travelers depending on the physical and operating characteristics, and the way the vehicle is accessed by the traveler. These characteristics are represented in a model via the transit network, which consists of transit lines, modes, operators, fares, speeds, and access connectors. These elements are discussed in detail in this chapter.

1.1 Transit Lines

The individual routes of public transportation vehicles are reflected as transit lines and are assembled into a transit line file. The coding of the line reflects the best possible representation of the routing, stop locations and frequency. The mode, operator, and route name are also identified, as well as any line-specific travel time adjustments. Stop locations are commonly identified to the nearest roadway intersections in the highway network.

Frequencies can be represented by the time of day. The line can have five different frequencies, reflected as headway. A transit route's headway is the time gap between two consecutive runs at a specific point. Each line should have at least two headways by default, one for the peak period and another for the off-peak period. If a line does not conduct service in that time period, the headway for that time period is coded as zero.

1.2 Modes

A region's transit service can consist of a single type of service, which is usually local bus service operating along arterial streets. But in many areas, transit service actually consists of many different kinds of services, with each type offering different travel characteristics. These varying characteristics have to be represented in the network in order to accurately reflect how they appear to the traveler. For example, the most important travel characteristic is travel time. Local buses, which regularly stop to board and discharge passengers and are subject to auto congestion, are typically slower than rail systems that operate on exclusive right-of-way.

The different services are reflected in the model in part by assigning them different mode numbers. Once a mode is identified, its characteristics can be mapped to the individual routes since each transit route is assigned a mode number. The default mode definitions used are summarized in Table 1 below. The default mode definitions are defined for one transit agency. The user can also define additional modes if necessary or desired. For instance, if there are two or more transit agencies, the user has to define additional modes for each agency. The second transit agency would be assigned modes 31-37, which mirror modes 21-27.

1.3 Operators

Transit operators are the agencies responsible for providing transit service. To be best reflected in the model, separate operators should be defined for each fare system offered by the transit

agency(ies). For example, if a transit agency or authority offers a single fare system, then a single operator is defined for that transit agency or authority. If a transit agency offers multiple fare systems, then multiple operators should be defined for each fare system offered by that agency.

Each transit line is assigned an operator number and the fare attached to the line is mapped to the operators. The default operators used are shown in Table 2 below.

Table 1: Default Modes and Mode Numbers

Mode	Number	Type
Walk connectors	1	Non-transit mode
PNR connectors	2	Non-transit mode
All walk connectors	4	Non-transit mode
Transfer connectors	11	Non-transit mode
Sidewalk connectors	12	Non-transit mode
Local bus	21	Transit mode
Premium service	22	Transit mode
Circulators (Skyway & trolley)	23	Transit mode
Urban(Light/Heavy) rail	24	Transit mode
Commuter rail	25	Transit mode
Other mode	26	Transit mode
Project mode	27	Transit mode

Table 2: Default Operators and Operator Numbers

Operator	Operator number
Local service	1
Circulator	2
Commuter rail	3

1.4 Fares

Transit fares are charges assessed to a traveler by an operator for using its public transportation service. There are boarding fares and transfer fares. Boarding fares are assessed upon boarding the first transit service used in a trip. Transfer fares are sometimes assessed when a traveler boards their second, third or fourth transit service on a trip. Transfer fares are typically lower than boarding fares.

There are three major fare structures used in Florida:
- Flat, where the fare is irrelevant of the journey length (e.g., $1 flat boarding fare, $0.50 flat transfer fare);
- Free, where riders board the service for free (e.g., LYMMO service in Orlando, trolley service in Jacksonville); and
- Zone-based, where the fare is based on the number of fare zones traversed (e.g., Tri-Rail).

Almost all operators in Florida utilize the flat or free structures. The initial boarding fare and transfer fares need to be coded for each operator. When using zone-based systems, it is important to remember to code FAREZONE on the node of each station in the transportation network. The recommended values for all fare systems are shown in Tables 3 and 4 below.

Table 3: Default Operator Fares

Operator	Boarding Fare
Local service	$1.50
Circulator	$0.00
Commuter Rail	$2.00

Table 4: Default Operator Transfer Fares

Faresystem ⟍ From / To	1	2	3
1 - Local Service	Free	$1.50	Free
2 - Circulator	Free	Free	Free
3 – Commuter Rail	$0.50	$2.00	Free

a. Speeds

Transit travel times are computed on a link-by-link basis in the transit model. Travel times for transit vehicles that operate in mixed-flow traffic are typically a function of auto travel time. The auto-transit time relationships used in Florida are categorized by facility type, area type and mode. Travel times for vehicles that operate on exclusive right-of-way (e.g., fixed-guideway and bus-only lanes) are computed using equations of motion.

The transit speeds have been set equal to the auto speeds in the model as default values. The user has to apply their own appropriate logic to define the speeds for all the peak and off-peak period transit modes present in the model.

b. Wait Curves

Wait curves are used to relate the frequency of transit services to the waiting time for the rider at a particular stop or station. In Florida, the wait time is assumed to be half of the service headway. The user can define up to 255 wait curves, assigning them to each stop or station node. The IWAITCURVE keyword is used to define the initial (i.e., first) boarding wait time, while the XWAITCURVE is used to define the wait time for any transfers. A minimum wait time of two minutes and a maximum wait time of 30 minutes are used. The wait curve used in the model is graphically shown in Figure 1.

c. Transit-Only Links

Occasionally it is necessary to add links that help to properly reflect transit routings that do not conform to the street network. This usually happens when buses circulate in suburban neighborhoods and use local streets not typically represented in the highway network. Representing the bus routing more accurately can provide a better reflection of bus travel times and distances. Rail lines also require special links to reflect the travel between stations. In both cases, these routings are coded as transit-only links in the highway network using a facility type of 69 and adding special fields. These fields are shown in the table below.

