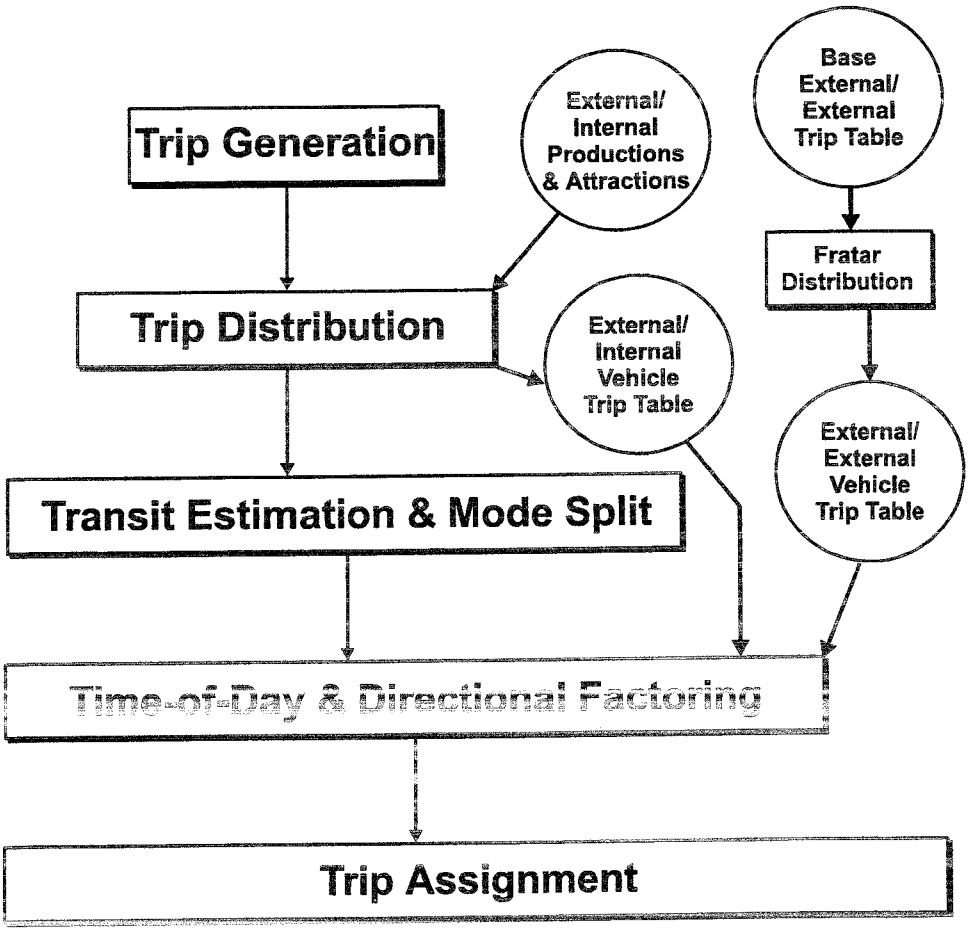
Session 8:
External and Truck Trips



Session 8, Part 1: External Trips

Session Outline for Part 1

- Terminology
- Key concepts
- Inputs and outputs
- Data collection
- Data analysis
- Forecasting trip tables
- Fratar example

