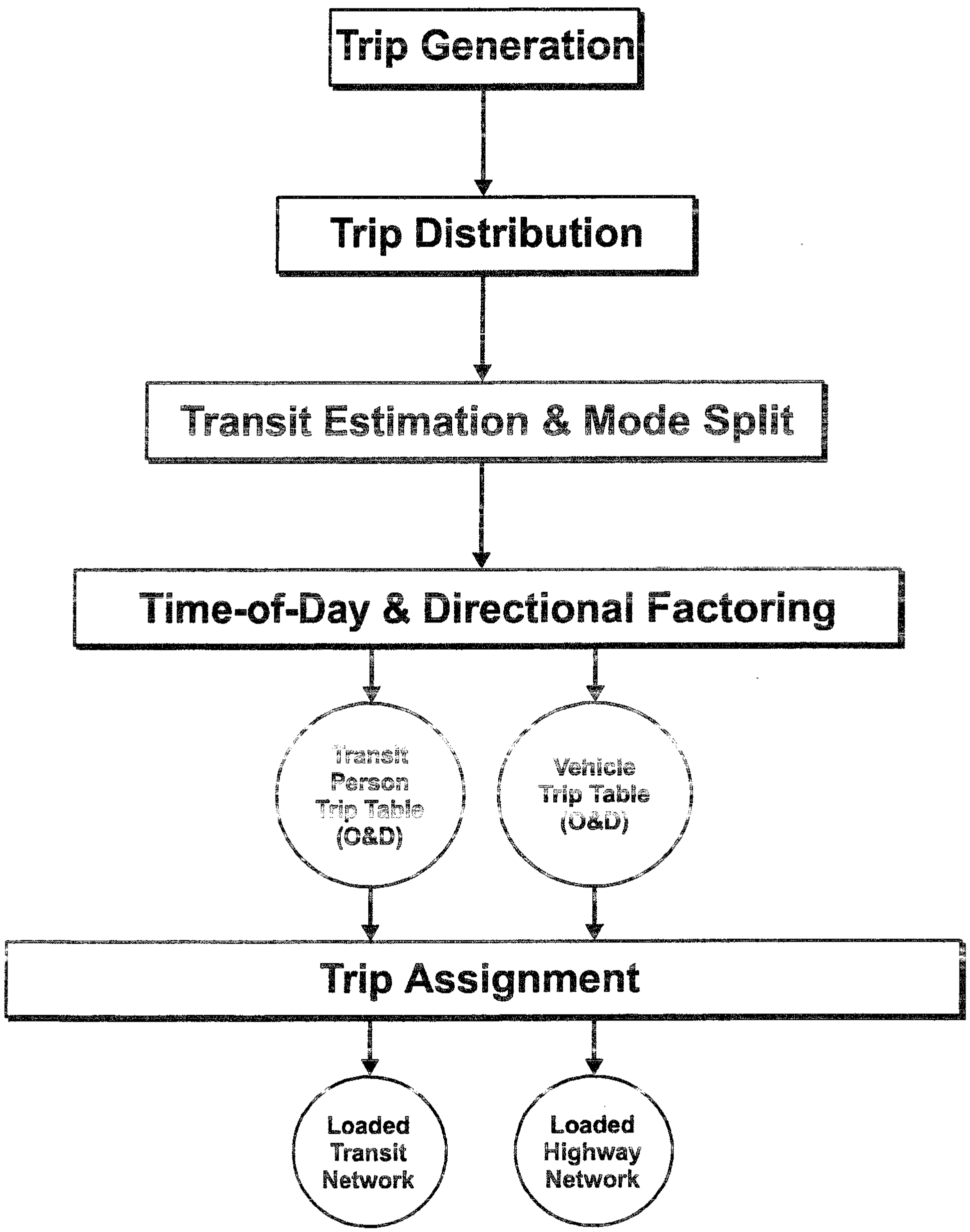
Session 10: Trip Assignment



Session 10:
Trip Assignment

Objectives:

- Explain the concept of an all-or-nothing assignment
- Explain the concept of an equilibrium assignment
- Identify the BPR formula
- Identify the sources of the input data to the BPR formula
- Explain the application of the BPR formula in an equilibrium assignment
- Explain the meaning of the volumes from an all-or-nothing assignment
- Explain the meaning of the volumes from an equilibrium assignment

Session 10:
Trip Assignment

Session Outline

- Terminology
- Key concepts
- Inputs and outputs for trip assignment
- Forecasting for future assignments
- Error checking and validation

Session 10:
Trip Assignment

SESSION OUTLINE

This session discusses the terminology involved in the trip assignment step and introduces the concepts used for an all-or-nothing assignment, an equilibrium assignment, a public transit assignment, and how speed changes as a function of roadway volume and capacity.

The session highlights inputs and outputs for traffic assignment, forecasting for future assignments, error checking, validation, and calibration.

Notes:

Terminology

- Highway/trip assignment
- Transit trip assignment
- All-or-nothing assignment
- Equilibrium assignment
- Freeflow speed
- Path finding
- Impedance
- Path loading
- Level of service
- Capacity restraint

Terminology

Highway/trip assignment is the fourth step in the traditional travel demand forecasting process. The highway assignment step determines the most probable set of routes through the highway network that will be used by a given set of origin to destination highway flows. This step often is called "loading the network" because this step assigns volume estimates to each coded link in the network.

Transit trip assignment is the step that determines the most probable set of routes through the transit network that will be used by a given set of origin to destination transit flows.

All-or-nothing assignment is the most basic form of trip assignment, which loads all trips for each zone pair to one shortest path. It assumes there are no congestion effects and that all drivers perceive and weigh route choice attributes the same way.

Equilibrium assignment is an iterative assignment technique where iterations are performed until all used routes between the O&D pair have equal and minimum impedance (travel time), while all unused routes have equal or greater impedance (travel time).

Freeflow speed is a speed that reflects typical roadway conditions without the effects of congestion.

Path finding is finding the minimum impedance paths between all TAZs in a network