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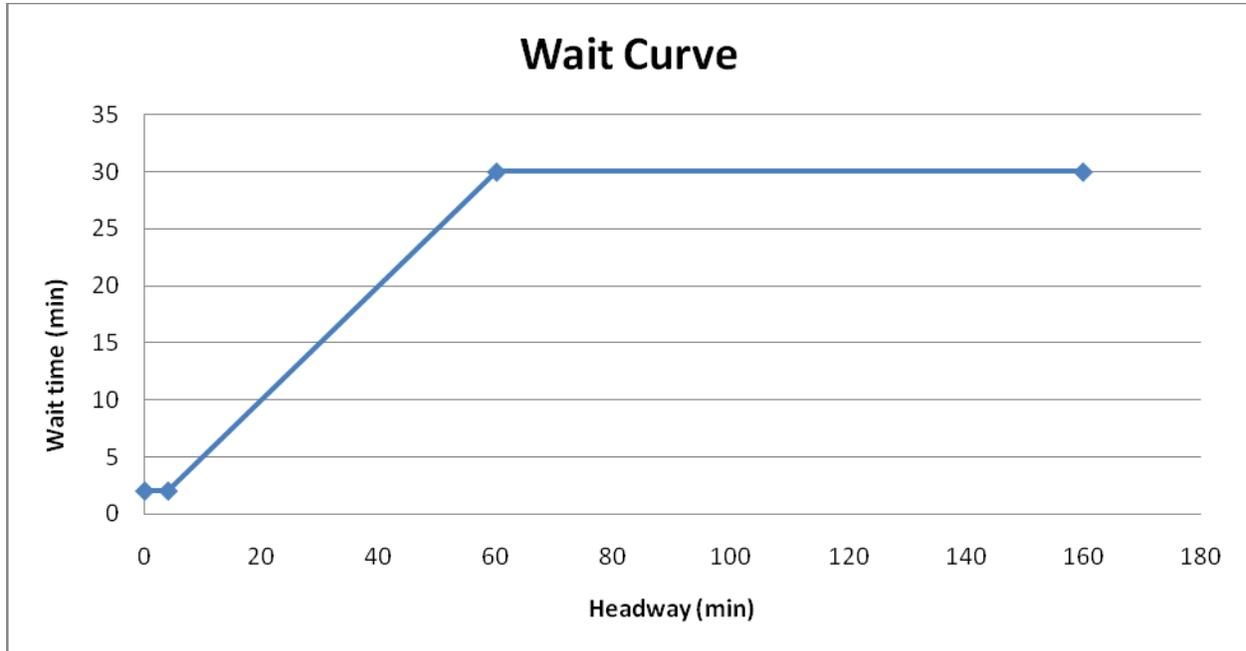
Wait Curve

Figure 1: Initial and Transfer Wait Curve Used

Table 5: Additional Fields in Transit Only Links

Parameter	Type	Description	Units
TBSDIST	Numeric	Distance for bus transit	DISTANCE (in miles)
TBSTIME	Numeric	Travel time for bus transit	Minutes
TFGDIST	Numeric	Distance for fixed-guideway transit	DISTANCE (in miles)
TFGTIME	Numeric	Travel time for fixed-guideway transit	Minutes
TFGMODE	Numeric	Applicable fixed-guideway transit mode	None

d. Station Micro-Coding

Transit stations with more than one boarding area are coded in more detail than normal transit stations. One platform is coded separately from the other in such stations. The purpose of the special coding is to reflect all known path characteristics in the network. This reduces the need for downstream adjustments, most notably via greater magnitude mode-specific bias constants in the mode choice model. It also helps to accurately represent the passengers' choices at the station. The default walk time on these links should be one minute, but should reflect the characteristics of the individual stations.

Figure 2 below illustrates the concept of micro-coding using the example of the San Marco Skyway Station in Jacksonville. The bus stop is a node on the highway network. The Skyway platform is connected to the bus stop by a transfer link with some small amount of travel time. Only the fixed-guideway system is able to access the platform. The parking area is coded somewhere between the bus stop and platform and has separate connections to both areas.
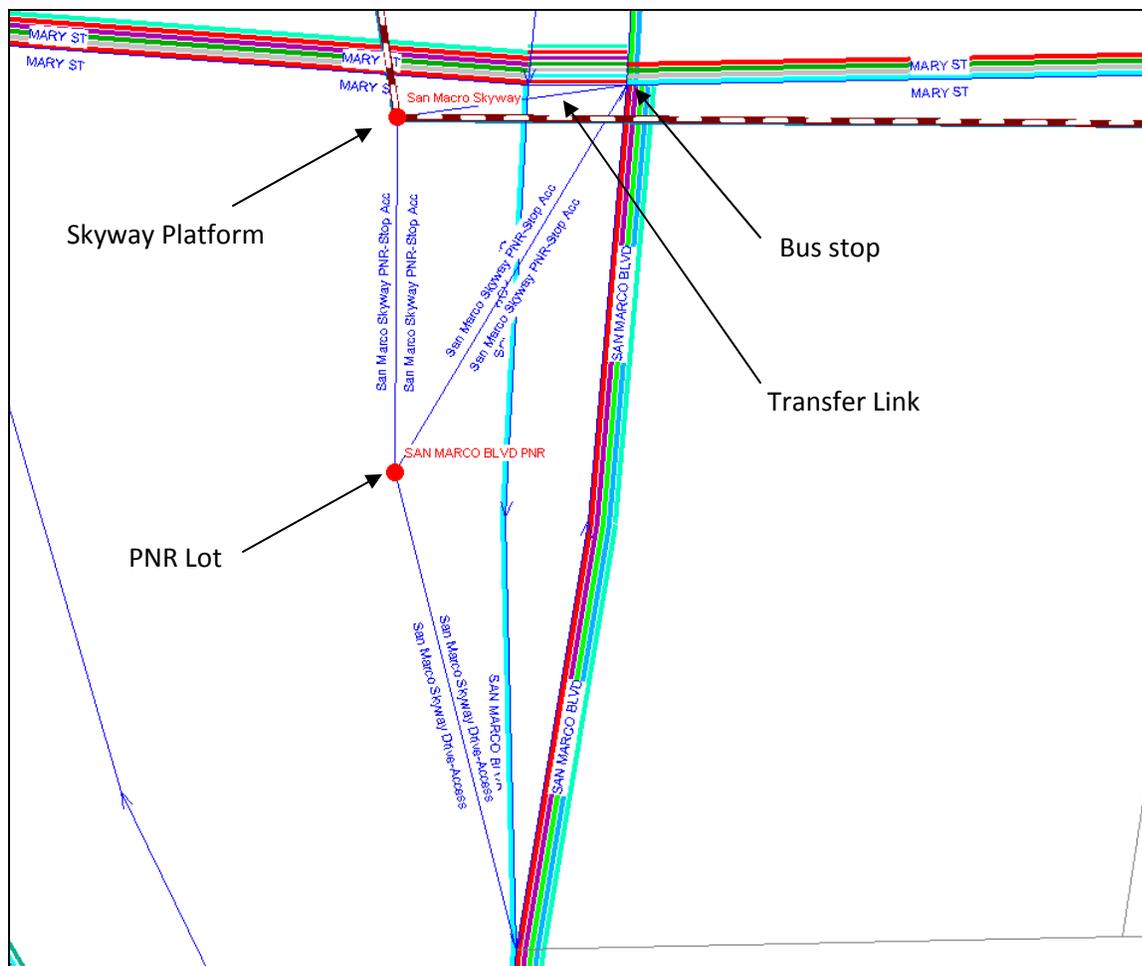
Figure 2: Micro-coding Example

e. *Park-Ride and Drop-Off Lots*

Park-ride lots are facilities where travelers may park their cars and utilize transit for the remainder of their journey. These lots have certain characteristics that need to be properly reflected in the model. These characteristics include the total number of parking spaces available, the parking cost, and the maximum roadway distance that is allowed for an auto access connector.