Session 8, Part 1: External Trips

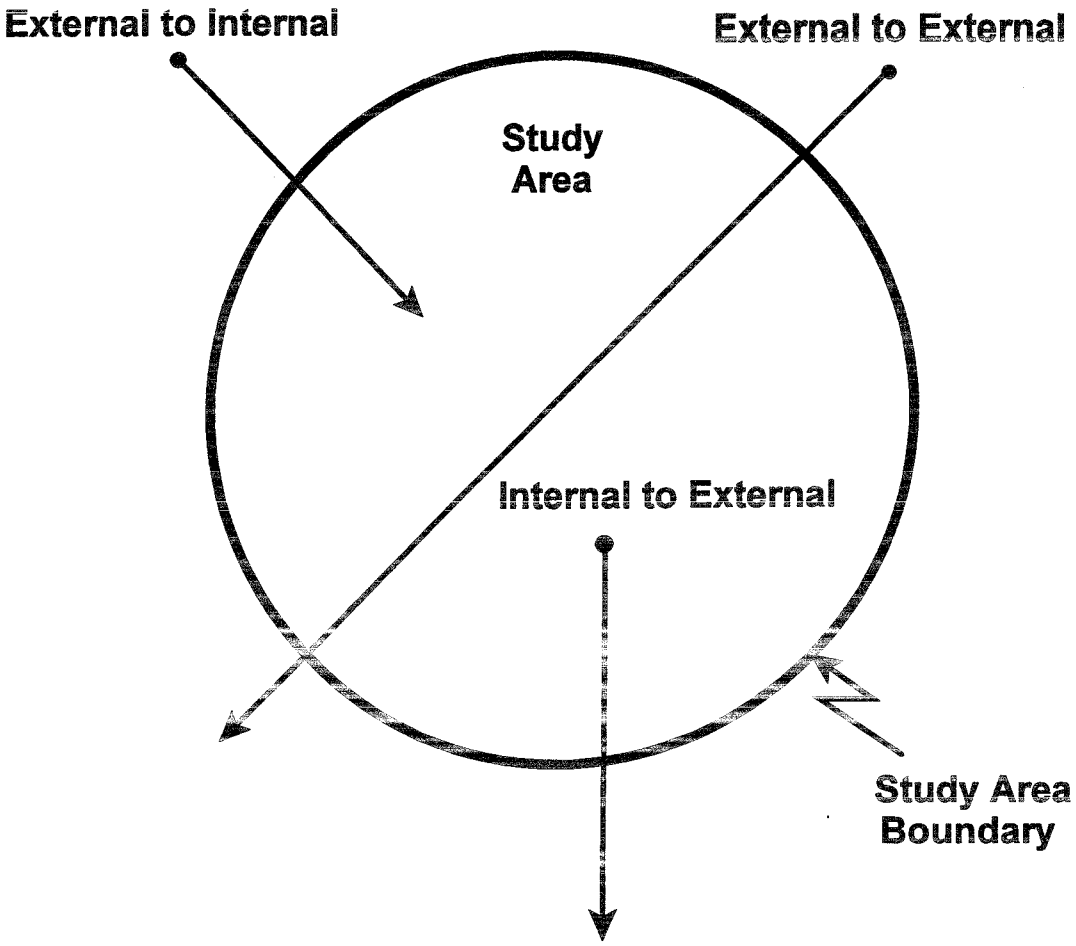
SESSION OUTLINE FOR PART 1

This session includes a discussion of the terminology used in determining external trips and the key concepts involved in determining these trips, including a discussion of the study area boundary, internal trips, external-internal trips, and external-external trips. The session also will include a discussion of inputs and outputs for trip distribution as well as data collection methods, including vehicle count and classification and vehicle survey methodology.

Also included in the session are discussions concerning data analysis, forecasting future year trip tables, and an example of Fratar trip distribution.

Notes:

Terminology



Terminology

Study area boundary is the boundary for the study area.

External station TAZ is the intersection of a roadway on the network with the study area boundary. For modeling purposes, this intersection point is treated in the model as a TAZ. External station TAZs typically are numbered sequentially after all internal study area TAZs have been numbered.

External–external trip is a trip whose origin and destination both are outside the study area boundary and which passes through the study area.

External–internal trip is a trip whose origin or destination is outside the study area boundary and whose other end is inside the study area.

External station travel survey is a survey conducted at the study area boundary.

Fratar is a method using external station growth factors and Fratar's method of successive approximations to forecast a trip table; it is typically used for the trip distribution of external-external trips.

Notes:

Key Concepts

Study Area Boundary Location

- Encompass current urban area plus forecasted urban area (20-25 years)
- Extend boundary to include commute trips into the area for work, etc.
- Have no more than 15% of VMT from trips that begin or end outside of study area

Trip Length Characteristics

- Trip characteristics differ depending on whether the trip maker lives within or outside of the study area

Key Concepts

STUDY AREA BOUNDARY LOCATION

The location of the study area boundary is important and needs to be given considerable thought at the beginning of the modeling work. The study area boundary needs to encompass all of the existing urban area plus that portion of the adjacent non-urban area that is forecasted to become urban during the next 20-25 years. Additionally, if there are a significant number of commute trips into the area for work, shopping, or services, extend the boundary so as to include the origin locations for the commute trips. The reason for this extension is that for trip generation forecasting, one needs to know the forecasted household characteristics for persons making trips within the study area. One will know these characteristics for persons living within the study area, but will not know these characteristics for persons living outside of the study area. Therefore, one wants to have most of the travel within the study area made by persons living within the study area; that is, one wants most of the travel to be internal travel.