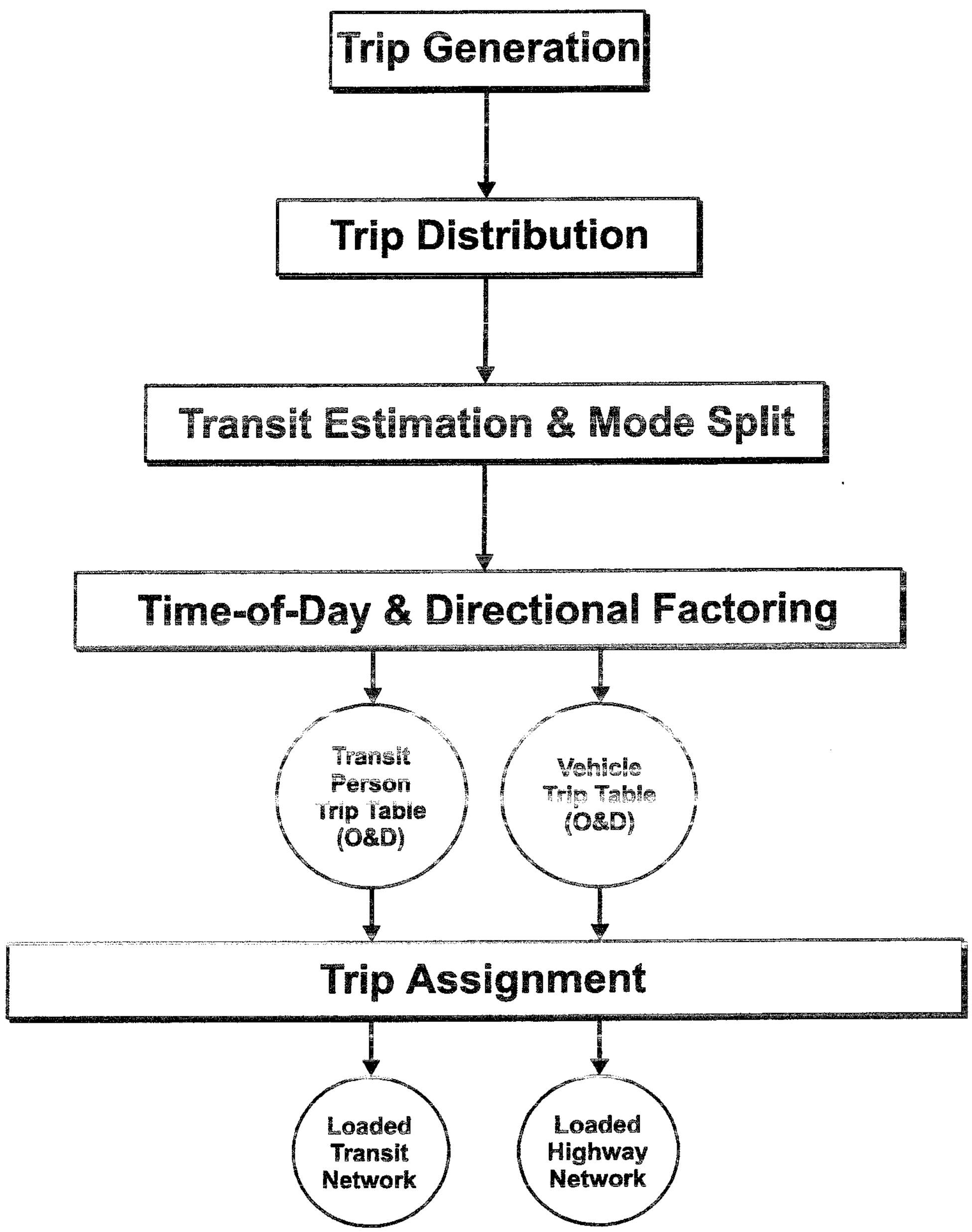
Impedance is a measure of time and/or cost expressed in terms of the "generalized cost" of traversing a particular link.

Path Loading is the actual "assigning" or loading of trips to the links comprising a path.

Level of services (LOS) is a qualitative measure describing operational conditions within the traffic stream, generally described in terms of factors such as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Capacity restraint is the process by which the assigned volume on a link is compared with the coded capacity of that link and the travel time or speed of the link adjusted to reflect the relationship between speed and volume and capacity. The procedure is iterative until a balance between the assigned volume and the coded capacity is achieved.

Key Concepts



Key Concepts

TRIP ASSIGNMENT

Trip assignment is the process of allocating a given set of trip interchanges to a specific road network. Traffic assignment accomplishes this by:

- Identifying a set of routes that might be used by drivers. The driver wants to minimize impedance, which is a function of freeflow speed, demand, and capacity. These routes are stored in a data structure called a tree. This step often is referred to as the tree-building stage.

- Assigning suitable proportions of the trip table to these routes or trees results in flows on the network.

- Searching for convergence. Different assignment techniques have different iteration strategies for achieving convergence.

Notes:

Trip Assignment Methods

- All-or-nothing assignment
- Equilibrium assignment
- Transit assignment

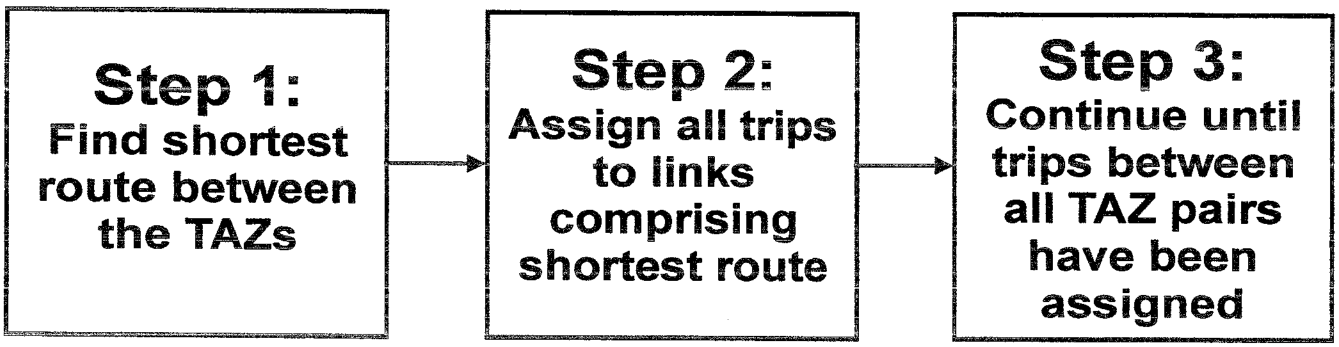
Trip Assignment Methods

Although manual traffic assignment techniques are possible for very small networks, traffic assignment requires the use of digital computers. These computerized approaches are based on the assumption that the underlying principle for route selection is *user equilibrium*. In a network where user equilibrium is reached, no user can improve travel time (impedance) by unilaterally changing routes. Most assignment methods use the concept of capacity restraint, as the volume/capacity ratio increases, travel time increases. The following trip assignment methods will be described in this session:

- all-or-nothing assignment,
- equilibrium assignment, and
- transit assignment.

Notes:

All-or-Nothing Assignment



Advantages

- Simple
- Inexpensive
- Results easy to understand

Disadvantage

- Assumes all traffic will travel on shortest path
- Creates unrealistic flow patterns

All-or-Nothing Assignment

In an all-or-nothing assignment, the minimum impedance (travel time) route (path) for each O&D pair is found. All flows (trip interchanges) between these pairs are loaded on these routes. A given route receives all or nothing of a given O&D pair's flow, without any consideration of the capacity available on the route.

To perform the all-or-nothing assignment, you need a trip table to be assigned and the link information (link length and freeflow speed) so that the uncongested impedance between the different O&D pairs can be computed. The following steps are performed:

Step 1: Compute the minimum impedance paths for each O&D pair using the uncongested travel impedance.

Step 2: Assign all trips from each origin to each destination to the minimum paths.

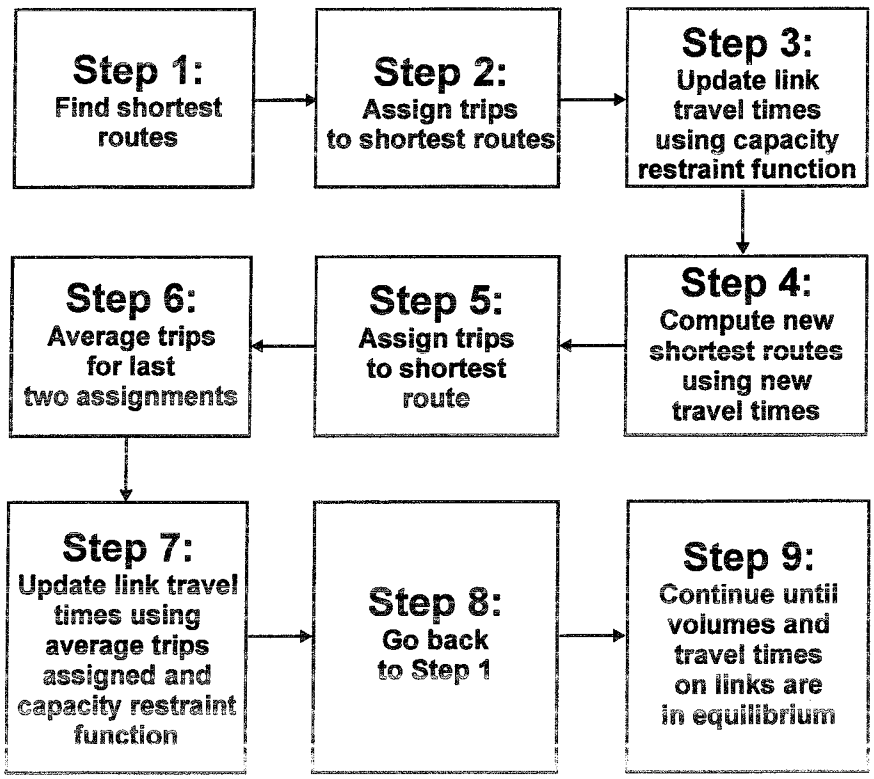
Step 3: Sum the trip volumes assigned to each link. Any particular link could be in the minimum impedance path for many O&D pairs.