Other characteristics include the station terminal time and time of day operations. After parking, travelers walk to the platform to board transit. The time from the parking lot to the platform is called the station terminal time. The station terminal time will likely be shorter if the traveler is being dropped off. Finally, some park and ride lots may be operational only in the peak period.
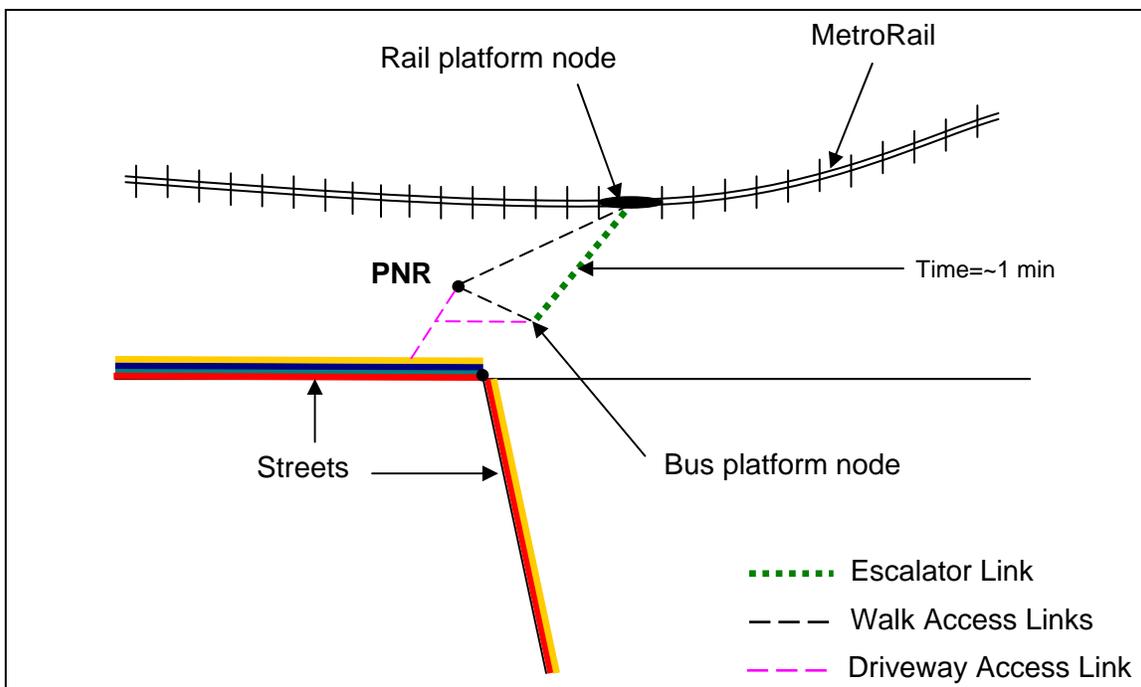
Figure 3: Park and Ride Lot Example

In order to reflect all these characteristics in the model, the distinct parking node is separated from the bus stop or platform node and allows for a more realistic representation of the park-ride lot and fixed-guideway stations. This is similar to the station micro-coding example discussed in the previous section. These characteristics of the park-and-ride lot are coded on the parking node, and not on the station/stop nodes. This coding scheme is expected by the AUTOCON program. Figure 3 above shows an example of a park-ride lot that allows the traveler to access either the Metrorail station or the bus platform.

f. Access to Transit

Transit access is the activity between a travelers' origin and the first transit vehicle boarding. From a modeling context, it occurs between the origin zone (i.e., centroid) and the transit network. It is represented by connectors between centroids and transit stops.

Accessing transit can happen by three forms: by walking, park-and-riding, or being dropped off by someone. Walk-access is walking between the origin and the first transit vehicle. Transit service must be within ½ mile (network distance) of the centroid. Park-ride-access (PNR-access) and drop-off (or kiss-ride)-access (KNR-access) occurs when a car is used from the origin to the first transit boarding. For PNR trips, the access trip portion is assumed to terminate at a formal or informal park-ride lot. KNR trips can terminate at various locations, but it is assumed that the KNR trips terminate only at locations where PNR trips terminate. This assumption allows for easier model maintenance and is based in part on a lack of sufficient information about KNR travel patterns. The different types of access connectors are explained in the following sections.

i.   *Walk Access Connectors*

A traveler walking from a centroid to a transit stop is represented in the network by a walk access connector. The path from a centroid to a transit stop is based on the shortest highway distance from the centroid to the transit stop. An average walking speed of 2.5 miles per hour is assumed. The travel time of the shortest distance is computed and stored in the cost variable on the access connector. Up to 99 walk access connectors are built from centroids to all transit stops within a 0.6 mile radius from the centroid. Longer walk connectors (up to a maximum distance of three miles) are built around PNR stations. Walk access connectors are usually generated as two-way legs to allow for complete movement. Figure 4 shows examples of walk access connectors.