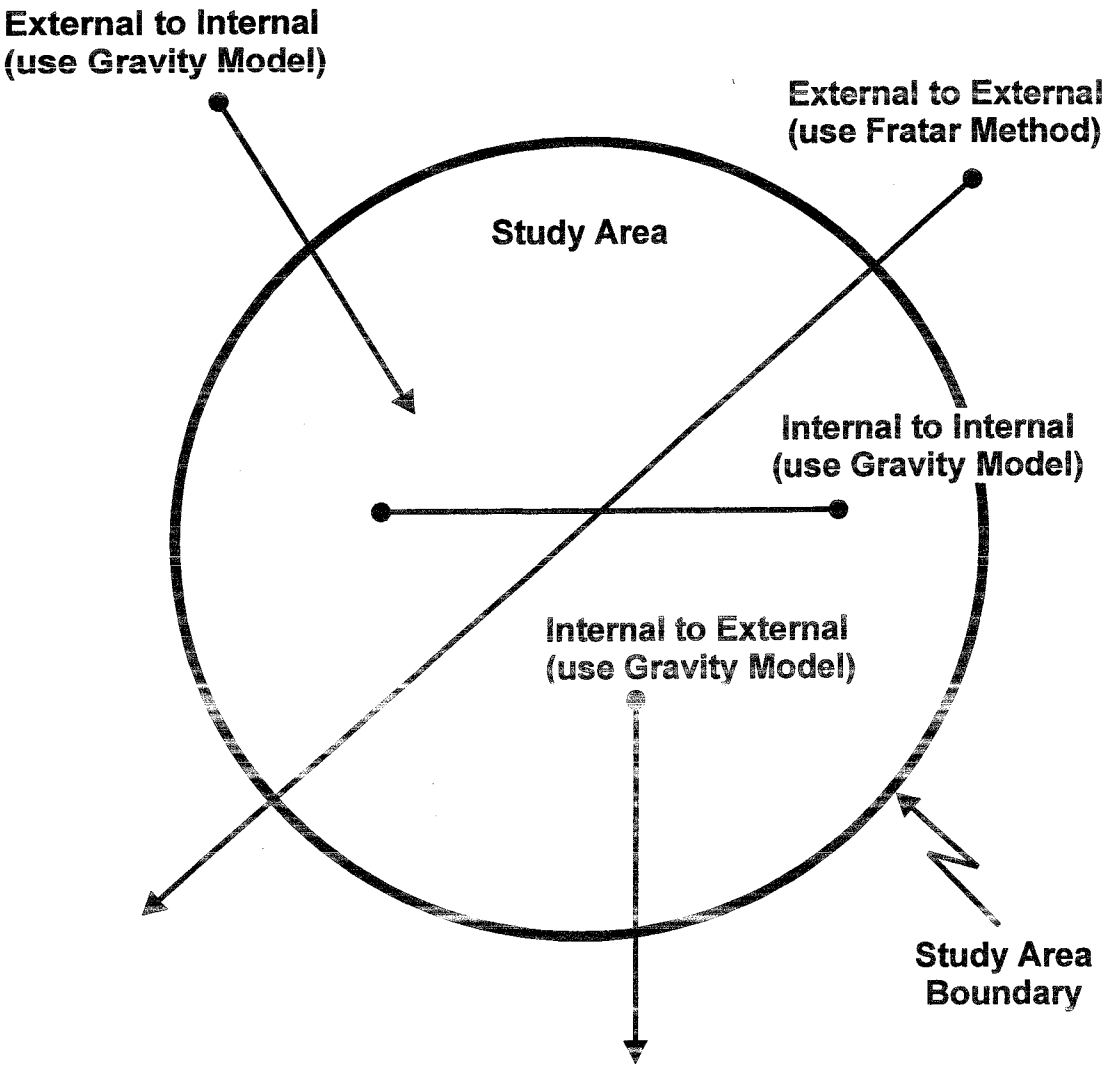
A good rule of thumb is to have no more than 15% of the total study area VMT accounted for by the external-external and external-internal trip purposes. Although is it possible to develop a good base-year model with a high percentage of VMT accounted for by the external–external and external–internal trip purposes, such a model will not be a good forecasting tool.