This is a simple and fast method. This method depicts the routes most travelers would use in the absence of capacity and congestion effects. Results of this method are easy to understand and interpret. This method is used to help determine if the network was coded correctly by computing and plotting trees. A tree is a record or plot showing the shortest impedance routes from a given zone to all other zones in the network. This method also provides a picture of the true desired route of travel and the resulting travel volumes if all travelers were to use the route.

The disadvantage of this method is that it generates unrealistic flow patterns in situations where capacity and congestion effects exist.

Notes:

Equilibrium Assignment



- Utilizes the concept of capacity restraint (link impedance depends on link flow levels)
- Assigns traffic in congested networks so that no individual trip maker can reduce path costs by switching routes
- Assumes trip makers know conditions on all routes

Equilibrium Assignment

The equilibrium assignment technique utilizes the concept of capacity restraint The concept of capacity restraint uses link flows (volumes), link capacities, and link speed to predict link impedance (travel time). This technique searches for a user equilibrium solution in which link flows and impedance are simultaneously solved. Under equilibrium conditions, traffic is assigned in congested networks so that no individual trip maker can reduce path impedance by switching routes. This assumes that trip makers know the traffic conditions on all routes.

Notes:

Transit Assignment

- Links include different services running between stops or stations
- Involves movement of passengers, not vehicles
- Complex interchange patterns associated with passengers
- Impedance functions includes fare structure
- Some paths offer more than one parallel service with complex associated choices (e.g., express bus versus local bus service)

Transit Assignment

Transit trip assignment is different and more complex than highway trip assignment because:

- The network of transit services is different from that for vehicles. Links in this network include bus or rail service running between two stops or stations. Many of the public transit services share road links with private cars. These differences result in an assignment to a more complex network.
- The transit assignment involves the movement of passengers, not vehicles. The travel time has an in-vehicle component as well as out-of-vehicle time, such as waiting at stops and walking to and from stops. Passengers also may transfer between two routes, and even drive part of the way to board a public transit service.
- In private car networks, the monetary cost is directly associated to fuel consumption, tolls, and parking. In transit services, the different fare structures determine the monetary cost associated with a trip. There also is transfer cost and parking if an auto is used to get to the transit station.
- For some O&D pairs, there are sections in the path where more than one parallel service is offered. This parallel service allows passengers to select a preferred service. This choice can be complex and requires a detailed assignment method.

Notes:

Capacity Restraint

Capacity Restraint

- Volume-delay relationship

- Average travel speed decreases with increased flow (volume)

- Average travel time increases as the volume-to-capacity ratio on a link increases

- The Bureau of Public Roads (BPR) formula, used as a default in most model packages, shows this relationship:

  $$T = T_0 \, [1 + 0.15 \, (v/c)^4]$$

  Where:

  T = congested link travel time;
  T_0 = original link (freeflow) travel time;
  v = assigned traffic volume; and
  c = the link capacity

Capacity Restraint

The trip assignment step uses volume-delay relationships. As traffic volumes increase, travel speeds decrease due to increased congestion. Capacity restraint uses the link freeflow speeds and capacities to control the final assigned link speeds. Recall from the session on network development that link speeds and capacities are determined by using look-up tables that relate these variables to the facility type or functional classification of the link, the area type surrounding the link, and the number of lanes. The capacity per lane is a function of the LOS used for coding the look-up table. A LOS D capacity is normally used with the Bureau of Public Roads (BPR) formula.