Walk access connections can sometimes have inconsistencies with the percent walk data, which estimates the percentage by area of a zone that can walk to a transit stop. This issue is discussed in detail in Sections 1.3.5 and 1.3.6.
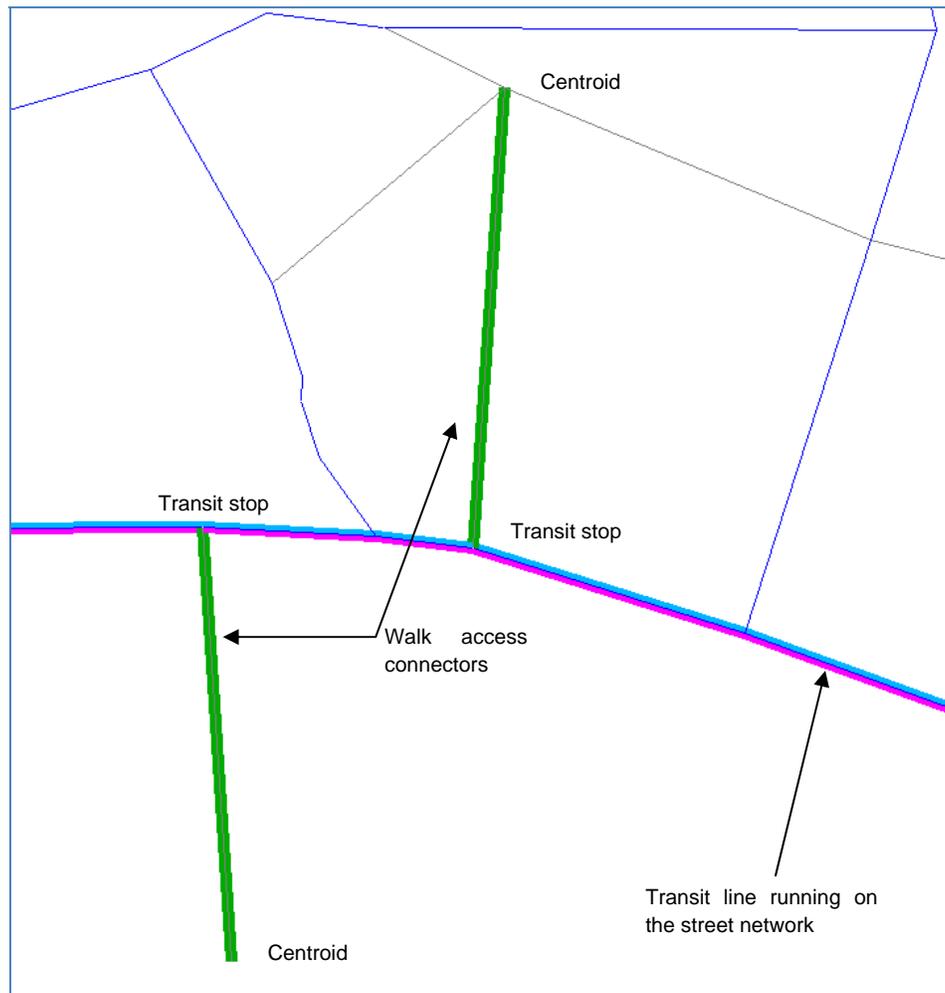
Figure 4: Walk Access Connector Example

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ii.   Auto Access Connectors

Auto-access connectors represent both PNR- and KNR-access connection. They are generated using the AUTOCON program. It is assumed that both connector types terminate at formal or well-known informal locations. Weights are used to convert the station and highway attributes (auto times, terminal time, and auto operating and parking cost) to in-vehicle travel time (IVTT) minutes. Table 6 shows the weights of the station attributes.

Auto-access connectors are built from every centroid to transit stations that are within a user-specified radius from the centroid. A maximum of three auto-access connectors are built for each zone. AUTOCON generates separate connectors to bus and rail platforms because PT does not allow consecutive non-transit legs in path-building.

Table 6: AUTOCON Station and Highway Attribute Weights

Attribute	Weight
Driving time	1.5
Terminal time	2.0
Station parking cost	$6/hr (peak), $3/hr (off-peak)
Auto operating cost	$6/hr (peak), $3/hr (off-peak)

iii.   All-walk Connectors

In some cases, the transit path from an origin zone to a destination zone may have a higher cost (in equivalent in-vehicle travel time minutes) than the walk path from the origin to the destination. In such cases, the transit skims must be removed from consideration during mode choice since walking is a better option than transit. In order to make this comparison, all-walk connectors are generated from every zone to every other zone and these connectors are assigned a mode number of 4. These connectors are generated similar to the walk to transit access connectors, with an average walk speed of 2.5 miles per hour. The shortest distance between all zones is computed. The travel time of the path is stored as the cost on the connector.

iv.   Transfer Connectors

A passenger is said to transfer when he or she alights from one transit service and boards a subsequent service on the same one-way trip. Transferring is not a form of access, but it is placed in this section as they have some common features with walk- and auto-access.

Transferring between transit services that do not stop at the same platform (i.e., stop node) require a transfer connector. These connectors are assigned a mode number of 11. There are three types of transfer connectors in the model:

- CBD sidewalks, which reflect bus stop-to-bus stop movements in downtown locations;
- Escalator links, which reflect the bus platform-to-rail platform movements (and vice-versa); and

- Station-to-nearby stops, which represent the connection between rail platform-to-nearby bus stop movements.

v.   Percent Walks

It is important to note that, on their own, the presence of walk-access connectors from a particular zone imply that transit is readily-accessible to all passengers within that zone. This is not always true because of variable zone sizes, spatial distribution of land uses and network topology. So, walk-transit coverage is estimated (usually via GIS) to better estimate a zone's transit accessibility via walk. In Florida, a ½ mile buffer is used to estimate walk-to-transit accessibility. These estimations, frequently called "percent walks", are simply a proportion of zonal area within walking distance to transit, between 0% and 100%. Percent walks are estimated for Tier B/C[1] models only. In Tier A models, transit is assumed to be readily-accessible for all zones with walk-access connectors.

It is important that if percent walks are generated using a GIS method, the following assumptions are implicitly made:

- Walk-access to transit is ubiquitously available throughout the zone;
- There is a uniform spatial distribution of productions/attractions; and
- There are no environmental/topological barriers that impede walking.

These assumptions do not conform to the walk-access connector logic employed by PT's GENERATE control statement. A method is used that balances the percent walk assumptions with the PT's connector logic. That method, the REWALK application, is discussed in the next section.

Percent walks are used for Tier B, C and D areas since zone sizes in some models are still large. Large zones exist in Tier A areas also, so a review of zone sizes for all models is strongly recommended. The percent walk of a zone is also used in mode choice calculations to develop different access markets (can walk, must drive and no transit). This is discussed in detail in Chapter 3.

vi.   REWALK

The REWALK application is a procedure that coordinates the percent walk results from GIS methods and walk-access connections developed by PT. It is needed because the assumptions and logic behind both procedures are inconsistent somewhat. This is because, the walk access connectors are generated based on shortest highway distance paths whereas percent walk of a

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[1] Refer to *FSUTMS-Voyager Transit Model Application Framework* at
http://www.fsutmsonline.net/images/uploads/mtf-files/Application_Framework-080207.pdf for the definitions of Tiers of cities.

zone is obtained based on the area of the zone that is 0.5 miles from a transit stop. The REWALK procedure coordinates these two data sets given these differing assumptions. For example, when the highway distance from the centroid to a transit stop is greater than 0.6 miles, no walk access connectors are built to that stop. In such a case, the percent walk of that zone must be changed to zero. On the other hand, the percent walk of a zone may be very small and a transit access connector may still exist. In such a case, the connector should be deleted and the percent walk must be changed to zero. These conditions are summed up in Table 7 below. Since percent walks are not estimated for Tier A models, REWALK application is not used for those models.