If the urban area is an Environmental Protection Agency (EPA) designated nonattainment or near nonattainment area, it is highly desirable to extend the study area boundary to include all of the nonattainment area. For ozone nonattainment areas, the boundaries usually are county boundaries. An urban area that is contiguous to another urban area presents particular modeling challenges that are not covered as part of this introductory class.

TRIP LENGTH CHARACTERISTICS

Trips made by persons living inside the study area exhibit different trip length characteristics than those trips made by persons who live outside the study area.

Key Concepts



Key Concepts

External–external trips are associated with the study area for only a small portion of their total journey and, therefore, exhibit distribution characteristics which have little to do with the study area. Consequently, it is generally desirable to treat the total universe of trips as three distinct types:

1. Internal trips, those with both ends of a trip within the study area;
2. External-internal trips, those with one end inside the study area and one external end; and
3. External-external trips, those with both ends outside the study area.

For the **internal trips**, the gravity model is used for trip distribution. For the **external–internal** trips, the gravity model also is used. However, since the trip length characteristics of these trips are different from internal trips, a separate gravity model analysis is done. The external–internal trips are considered to be produced at the external stations and attracted to the internal TAZs. For the **external–external** trips, travel surveys are used for the base-year trip distribution, and a growth factor technique called Fratar is used for the forecast trip distribution.

Some persons making external–internal trips (e.g., persons who commute into the study area for work) also make internal trips during the day. Typically, these internal trips are not picked up as part of the external station survey; consequently, these trips are not modeled. For some urban areas, such travel may be a modest part of the total travel, and the loss of these trips is not significant. For other urban areas—resort areas in particular—internal travel by persons who commute into the study area is significant; consequently, these trips should not be omitted from the model. Where this is the case (e.g., Galveston and Corpus Christi, Texas), a separate internal trip purpose called **external–local** is used. The characteristics of these trips are obtained through an expanded set of questions administered as part of the external station survey. The participants are asked to answer questions about their internal trips in addition to their external–internal trip. A separate trip generation and gravity model analysis is made for this internal trip purpose called external–local. This trip purpose is not discussed further in this introductory course.

Notes:

Inputs and Outputs

Inputs for external–internal trips

- Productions for each external station TAZ
- Trip length frequency distribution
- Travel time impedance matrix
- Scaled NHB attractions by TAZ

Inputs for external–external trips

- Productions and attractions for each external station TAZ
- Origin and destination trip table (base-year)

Outputs

- 24-hr external–internal trip table (P&A)
- 24-hr external–external trip table (O&D)

Inputs and Outputs

This is a trip distribution step with the same inputs and outputs used for the trip distribution step for the internal trip purposes—that is, the number of productions and attractions by trip purpose for each TAZ, the impedance matrix, and a set of friction factors. However, the sources of the inputs are considerably different.

Inputs (base year) for the **external–internal** trip purpose include:

- productions for each external station TAZ from the external station travel survey;
- trip length frequency distribution obtained from analysis of the external station survey trips;
- TAZ-to-TAZ travel time impedance matrix obtained from skimming the network; and
- scaled NHB attractions by internal TAZs from trip generation.

Inputs (base year) for the **external-external** trip purpose include:

- productions and attractions (P&A) for each external station TAZ from the external station travel survey; and
- a base-year trip table, in origin-destination (O&D) format, obtained from analysis of the external station survey trips.

Outputs include:

- 24-hour external–internal trip table in P&A format; and
- 24-hour external–external trip table in O&D format.

Notes:

Data Collection

Vehicle Counting and Classification

- 24-hr traffic counts for each external station TAZ
- Manual counts used to correct automatic counts

Data Collection

VEHICLE COUNTING AND CLASSIFICATION

Twenty-four hour traffic counts, by direction, are made for each external station location. The traffic counts provide a method for expansion of the travel survey interviews, that are typically made only during daylight hours, to a 24-hour period. Ideally, these counts are made as vehicle classification counts, by direction, and summarized every 15 minutes. Manual vehicle classification counts, using the FHWA vehicle classes, made during daylight hours provide a method for correcting the 24-hour counts made with automatic vehicle classification (AVC) equipment. The classification counts provide the data needed to separate out commercial truck trips.

Notes:

Data Collection

External Station Survey Methodology

- Have an approved traffic control plan
- Survey in outbound direction
- Move vehicles out of traffic stream
- Conduct interviews or give postcards
- Interview in daylight hours only
- Survey maximum number of vehicles
- Sample all high volume locations
- Take random sample of low volume locations

Data Collection

EXTERNAL STATION SURVEY METHODOLOGY

- Have a traffic control plan developed and approved by a qualified traffic engineer.
- Generally, survey only in the outbound direction. This technique assures that most commuters will be on their way home instead of going to work and, consequently, will be less annoyed by the delay. It also means that, if trip diary information is being collected for internal trips made within the study area, these trips already will have been made.
- Move interviewed vehicles out of the traffic stream.
- May use a postcard survey instrument to be completed by the motorists and returned via the mail, but a roadside interview conducted by a trained interviewer is preferable.
- Conduct interviews only during daylight hours, for the safety of the interviewers and the motorists.
- Survey the maximum number of vehicles possible given the traffic conditions at each location. Not all vehicles need to be surveyed, because the vehicle counts provide a method of expanding the sample trip data collected at each location to 24-hour trip activity.
- Sample all high volume external station locations, and take a random sample of all low volume locations.

Notes:

Data Collection

Data Elements to Collect

- Number of persons in vehicle
- Highway name/number
- Time entered study area
- Time departed study area
- Address of last stop in study area
- Trip purpose

Data Collection

DATA ELEMENTS TO COLLECT

1. Number of persons in the vehicle (for vehicle occupancy)

2. Designation of highway (name/number) used to enter study area

3. Designation of highway (name/number) used to depart study area

4. Time the vehicle entered the study area

5. Address of last stop within the study area

6. Time the vehicle departed the study area

7. Trip purpose for last stop and next stop:
   a. Home/return home
   b. Go to work
   c. Work related
   d. School
   e. Social/recreational
   f. Shop, buy gas, etc.
   g. Change travel mode
   h. Delivery
   i. Other

8. Home address of driver (to identify persons who live in study area and those who do not)

Notes:

Data Analysis

1. Expand survey data

2. Separate trips between external–internal and external–external

3. Develop TLFD for external–internal trips

4. Distribute external–internal trips

5. Apply the gravity model

Data Analysis

EXTERNAL-INTERNAL TRIP PURPOSE

1. After data coding and edit checking, expand the trips for each external station count location by the ratio of the counted number of vehicles to the interviewed number of vehicles.

2. Separate the trips between the external–internal trip purpose and the external–external trip purpose.

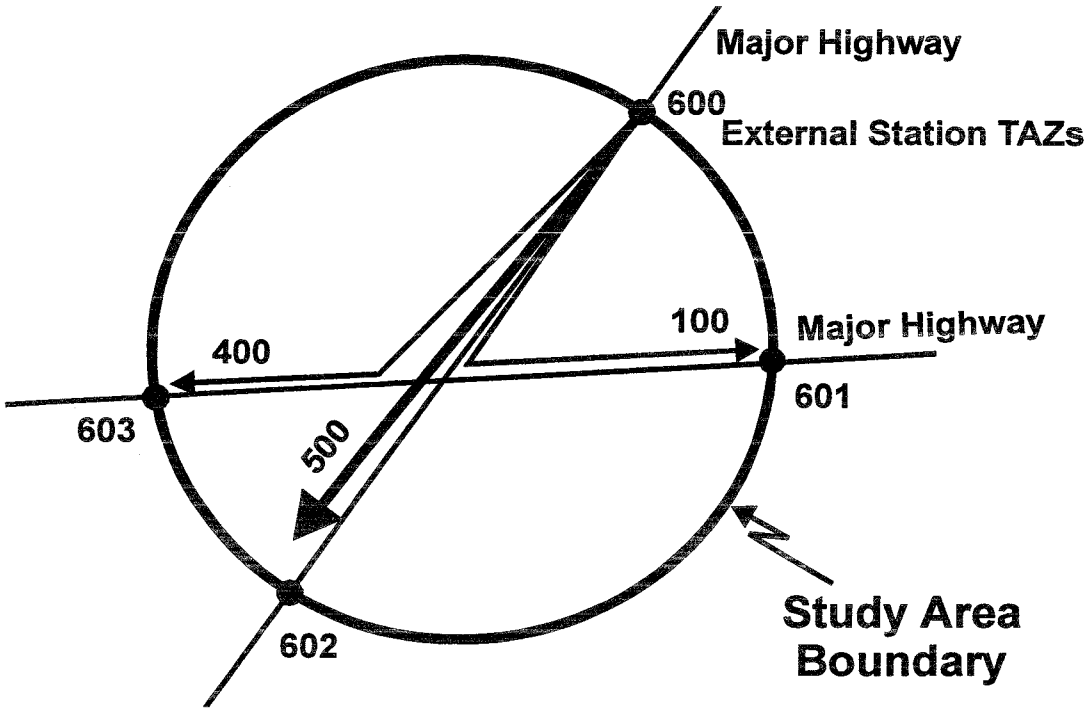
3. For the external–internal trip purpose, develop a trip length frequency distribution (TLFD). The internal trip ends are first geocoded by TAZ. Travel impedance skims are calculated using the highway network. Calculate TLFD. Gravity model friction factors then are calibrated in the same method used for internal trip purposes. Alternatively, the friction factors calibrated for the NHB trip purpose may be adjusted to achieve a longer average trip length (truncating the short trips) while keeping the general shape of the friction factor curve the same.

4. Distribute external–internal trips. Scale the NHB trip attractions to equal the number of expanded external–internal trip productions calculated from the external station survey. Note that the travel survey is used primarily to get the number of external–internal trip productions for each external station TAZ and the trip length frequency distribution for these trips. The external station survey will not provide sufficient trip end data to estimate attractions by TAZ. Instead, the assumption is made that the attraction end of external-internal trips are distributed among TAZs in the same manner as the attraction end for the NHB trips. Note: the NHB trips do not change; they are used only as a surrogate for the external-internal trip purpose attractions.

5. Apply the gravity model.

Notes:

Data Analysis



Trips from external station 600 to other external stations

External-External Trip Table

TAZ	600	601	602	603
600	0	100	500	400
601	150	0	400	500
602	450	450	0	150
603	400	500	150	0

EXTERNAL-EXTERNAL TRIP PURPOSE

Distribute external–external trips. The external-external trip table is built directly from the expanded external station survey. The number of external station trips for each external station simply is the expanded number of trips for that station. The assumption is made that, for 24 hours, the number of trips inbound at an external station location is equal to the number of outbound trips at the station, with the number of outbound trips being calculated from the expanded survey data. These external station totals are the row and column totals for the external–external trip table.

The trip interchange volumes between all external station TAZs also are calculated from the survey data. Since there are a small number of external stations and the origin and destination TAZ for each external–external trip is known, it is a simple matter to calculate the base-year trip table.

Notes:

Forecasting Trip Tables

Forecasting Future Year Trip Tables

- Forecast total volume for each external station
- Assume split between external–internal and external–external trips is same as base year
- Forecast external–internal trip tables
- Forecast external–external trip tables

Forecasting Trip Tables

FORECASTING FUTURE YEAR TRIP TABLES

To forecast future year external–internal and external–external trip tables, one additional analysis must be performed. The total volume of traffic for each external station TAZ must be projected from the base year into the future. Many state departments of transportation perform annual traffic volume counts at all external station locations within their state. Using these data, external growth factors are estimated for each external station using a simple trend line, time series regression line, or other projection technique. In the absence of these data, some other data source must be found with which external station growth factors can be estimated; for example, a nearby automatic traffic recording (ATR) station may be used. Future external station TAZ traffic volumes then are estimated for each analysis year.

The assumption is made that the split between external–internal trips and external–external trips for each external station TAZ will remain the same as was observed in the base year. With this assumption, the number of trip productions for the two external trip purposes for each future analysis year can be estimated.

The forecasted **external–internal** trip purpose trip tables are estimated using the scaled attractions from the forecasted NHB trips, the base-year gravity model friction factors, and the application of the gravity trip distribution model.

The forecasted **external–external** trip tables are estimated using the base-year external–external trip tables, forecasted trip table row and column totals developed using the external growth factors, and a successive approximation technique known as Fratar. The inputs to the Fratar technique are a base-year trip table and the forecasted row and column totals. Application of the technique results in new forecasted trip table interchange volumes.

Notes:

Fratar Example

Base-Year External-External Trip Table

TAZ	600	601	602	603	Total
600	0	100	500	400	**1,000**
601	150	0	400	500	**1,050**
602	450	450	0	150	**1,050**
603	400	500	150	0	**1,050**
Total	**1,000**	**1,050**	**1,050**	**1,050**	**4,150**

Forecast-Year External-External Trip Table

TAZ	600	601	602	603	Total
600					**1,100**
601					**1,260**
602					**1,365**
603					**1,260**
Total	**1,100**	**1,260**	**1,365**	**1,260**	**4,985**

Fratar Example

Example Problem: Fratar

Fratar is a method of successive approximations, which are illustrated in this simple example. The external station TAZ base-year trip table is estimated from external station travel surveys. Using historical data for each external station, a trend line forecast is used to estimate the future year external station volumes for each external station. In this example, external station volumes for TAZ 600 are forecast to grow from 1,000 trips per day in the base year to 1,100 trips per day in the forecast. Similarly, TAZ 601 trips are forecast to grow from 1,050 trips to 1,260 trips, etc. These future trips are the desired future year row and column totals. Fratar provides a method to estimate the future year cell interchange values.

Notes:

Fratar Example

Forecast-Year External-External Trip Table-Fratar Iteration One (rows)

TAZ	600	601	602	603	Total
600	0	110	550	440	**1,100**
601	180	0	480	600	**1,260**
602	585	585	0	195	**1,365**
603	480	600	180	0	**1,260**
Total	**1,245**	**1,295**	**1,210**	**1,235**	**4,985**

Forecast-Year External-External Trip Table Fratar Iteration Two (columns)

TAZ	600	601	602	603	Total
600	0	107	621	449	**1,177**
601	159	0	541	612	**1,312**
602	517	569	0	198	**1,285**
603	424	584	203	0	**1,211**
Total	**1,100**	**1,260**	**1,365**	**1,260**	**4,985**

Forecast-Year External-External Trip Table Fratar Iteration Three (rows)

TAZ	600	601	602	603	Total
600	0	100	580	420	**1,100**
601	153	0	520	587	**1,260**
602	550	604	0	211	**1,365**
603	441	608	211	0	**1,260**
Total	**1,144**	**1,312**	**1,311**	**1,218**	**4,985**

Fratar Example

Multiply the base-year row cell values by the ratio of the row total of desired number of trips and the base year number of trips for each row. This results in the new row values shown in the first iteration trip table. Add the cell values to get the new column totals. Multiply the new column cell values by the ratio of the desired number of trips and the estimated number if trips for each column. This results in the new column values shown in the second iteration trip table. Add the cell values to get new row totals. Notice that the estimated and observed row values now are closer but do not exactly match the desired row values. This procedure is repeated until the desired and estimated row and column totals are reasonably close.

Notes:

Fratar Distribution Workshop

Base-Year External-External Trip Table

TAZ	600	601	602	603	Total
600	0	100	500	400	**1,000**
601	150	0	400	500	**1,050**
602	450	450	0	150	**1,050**
603	400	500	150	0	**1,050**
Total	**1,000**	**1,050**	**1,050**	**1,050**	**4,150**

The base year trip table is developed from the expanded external station travel survey.

Forecast-Year External-External Trip Table

TAZ	600	601	602	603	Total
600					**1,100**
601					**1,260**
602					**1,365**
603					**1,260**
Total	**1,100**	**1,260**	**1,365**	**1,260**	**4,985**

The row and column totals are forecasted using a trend line projection of historical external station traffic volumes, and the split between external-internal trips and external-external trips calculated from the external station travel survey.

Fratar Distribution Workshop

Forecast-Year External-External Trip Table-Fratar Iteration One (rows)

TAZ	600	601	602	603	Total
600					1,100
601					1,260
602					1,365
603					1,260
Total					4,985

For each row, multiply each cell value by ratio of the desired row total (the forecasted volume) to the base year row total.

Forecast-Year External-External Trip Table Fratar Iteration Two (columns)

TAZ	600	601	602	603	Total
600					
601					
602					
603					
Total	1,100	1,260	1,365	1,260	4,985

For each column, multiply each cell value by the ratio of the desired column total (the forecasted volume) to the column total from iteration one.

Fratar Distribution Workshop

Forecast-Year External-External Trip Table Fratar Iteration Three (rows)

TAZ	600	601	602	603	Total
600					1,100
601					1,260
602					1,365
603					1,260
Total					4,985

For each row, multiply each cell value by the ratio of the desired row total to the row total from iteration two.