The BPR function is the most commonly used function for relating changes in travel speed to increases in travel volume. The BPR function is specified as follows:

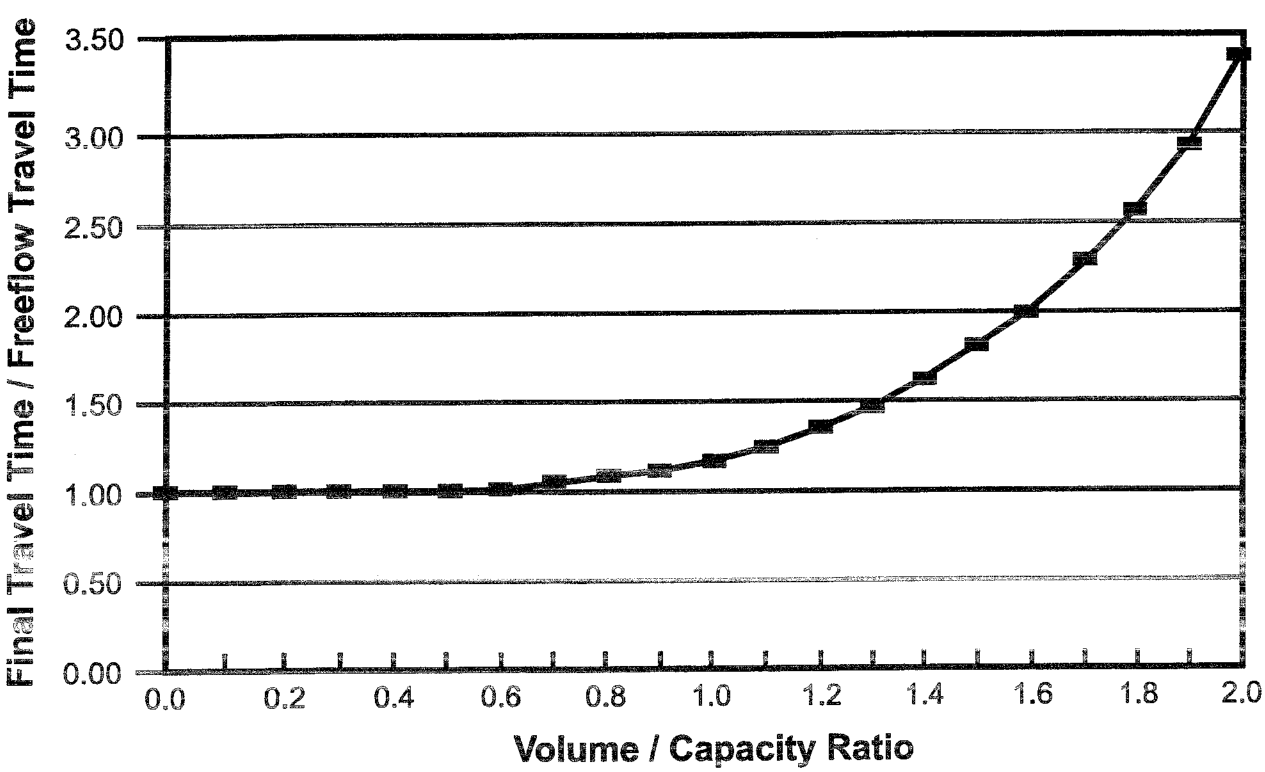
$$T = T_0 \, [1 + 0.15 \, (v/c)^4]$$

Where:

- T = congested link travel time;
- T_0 = original (freeflow) link travel time;
- v = assigned traffic volume; and
- c = the link capacity

Notes:

Final Travel Time/Freeflow Travel TimeVersus Volume/Capacity Ratio



Final Travel Time/Freeflow Travel TimeVersus Volume/Capacity Ratio

The graph on the preceding page and table below show how the ratio of the final travel time and the freeflow travel time increases with increased traffic volume on a specific link by applying the BPR formula.