Table 7: REWALK Logic

Rule	If the following conditions exist…	Then these changes occur…	Because…
1	No connectors were generated	Reset all percent walks to zero	The percent walk data is likely over-estimating the accessibility of transit.
2	No transit stop at centroid connector and percent walk less than 95%	Reset all percent walks to zero and delete all connectors	Unable to determine centroid connector length. Also, connectors are likely exceeding ½ mile range from zone.
3	No transit stop at centroid connector, percent walk greater than or equal to 95% and shortest connector is less than ½ mile	None	Meant as an exception to rule #2 targeted towards CBD zones. Buses typically stop near the street corner rather than mid-block (where centroid connectors are typically coded). They are typically small zones and have good transit coverage but need to walk just beyond the zone boundary to access it.
4	No transit stop at centroid connector, percent walk greater than or equal to 95% and shortest connector greater than ½ mile	Reset all percent walks to zero and delete all connectors	Probably not a CBD zone and so rule #2 is enforced.
5	Transit stop(s) at centroid connector and zone is 100% walk	None	Percent walk data and connector length(s) are likely consistent
6	Transit stop(s) at centroid connector and percent walk is between minimum threshold and 100%	Adjust all connector times to ½ mile walk	Reasonable transit exists nearby and zone is likely too large to accurately represent walk-access time
7	Transit stop(s) at centroid connector and percent walk is less than minimum threshold	Reset all percent walks to zero and delete all connectors	The percent walk data is likely over-estimating the accessibility of transit. It is likely not accessible in reality.

CHAPTER 2: Paths and Skims

2.1 Introduction

A person traveling from their origin to their destination using the transit network elements (i.e., access connectors, transit lines and transfer connectors) creates a "path" between the two endpoints. The process of automatically generating paths, expressed in terms of generalized travel cost, between all zone pairs is called "building paths". One path – the shortest one or, more specifically, the least costly one - is produced for each origin/destination pair.

The role of the mode choice model is to evaluate all possible types of paths. Evaluating a transit path is computationally difficult. So the travel components (e.g., wait time, in-vehicle time, and the number of transfers) of the path are assembled individually into separate tables. The summary values of the components are called "skims". Assembling the individual values is called "skimming" the path. Skims are used by the mode choice model.

More than one transit path can exist in a region because of the different types of transit service and access to transit available. Different types can have a different number of travel time components altogether (e.g., walk-to-transit paths do not include auto-access time). Travel behavior, especially the immeasurable attributes of the path, can also vary by path. An example is the common "rail bias" anecdote, where rail modes have been found to attract more riders than bus modes in some areas, even when the routings of the two modes are similar.

2.2 Path Building

Four different types of paths are built for Tier B/C cities: walk-to-bus, drive-to-bus, walk-to-project, and drive-to-project. The walk-to-bus and drive-to-bus paths are built with the transit portion of the trip consisting entirely of local buses (or circulators). The only difference between walk-to-bus and drive-to-bus paths lies in the way the bus stop is accessed. To compete with the local bus paths, another set of paths (walk-to-project and drive-to-project) are built where the transit portion of the trip can wholly or partially consist of project/premium modes. However, when the transit portion of a project path consists entirely of local buses, such project paths are removed from the skim files. Table 8 shows the modes used in building different paths.

All the four paths are built from every zone to every other zone by time period. As passengers perceive different attributes of the travel differently, perceived values of attributes are used in building paths. For example, passengers usually perceive out-of-vehicle travel time (OVTT) component of the trip to be more onerous than an in-vehicle travel time (IVTT) component. So the OVTT component is given a higher weight than IVTT. All the components of the trip are weighed in order to convert them to their perceived values. The following table shows the travel time attributes and weights by path.

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Table 8: Modes Used in Different Paths

Mode		Path			
		Walk-to-bus	Walk-to-project	Drive-to-bus	Drive-to-project
Access mode	Walk access	✓	✓		
	Auto access			✓	✓
Transit mode	Local bus	✓	✓	✓	✓
	Premium bus		✓		✓
	Circulators	✓	✓	✓	✓
	Urban rail		✓		✓
	Commuter rail		✓		✓
	"Other" mode		✓		✓
	Project mode		✓		✓

Table 9: Path Weights

Travel Component	Walk-to bus	Walk-to-project	Drive-to-bus	Drive-to-project
Walk access time	2.00	2.00	2.00	2.00
Auto access time	1.00	1.00	1.00	1.00
All-walk time	9.99	9.99	9.99	9.99
Transfer time	2.00	2.00	2.00	2.00
Sidewalk time	2.00	2.00	2.00	2.00
Local bus travel time	1.00	1.30	1.00	1.30
Premium service travel time	9.99	1.00	9.99	1.00
Circulator travel time	1.00	1.30	1.00	1.30
Urban rail travel time	9.99	1.00	9.99	1.00
Commuter rail travel time	9.99	1.00	9.99	1.00
"Other" mode travel time	9.99	1.00	9.99	1.00
Project mode travel time	9.99	1.00	9.99	1.00
Boarding penalty	-	-	-	-
Initial and transfer wait time	2.00	2.00	2.00	2.00
Transfers (no. of transfers)	10.00	10.00	10.00	10.00

Two different types of paths are built for Tier A cities: walk-to-transit and drive-to-transit. In both types of paths, the transit portion of the trip can consist of any transit mode in the model. The only difference between walk-to-bus and drive-to-bus paths lies in the mode of access.

2.3 Transit Skims

The individual values of the travel components are stored in skim files and are used in the mode choice step to set up the utilities for the transit paths. The values stored in skim files represent the actual values of the attributes, and not the weighted value used in path building step. The following table explains the skim tables that are used in the mode choice step.

Table 10: Transit Skims Tables

Table No.	Table Name	Description
1	Walktime	Walk access (mode 1 link) connector travel time
2	Autotime	Auto access (mode 2 link) connector travel time
3	Sidewalktime	Transfer and sidewalk travel times (mode 11 link travel time+mode 12 link travel time)
4	Bustime	Local bus travel time (mode 21 link)
5	Pbustime	Premium bus travel time (mode 22 link)
6	Circtime	Circulator travel time (mode 23 link)
7	Railtime	Urban rail travel time (mode 24 link)
8	Comrltime	Commuter rail travel time (mode 25 link)
9	Othtime	"Other" mode travel time (mode 26 link)
10	Prjtime	Project mode travel time (mode 27 link)
11	Xfer	Number of transfers
12	Iwait	Initial wait time
13	Xwait	Transfer wait time
14	Fare	Transit fare
15	Tottime	Total time

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CHAPTER 3: Mode Choice

3.1 Introduction

The purpose of the mode choice model is to estimate the shares of person trips using different modes. The Tier B/C mode choice model evaluates three auto sub-modes (i.e., drive alone, high occupancy vehicle-two occupants, and high occupancy vehicle-three or more occupants) and six transit sub-modes (walk-bus, walk-project/premium mode, PNR-bus, PNR-project/premium, KNR-bus and KNR-project/premium). The Tier A mode choice model has the same auto sub-mode structure as the Tier B/C model, and three transit sub-modes (walk-transit, PNR-transit and KNR-transit).

The FSUTMS mode choice model is a nested logit model, which is a behavioral model that is used to predict a decision maker's choice of one alternative from a set of alternatives. For any given choice, the probability of a mode being chosen is given by:

$$P_m = \frac{e^{U_m}}{\sum_{i=1}^{M} e^{U_i}}$$

Where:

P_m = Probability of choosing mode m
U_m = Utility of mode m
M = Number of different modes to be chosen among

A nested logit model is developed by grouping subsets of available alternatives that are more similar to each other than they are to other alternatives. The nesting structures of the mode choice models used for Tier A and Tier B/C areas are shown in Figures 5 and 6.

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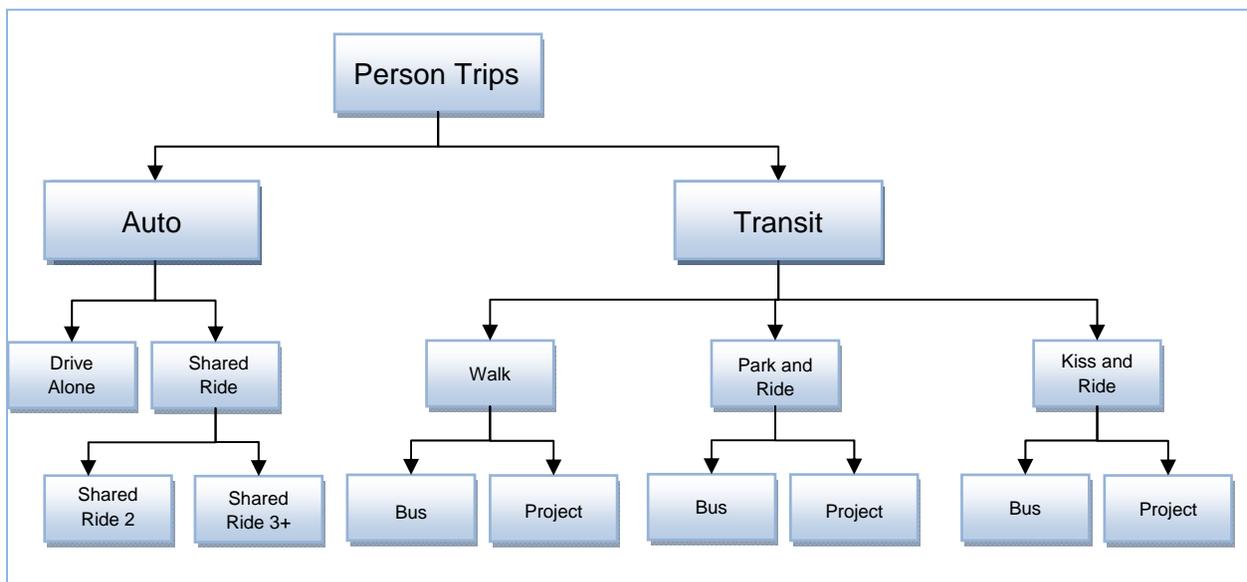
**Figure 5: Nested Logit Structure for Tier B/C Areas**
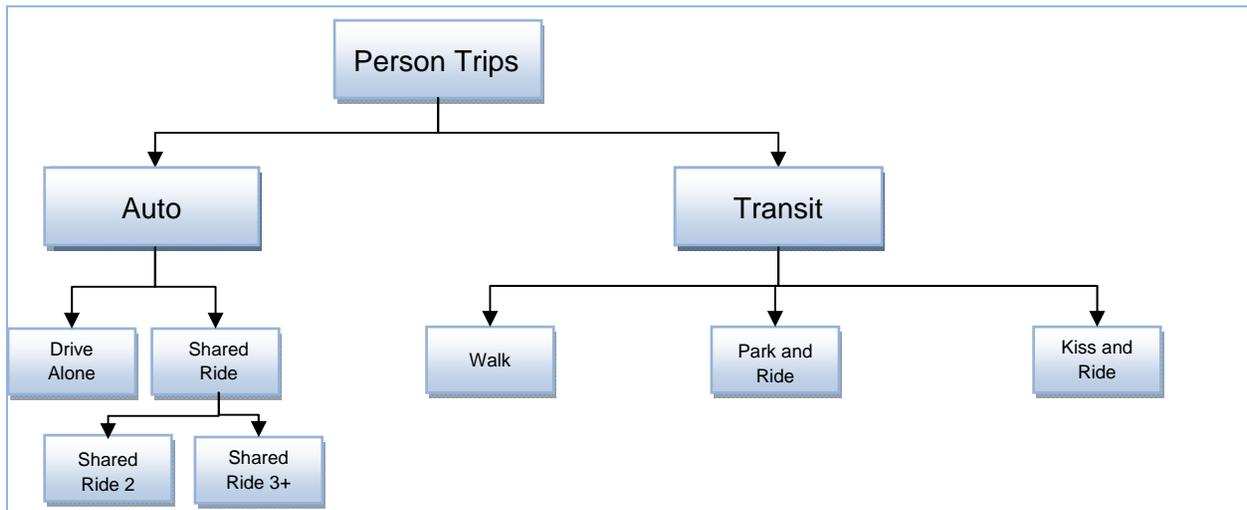
Figure 6: Nested Logit Structure for Tier A Area

The choices at the top level are auto and transit. The auto nest is divided into drive alone and shared ride trips. Shared ride trips are further divided into two passenger trips (SR2) and three or more passenger trips (SR3+). The transit nest is divided into the various access markets: walk, PNR, and KNR trips. The access trips are further sub-divided into bus and project modes (where available). By default, bus rapid transit (BRT) is included in the bus nest.

A nested logit mode choice model works by computing the utility for each of the bottom level choices (for example, in Figure 6, drive alone, SR2, SR3+, transit with walk access, transit with PNR, transit with KNR). This utility represents the total economic "cost" in terms of travel time, cost, and other impediments/inducements to travel associated with each mode. It is typically constructed as a linear function of the different components of time and cost as shown below:

$$U_m = (C_1 * IVTT_m + C_2 * OVTT_m + C_3 * WAIT_m + C_4 * COST_m + C_5 * DATA1_m + \ldots + C_{0m}) * 1/NC_m$$

Where:

U_m = Utility for mode *m*
$C_1, C_2, C_3, C_4, C_5..$ = Statistically estimated coefficients
C_{0m} = Mode-specific constant for mode *m*
$IVTT_m$ = In-vehicle travel time for mode *m*
$OVTT_m$ = Out-of-vehicle travel time for mode *m*
$WAIT_m$ = Wait time for mode *m*
$COST_m$ = Travel cost or fare for mode *m*
$DATA1_m \ldots$ = Other data elements characterizing the mode *m* trip
NC_m = Product of the nest coefficients for all upper nests

The components of utility for all the alternatives of the mode choice model for Tier B/C and Tier A cities are shown in Tables 11 and 12.

Table 11: Utility Components of Mode Choice (Tier B/C area)

Component	Drive alone	Shared Ride		Walk		Park-and-ride		Kiss-and-ride	
	DA	SR2	SR3+	Bus	Project	Bus	Project	Bus	Project
Bias constant	✓	✓	✓	✓	✓	✓	✓	✓	✓
Terminal time	✓	✓	✓						
Auto in-vehicle time	✓	✓	✓						
Auto access time						✓	✓	✓	✓
Toll cost	✓	✓	✓						
Auto parking cost	✓	✓	✓			✓	✓		
Auto operating cost	✓	✓	✓						
Walk and transfer time				✓	✓	✓	✓	✓	✓
Initial and transfer wait				✓	✓	✓	✓	✓	✓
Transit-in-vehicle time				✓	✓	✓	✓	✓	✓
Number of transfers				✓	✓	✓	✓	✓	✓
Transit fare				✓	✓	✓	✓	✓	✓
CBD dummy	✓	✓	✓	✓	✓	✓	✓	✓	✓
Exurban production dummy	✓	✓	✓	✓	✓	✓	✓	✓	✓
Exurban attraction dummy	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 12: Utility Components of Mode Choice (Tier A area)

Component	Drive alone	Shared Ride		Walk	Park-and-ride	Kiss-and-ride
	DA	SR2	SR3+	Bus	Bus	Project
Bias constant	✓	✓	✓	✓	✓	✓
Terminal time	✓	✓	✓			
Auto in-vehicle time	✓	✓	✓			
Auto access time					✓	✓
Toll cost	✓	✓	✓			
Auto parking cost	✓	✓	✓		✓	✓
Auto operating cost	✓	✓	✓			
Walk and transfer time				✓	✓	✓
Initial and transfer wait				✓	✓	✓
Transit-in-vehicle time				✓	✓	✓
Number of transfers				✓	✓	✓
Transit fare				✓	✓	✓

The utility for an upper level nest is computed by taking the logsum of the lower level nests. For example, the utility for all auto for the nesting structure of Figures 5 and 6 is computed from the utilities for drive alone, SR2, and SR3+ modes as follows:

$$U_{auto} = NC_{auto} * \ln(\exp(U_{da}) + \exp(U_{sr2}) + \exp(U_{sr3+}))$$

Where:
U_{auto} = Utility for auto
NC_{auto} = Nest coefficient for auto nest
$\ln()$ = Natural logarithm
$\exp()$ = Exponential function
U_{da} = Utility for drive-alone
U_{sr2} = Utility for shared ride 2 mode

U_{sr3+} = Utility for shared ride 3+ mode

The total market is divided into zero-car, one-car and two or more-car households for the home-based-work (HBW) and home-based-other (HBO) purposes. No market segmentation is done for the non-home-based (NHB) purpose.

The mode choice and CBD coefficients are summarized in Table 13 below. The default values of all constants – included CBD constants - are set to 5.00 and should be calibrated in the model by the user.

Table 13: Mode Choice Default Coefficients

Row #	HBW	HBNW	NHB	Description
1	-0.025000	-0.012500	-0.025000	IVTT coefficient
2	-0.025000	-0.012500	-0.025000	IVTT coefficient for commuter rail
3	-0.050000	-0.025000	-0.050000	OVT coefficient
4	-0.002500	-0.002500	-0.005000	Cost coefficient
5	-0.037500	-0.018750	-0.037500	Auto access time coefficient
6	-0.250000	-0.125000	-0.250000	Number of transfers coefficient
7	0.000000	0.000000	0.000000	Not used
8	0.000000	0.000000	0.000000	Not used
9	0.000000	0.000000	0.000000	Not used
10	0.500000	0.500000	0.500000	Transit access nest coefficient
11	0.500000	0.500000	0.300000	Transit nest coefficient
12	0.800000	0.800000	0.800000	Auto nest coefficient
13	0.200000	0.200000	0.200000	Auto access nest coefficient
14	0.000000	0.000000	0.000000	Not used
15	5.000000	5.000000	5.000000	CBD Constant Walk Paths
16	5.000000	5.000000	5.000000	CBD Constant PNR Paths
17	5.000000	5.000000	5.000000	CBD Constant KNR Paths
18	0.000000	0.000000	0.000000	Not used

Table 14 shows the constants used in the model. The default constants are all set to 5.00 and need to be calibrated in the model by the user. Utility constants having a value of -999.99 effectively produce zero trips for a particular sub-mode.

The final step in the mode choice application is placing the auto vehicle portion of the auto access transit trip onto the highway vehicle trip table. Each auto-access trip is divided by a user defined occupancy rate is added from the origin zone to the parking or drop-off zone.

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Table 14: Mode Choice Default Constants

Row #	HBW	HBNW	NHB	Market	Description
1	-999.990000	-999.990000	0.000000		Drive alone
2	5.000000	5.000000	5.000000		Shared ride 2 passenger
3	5.000000	5.000000	5.000000		Shared ride 3+ passengers
4	5.000000	5.000000	5.000000		Walk bus
5	5.000000	5.000000	5.000000		Walk project
6	-999.990000	-999.990000	5.000000	Zero-car households	PNR bus
7	-999.990000	-999.990000	5.000000		PNR project
8	5.000000	5.000000	5.000000		KNR bus
9	5.000000	5.000000	5.000000		KNR project
10	-999.990000	-999.990000	-999.990000		Not used
11	-999.990000	-999.990000	-999.990000		Not used
12	-999.990000	-999.990000	-999.990000		Not used
13	5.000000	5.000000	-999.990000		Drive alone
14	5.000000	5.000000	-999.990000		Shared ride 2 passenger
15	5.000000	5.000000	-999.990000		Shared ride 3+ passengers
16	5.000000	5.000000	-999.990000		Walk bus
17	5.000000	5.000000	-999.990000		Walk project
18	5.000000	5.000000	-999.990000	One-car households	PNR bus
19	5.000000	5.000000	-999.990000		PNR project
20	5.000000	5.000000	-999.990000		KNR bus
21	5.000000	5.000000	-999.990000		KNR project
22	5.000000	5.000000	-999.990000		Not used
23	-999.990000	-999.990000	-999.990000		Not used
24	-999.990000	-999.990000	-999.990000		Not used
25	0.000000	0.000000	-999.990000		Drive alone
26	5.000000	5.000000	-999.990000		Shared ride 2 passenger
27	5.000000	5.000000	-999.990000		Shared ride 3+ passengers
28	5.000000	5.000000	-999.990000		Walk bus
29	5.000000	5.000000	-999.990000		Walk project
30	5.000000	5.000000	-999.990000	Two-car households	PNR bus
31	5.000000	5.000000	-999.990000		PNR project
32	5.000000	5.000000	-999.990000		KNR bus
33	5.000000	5.000000	-999.990000		KNR project
34	-999.990000	-999.990000	-999.990000		Not used
35	-999.990000	-999.990000	-999.990000		Not used
36	-999.990000	-999.990000	-999.990000		Not used

3.2 Mode Choice Auto Calibration

Calibrating the mode choice model is the process of adjusting the mode-specific bias constants until the resulting shares correspond with observed values. This can be accomplished by using the auto-calibration routine included in the transit model. The routine adjusts the constants based on the shares specified. During calibration, the constants and CBD coefficients (also constants, but placed in the coefficient file) are overwritten. The number of required iterations depends on the difference between estimated and observed values. It may take 30 iterations to calibrate the first time.

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3.3 Summit Data Files

The FSUTMS mode choice model includes a utility called TPP2UB, which converts specially constructed matrices to data files for use with the Federal Transit Administration's Summit program. The format of the matrices produced from the mode choice model is shown in Table 15. Summit is meant for large-scale transit projects that are seeking federal funding, but it can be used for any transit project if appropriate. TPP2UB creates Summit binary files for each of the three trip purposes. They can be directly read by the Summit program.

Table 15: Summit Data File Tables

Table No.	Table Name	Description
1	PerTrip0	Person trips in the 0 car market segment
2	Auto Trn Trip0	Motorized trips in 0 car market segment
3	AutoPrice0	Exponentiated auto utility
4	WalkFrac0	Share of total trips that can walk among 0 car market segment person trips
5	WalkShare0	Share of 0 car transit trips that can walk among total 0 car trips that can walk
6	DriveFrac0	Share of total trips that must drive among 0 car market segment person trips
7	DriveShare0	Share of 0 car transit trips that must drive among total 0 car trips that must drive
8	PerTrip1	Person trips in the market segment
9	Auto Trn Trip1	Motorized trips in market segment
10	AutoPrice1	Exponentiated auto utility
11	WalkFrac1	Share of total trips that can walk among 1 car market segment person trips
12	WalkShare1	Share of 1 car transit trips that can walk among total 1 car trips that can walk
13	DriveFrac1	Share of total trips that must drive among 1 car market segment person trips
14	DriveShare1	Share of 1 car transit trips that must drive among total 1 car trips that must drive
15	PerTrip2	Person trips in the market segment
16	Auto Trn Trip2	Motorized trips in market segment
17	AutoPrice2	Exponentiated auto utility
18	WalkFrac2	Share of total trips that can walk among 2 car market segment person trips
19	WalkShare2	Share of 2 car transit trips that can walk among total 2 car trips that can walk
20	DriveFrac2	Share of total trips that must drive among 2 car market segment person trips
21	DriveShare2	Share of 2 car transit trips that must drive among total 2 car trips that must drive

CHAPTER 4: Transit Assignment

4.1 Transit Assignment Process

Transit assignment is the process of loading the transit trip tables onto the transit paths. The trip table obtained from the mode choice model is assigned to the paths built during the path building step. Transit trips are assigned to the minimum cost path by an all-or nothing method for each combination of mode and access. Unlike trips estimated during the mode choice step, assigned transit trips can be identified on all modes that they use to get to a destination. In other words, transit trips are measured by route and represent unlinked trips by mode. HBW trips are assigned to the peak period transit paths and the non-work trips are assigned to off-peak period paths. Trips from all trip purposes are always assigned in the P-to-A direction. For example, if there are 100 trips from zone *i* to zone *j*, and 60 trips from zone *j* to zone *i*, P-to-A assignment assigns 160 trips in the *i-j* direction. Because of this directionality, all transit assignment results must be post-processed to derive any time-of-day results.

4.2 Reporting

The results of transit assignment are a series of reports that detail the boarding and alighting activity along each route and station. Four different reports are produced: transit assignment summary report, route report, station activity report and network volume report. The transit assignment summary report presents the total travel time, frequency, and total number of passengers, passenger miles, passenger hours, and maximum load by route, mode, and operator. The route report presents the leg travel time, the cumulative travel time, ons, offs, leg distance, cumulative distance and the load for all the routes. Further, the total passenger miles, passenger hours, and the average trip length are reported.

The station activity report presents the frequency of all the transit services visiting the station, the number of passengers accessing and egressing the station, and the boardings and alightings at the station. The access and egress data presented in this report are based on P-to-A assignment. It should be noted that the boardings at a station can exceed the sum of accesses from all access modes as there can be transfers between transit routes at a station. Such transfers will appear in the boarding column but not in any of the access mode columns.

Total transit volumes along corridors (by each link in the corridor) can be visually displayed in a specially-prepared network called TransitLinkLoad_{alt}{year}.NET (n.b., {alt} stands for the catalog key representing the alternative and {year} stands for the catalog key representing the year). The link transit volumes are calculated by summing the transit volumes of all the routes traveling on that link.