Travel Time Versus V/C Ratio

V/C	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
T/T_0	1.00	1.00	1.00	1.02	1.06	1.15	1.31	1.58	1.98	2.57	3.40

Where:

V/C = Volume/capacity ratio
T/T_0 = Final travel time/freeflow travel time

Notes:

Inputs and Outputs

Inputs

- O&D trip table
- Coded network

Outputs

- Link flows as per coded network
- Link travel times/speeds
- VMT
- Vehicle hours of travel

Inputs and Outputs

Inputs for trip assignment include:

- An O&D trip table expressing estimated demand. This trip table is a peak-hour or peak period trip table for large urban areas. A 24-hour trip table is often used for uncongested small urban areas.

- A coded network includes the following:
  - nodes;
  - links, direction of flow;
  - link distance, in hundredths of miles;
  - facility type;
  - number of lanes; and
  - area type.

The facility type, area type, and number of lanes are used with a look-up table to determine the link freeflow speed and the link capacity.

Outputs for trip assignment include:

- assigned volumes on each link in the network;
- congested travel time on each link in the network;
- VMT; and
- vehicle hours of travel.

Notes:

Forecasting for Future Assignments

- Forecast household and employment data for each TAZ
- Apply trip generation model
- Forecast and code future year networks
- Apply trip distribution model
- Apply mode split or auto occupancy model
- Apply time-of-day and directional factoring
- Apply trip assignment model

Forecasting for Future Assignments

Trip assignment is the fourth step in the traditional traffic forecasting process. When using a validated model for trip forecasting, the future demand for transportation must be forecast, and the future supply of transportation must be forecast. The demand for transportation is a function of the forecast household characteristics and employment by TAZ. Where will people live and work in the future? The supply of transportation is represented in the model by the coded future year highway and transit networks. Where will additional roadways be built, and what additional public transit services will be provided? The other model functions (trip P&A submodels, gravity model friction factors, speed and capacity look-up tables, mode split model utility functions, BPR formula coefficients, etc.) are assumed to remain constant between the model validation year and the model forecast year.

Notes:

Error Checking and Validation

- Examine plotted trees

- Compare counted VMT with modeled VMT

- Compare external station counted volumes with modeled volumes

- Compare counted and modeled screen line volumes

- Compare assigned volumes to ground counts for links grouped by facility type and by volume groups

Error Checking and Validation

In contrast with the other three steps—trip generation, trip distribution, and mode split—there is no standard calibration procedure to ensure that the assignment stage reproduces closely matched observations. Since the assignment of trips to the network is the final output of the modeling process, assignment provides an ideal opportunity to conduct a number of error checks. Many of these checks focus on the highway and transit assignment results compared to observed values. Some of the more important aspects to consider as part of validation and error checking are:

- The plotted trees will show if network building follows logical routes.
- VMT is an important indicator of adequate model calibration since it addresses all four steps in the travel demand modeling process. The observed VMT is obtained from a traffic counting program and compared with the modeled values. The allowable difference between the two values should be 5% or less for regional models.
- For the base year, compare the external station volumes with the actual counts. For the forecast year, compare the volumes to the base year counts, and evaluate the reasonableness of the growth.
- Compared counted and modeled screen line volumes. These differences should be in the range of plus or minus 15%.
- Compare assigned volumes to ground counts for groups of links. Assigned volumes should reasonably compare to ground counts, recognizing that both assigned volumes and ground counts are estimates.

Notes: