CAMBRIDGE SYSTEMATICS

A Recommended Approach to Delineating Traffic Analysis Zones in Florida

prepared for

Florida Department of Transportation Systems Planning Office

prepared by

Cambridge Systematics, Inc.

in association with

AECOM Consult

September 27, 2007

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1.0 Introduction

The purpose of this white paper is to provide travel demand modelers within Florida with detailed guidance on the best practices in delineating **traffic analysis zones** (TAZ), either for a new travel demand model, or to further refine an existing travel demand model. One can define a **TAZ**, also referred to as a zone, as the following:

> *Geographic areas dividing the planning region into relatively similar areas of land use and land activity. Zones represent the origins and destinations of travel activity within the region… every household, place of employment, shopping center, and other activity… are first aggregated into zones and then further simplified into a single node called a centroid.*[1]

TAZs serve as the primary unit of analysis in a travel demand forecasting model. They contain socioeconomic data related to land use. TAZs are where trips begin and end.

One may refine TAZs to improve the accuracy of a model, such as to reflect a new or revised development of regional impact (DRI), conduct a subarea analysis, reflect new roads or political boundaries, for the purpose of validating a model, and/or to assist in delineating socioeconomic data based on Census boundaries and other geographies.

One should consider roadway network and physical geography when delineating TAZ boundaries. However, there are other considerations that are sometimes overlooked. One should also consider the following additional factors when delineating TAZs:

- Highway network compatibility:
  - Existing and planned transportation facilities; and
  - Centroid connector loadings.
- Boundary compatibility:
  - Physical geography;
  - Census geography;
  - Political geography;

[1] Barton-Aschman Associates, Inc. and Transportation Research Board, *Report 365 – Travel Estimation Techniques for Urban Planning*, National Cooperative Highway Research Program, 1998.

  - Planning District/Sector boundaries; and
  - Irregular zone geography.
- Socioeconomic data (existing and future):
  - Homogeneous land uses, where feasible;
  - Special generators;
  - Trips per zone; and
  - Developments of regional impact.
- Access:
  - Transit access; and
  - Freight/intermodal facilities.
- Other considerations:
  - Zone size and intrazonal trips; and
  - Internal versus external zones.

Section 2.0 includes a summary of recommendations, including a comprehensive checklist for delineating TAZs. Sections 3.0 and 4.0 provide further detail on each of these topics. Section 5.0 discusses in detail the process of actually splitting the TAZs, both the boundaries themselves and the respective socioeconomic data. Section 6.0 discusses other topics to be considered for further research in the future, followed by a List of Data Sources and a Glossary of Terms in the appendices.

2.0 Summary of Recommendations

The following can serve as a checklist summarizing recommendations on the best practices in delineating TAZs. It is important that these recommendations be considered for both base year and future year conditions, where feasible.

Did you consider the following when delineating your TAZ structure?

- ✓ The number of people per TAZ should be greater than 1,200, but less than 3,000 for the base and future years;
- ✓ Each TAZ yields less than 15,000 person trips in the base and future year;
- ✓ The size of each TAZ is between 0.25 to one square mile in area;
- ✓ There is a logical number of intrazonal trips in each zone, based on the mix and density of the land use;
- ✓ There are no irregular-shaped TAZs;
- ✓ Each centroid connector loads less than 10,000 to 15,000 vehicles per day in the base and future year;
- ✓ The study area is large enough so that nearly all (over 90 percent) of the trips begin and end within the study area;
- ✓ The TAZ structure is compatible with the base and future year highway and transit network;
- ✓ The centroid connectors represent realistic access points onto the highway network;
- ✓ Transit access is represented realistically;
- ✓ The TAZ structure is compatible with Census, physical, political, and planning district/sector boundaries;
- ✓ The TAZs are based on homogeneous land uses, when feasible, in both the base and future year and consider future DRIs; and
- ✓ Special generators and freight generators/attractors are isolated within their own TAZ.

It is recommended that the guidelines provided in this document be followed when Florida Department of Transportation (FDOT) districts and metropolitan planning organizations (MPOs) review their current TAZ structure. The first step could be to calculate the area of their TAZs using a geographic information system (GIS) to determine if they are too large for the density of their area. Additionally, one can overlay their current TAZ structure with Census and political boundaries to determine their current compatibility.

3.0 Guidelines in Delineating TAZs for Base Year Model

The TAZ structure should generally be consistent between model years and begin with the base year model, as this is likely to have a significant impact on model validation. As a result, Section 3.0 discusses guidelines for delineating TAZs for a base year model with the understanding that future land use and planned roadways or transit corridors, as discussed in Section 4.0, may also have an impact on the TAZ structure.

3.1 ZONE SIZE AND QUANTITY

3.1.1 Zone Size and Intrazonal Trips

The ideal size of a TAZ depends on what the model will be used for. Below are ideal zone sizes for three typical uses:[2]

1. **Large-Sized Zones for System or Statewide Planning –** TAZs can be larger than the arterial grid and with up to approximately 20,000 persons per zone;
2. **Medium-Sized Zones for Arterial Planning –** Two or more arterials should not traverse the TAZ in any direction and with up to approximately 4,000 persons per zone; and
3. **Small-Sized Zones for Corridor Analysis –** TAZs in a corridor or subarea should be more refined and should be greater than 1,200, but less than 3,000 persons per zone.

If the model network is sparse, the TAZ structure usually includes larger zones to accommodate the sparse highway network. If a model network is more detailed, smaller TAZs are required to accommodate the additional network detail.

Although TAZs can be as small as a single block, they are usually between 0.25 to one square mile in area.[3] One should consider the intended use of the model and what data is used to populate the TAZs when determining the appropriate size

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[2] Barton-Aschman Associates, Inc. and Transportation Research Board, *Report 365 – Travel Estimation Techniques for Urban Planning*, National Cooperative Highway Research Program, 1998.

[3] Beinborn, Edward A., *A Transportation Modeling Primer*, Center for Urban Transportation Studies, University of Wisconsin-Milwaukee, 1995.

of the TAZs. One can calculate the area of a TAZ in GIS using the TAZ boundary shapefile, and then querying all TAZs with an area greater than one square mile. Those larger TAZs can then be reevaluated to determine if further disaggregation is feasible. Most models usually have between 500 and 2,000 TAZs,[4] depending upon the size and density of the planning area. The smaller the TAZs, the more accurate the forecasts might be. However, having a higher number of TAZs in the model does require more detailed data. It is recommended that the model developer consider any TAZ splits made during corridor studies for inclusion during the next model update.

According to the U.S. Census, Census tracts should include between 1,200 and 8,000 persons, with an optimum size of 4,000 persons. Trip production rates vary among household type, auto availability, and other household characteristics. Trip attraction rates vary among employment type and region. However, using a national average trip production rate of 3.64 to 3.87 trips per person,[5] assuming 4,000 people per Census tract, approximately 15,000 trips per day are produced from the one Census tract, assuming the zone did not include any employment to attract trips. One should consider splitting zones exceeding 15,000 daily trips to achieve smaller-sized zones, such as those used for corridor planning. If the Census tract were more dense with upwards of 8,000 persons, one would need to disaggregate the Census tract further for the purposes of defining the TAZ structure, based on person trips generated per zone alone. The Census Bureau is currently considering increasing the minimum number of persons per block group (and potentially TAZs) to 1,200 persons (previously 600) or 480 households. The existing maximum thresholds of 3,000 persons and 1,200 households per block group remain unchanged. As a result, the number of persons per TAZ should be greater than 1,200, but less than 3,000 for base year TAZs.

If the geographic size of a TAZ is too large and a TAZ has both productions and attractions (dwelling units and employment), one may reduce the trips assigned to the roadway network due to a larger number of intrazonal trips. **Intrazonal trips** are those that are short enough to begin and end within the same zone and, thus are not assigned to the roadway network. TAZs that include only employment or only dwelling units may also have intrazonal trips, but only for the nonhome-based trip purpose.[6] One may reduce the number of intrazonal trips by decreasing the size of the TAZ. In addition, reducing zone size should

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[4] Beinborn, Edward A., *A Transportation Modeling Primer*, Center for Urban Transportation Studies, University of Wisconsin-Milwaukee, 1995.

[5] Barton-Aschman Associates, Inc., and Cambridge Systematics, Inc., *Model Validation and Reasonableness Checking Manual*, prepared for Travel Model Improvement Program/ Federal Highway Administration, February 1997.

[6] Federal Highway Administration, *Calibration and Adjustment of System Planning Models*, December 1990.

decrease intrazonal travel times, potentially enhancing performance of the gravity model trip distribution process.

Additionally, if the TAZ is too large, an over-representation of trips on centroid connectors can erroneously load an excessive number of trips on a highway network link. As a general rule of thumb, centroid connector loadings should be less than 10,000 to 15,000 vehicles per day.[7]

Lastly, if two or more transit stations or highway interchanges are located on the same TAZ boundary, one may likely need to split the zone to achieve a proper loading of trips.

3.1.2 Internal Versus External Zones

TAZs inside the study area, or model boundaries, are defined as **internal zones**. Those zones outside the study area along the model boundaries are defined as **external zones** or **external stations**. To accurately reflect travel patterns within the study area, the study area should be large enough so that nearly all (over 90 percent) of the trips begin and end within the study area.[8]

3.2 BOUNDARY COMPATIBILITY

3.2.1 Physical Geography

Physical geography refers to any permanent visible feature that might restrict access and act as a barrier for free movement. Some of these features may include:

- Water bodies, such as bays, lakes, rivers, and canals; and
- Natural barriers, such as wetlands and steep slopes.

Why Use Physical Geography?

The primary reason for using physical geography to delineate TAZ boundaries is to provide realistic access from the TAZ centroid to the nodes on the model network. **Centroids** are coded into the model network to identify the center of activity within a zone. **Centroid Connectors** are coded into the model network to connect the centroids to transportation facilities, usually representing access via local roads or major driveways. Having a centroid connector passing through a physical barrier conflicts with the assumption of free movement from the TAZ onto the network, as the barrier does not allow for such movement.

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[7] Federal Highway Administration, *Calibration and Adjustment of System Planning Models*, December 1990.

[8] Beinborn, Edward A., *A Transportation Modeling Primer*, Center for Urban Transportation Studies, University of Wisconsin-Milwaukee, 1995.

Understanding the physical geography provides the modeler with an ability to determine accessibility between TAZs and transportation facilities. Section 3.5 includes more detail on centroid connectors. Figures 3.1a, 3.1b, and 3.1c provide a few examples of how physical geography affects zonal access. In the figures, red lines indicate the location of corridors in the model network and black dotted lines indicate the access links (centroid connectors) from the centroid of the TAZ.

Figure 3.1 Delineating TAZs Consistent with the Physical Geography

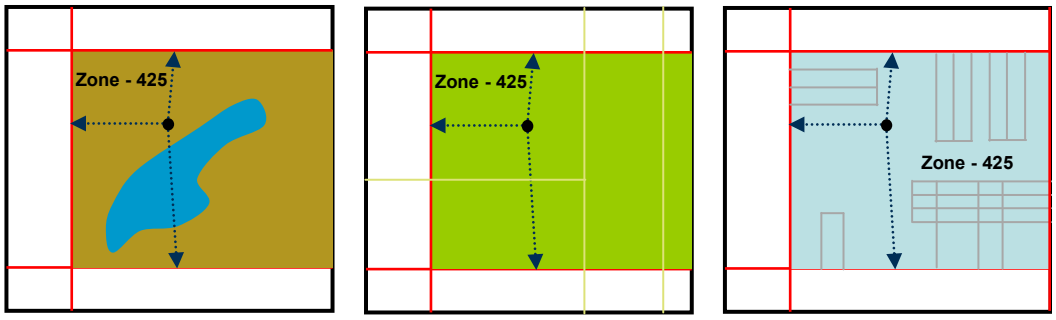


Figure 3.1a *indicates access links traversing water body.*

Figure 3.1b *indicates access links over collectors shown in yellow.*

Figure 3.1c *indicates access links connect to model network ignoring the lack of underlying connectivity of all local roads (in gray).*

As shown in Figure 3.1a, not considering the existence of a water body may result in the centroid connector traversing the water body. Figure 3.1b indicates centroid connectors crossing collector roads. In reality one would use collector streets to connect with major roads. Figure 3.1c indicates the need for understanding the connectivity of underlying local roads, even if they are not included in the model network. This understanding helps in providing realistic linkage to the model network. In Figure 3.1c, the underlying local road structure indicates that local street access exists to all four bordering arterial streets, but no centroid connector is included to the right (east). The next section discusses better ways to delineate TAZs in the above three scenarios.

How to Use Physical Geography

One can collect data on physical features that may potentially restrict movement from several publicly available sources. As mentioned earlier, a few important features include water bodies and any topological and environmental barriers.

In terms of water bodies, all kinds of water bodies, such as marshy lands, lakes, or rivers, provide physical barriers, and hence, one must consider them in determining TAZ boundaries. One should also consider other barriers, such as steep slopes, presence of natural habitats, and conservation areas.

Upon obtaining the data layers for these physical features, a simple rule of thumb is to delineate TAZs bounded by these permanent physical features. As depicted

in the figures below, delineating TAZs bounded by these permanent barriers would assist in providing realistic linkages between the TAZ centroids and the network. Referring to earlier examples, Figure 3.2a represents a better way of delineating TAZs for scenarios depicted in Figure 3.1a. As shown in the figure, delineating TAZs along the water body boundary avoids the erroneous connection of the zone to the model network by isolating trips from each side of the water body. One can apply similar logic to any other kinds of physical barriers.

Figure 3.2 Delineating TAZs Based on Permanent Barriers

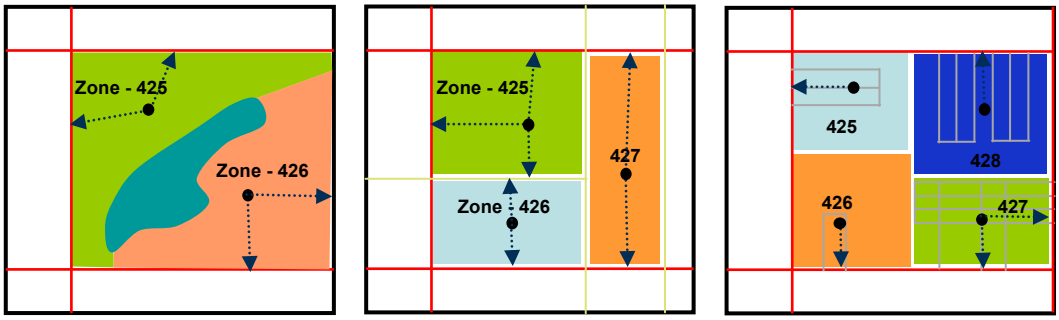


Figure 3.2a *indicates zones being delineated using boundaries of water body.*

Figure 3.2b *indicates zones being delineated using major roads as boundaries.*

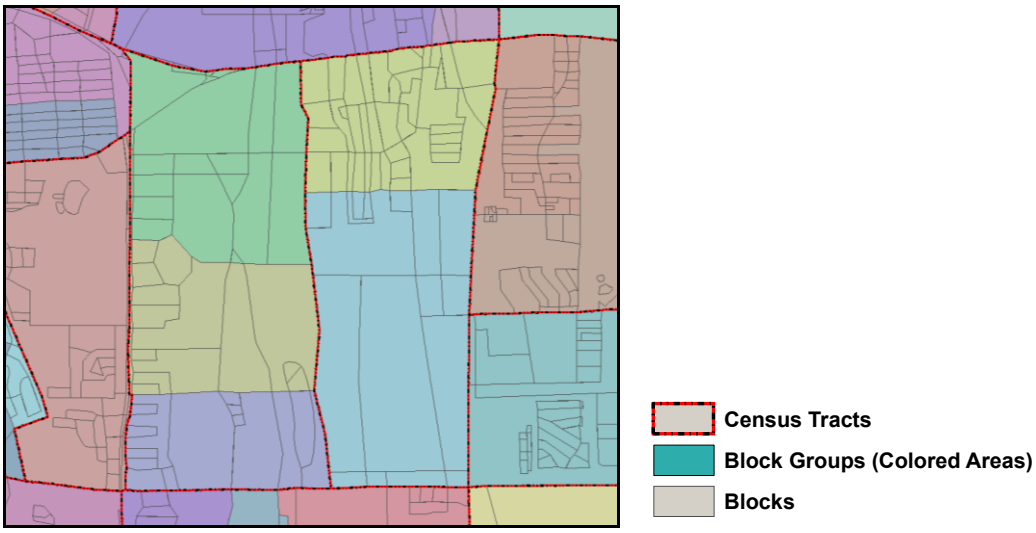
Figure 3.2c *indicates zones being delineated using connectivity depicted by local roads.*

Similarly, Figure 3.2b shows how TAZs can be delineated based on the location of major roads, while Figure 3.2c shows the usefulness of having data on minor roads in terms of delineating TAZ boundaries. A separate discussion of transportation facilities and their impact on TAZ structure is found in Section 3.6.

3.2.2 Census Geography

Census boundaries cover a wide range of geographic detail, ranging from Census blocks to block groups and Census tracts. Figure 3.3 below provides an example of blocks (light grey streets), the smallest geographic unit of the Census; block groups (shaded colors); and Census tracts (red boundaries).

Figure 3.3 Blocks versus Block Groups versus Census Tracts



Why Use Census Geography?

Travel demand models typically use a variety of demographic data as inputs. These data are developed at a TAZ level and input into the models. Population and dwelling units are two widely used attributes that are also available at a variety of Census geographies. The Census collects and reports these data every 10 years by Census geography.

Formulating TAZ boundaries along the Census geography enables modelers to readily access all Census demographic data or any other datasets like the Census Transportation Planning Package (CTPP) that are based on census geography. CTTP is a comprehensive set of special tabulations from the decennial census designed for transportation planners to enable them to analyze demographic and travel trends[9] that facilitate validation of model inputs. CTPP typically provides data at various census geographic levels (from state to block group); hence, formulating TAZ boundaries along census geography provides seamless access to all information from CTPP. Further, with the growing importance of the American Community Survey (ACS) in regard to travel demand model calibration and validation, another census geography known as Public Use Microdata Areas (PUMAs) can be beneficial. A PUMA is an area with a decennial census population of 100,000 or more people for which the Census provides specially selected extracts of raw data from a sample of long-form

[9] United States Department of Transportation, *What is the Census Transportation Planning Package (CTPP)?* (http://www.fhwa.dot.gov/ctpp/about.htm).

census records.[10] The delineation of PUMAs are based on Census 2000 population counts and are based on several rules and guidelines prescribed by the Census Bureau (http://www.trbcensus.com/articles/pumaguidelines.pdf). According to these guidelines, PUMA boundaries should be for the most part, contiguous (except when counties are discontiguous), and can only follow the boundaries of geographic areas such as counties or statistical equivalent areas, minor civil districts (MCDs), Census tracts (but only within counties that have more than 100,000 people) and places (with exceptions for unincorporated places). The information that the Census provides is referred to as a ''public use microdata sample (PUMS)'' file. Typically, two types of PUMAs are delineated as follows:

- Areas that contain at least 100,000 people. The PUMS files for these PUMAs contain a five percent sample of the long-form records. Figure 3.4 illustrates the PUMAs that contain a five percent sample.
- Areas that contain at least 400,000 people, also known as super-PUMAs. The PUMS files for these super-PUMAs contain a one percent sample of the long-form records. The larger one percent PUMAs are aggregations of the smaller five percent PUMAs.

PUMAs of both types, wherever the population size criteria permit, comprise areas that are entirely within or outside metropolitan areas or the central cities of metropolitan areas.[11]

ACS, which is a key part of the Census Bureau's Decennial Census Program, provides annually updated data on the characteristics of housing and population. The bureau releases this data for legal, administrative, or statistical areas with estimated populations of 65,000 or more.[12] Although ACS estimates are available for several census geographies, PUMAs are the smallest geographic areas (that include both rural and urban areas) at which ACS data is published. Nesting TAZ boundaries within PUMAs enables modelers to take advantage of ACS microdata that assists in evaluating relationships among variables not shown in the standard products offered by the Census Bureau.

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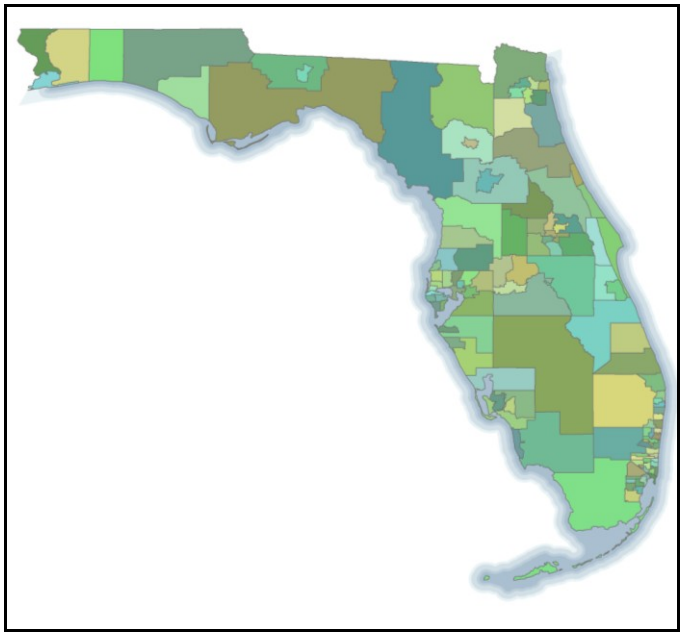
[10] United States Census Bureau, *Appendix A. Census 2000 Geographic Terms and Concepts*, page A19, http://www.census.gov/geo/www/tiger/glossry2.pdf.

[11] United States Department of Transportation, *What is the Census Transportation Planning Package (CTPP)?* (http://www.fhwa.dot.gov/ctpp/about.htm).

[12] United States Census Bureau, American Community Survey, *Using Data from the 2005 American Community Survey*, http://www.census.gov/acs/www/UseData/advance_copy_user_guide.pdf.

Figure 3.4 PUMAs in Florida that Contain a Five Percent Sample (at least 100,000 people)



However, note that since Census geography is oriented around population and dwelling units, employment-oriented areas, such as Central Business Districts (CBDs), warehouse districts, and office parks tend to have very large tracts. As a result, employment-oriented areas likely need further subdividing.

In addition to covering a wide range of geography, Census geography offers an advantage of being hierarchically nested. This nesting enables users to easily aggregate and disaggregate Census data over a variety of geographies. For example, data from a lower geographic unit, such as block groups, can be aggregated to relate to data from tracts, and disaggregated to relate to data from blocks. Having a TAZ structure consistent with Census geography also enables such disaggregation or aggregation to be conducted at a TAZ level, using data from Census geographies. This can be extremely useful when refining TAZ boundaries in terms of being able to use data from the Census geographies to derive data for refined TAZ boundaries.

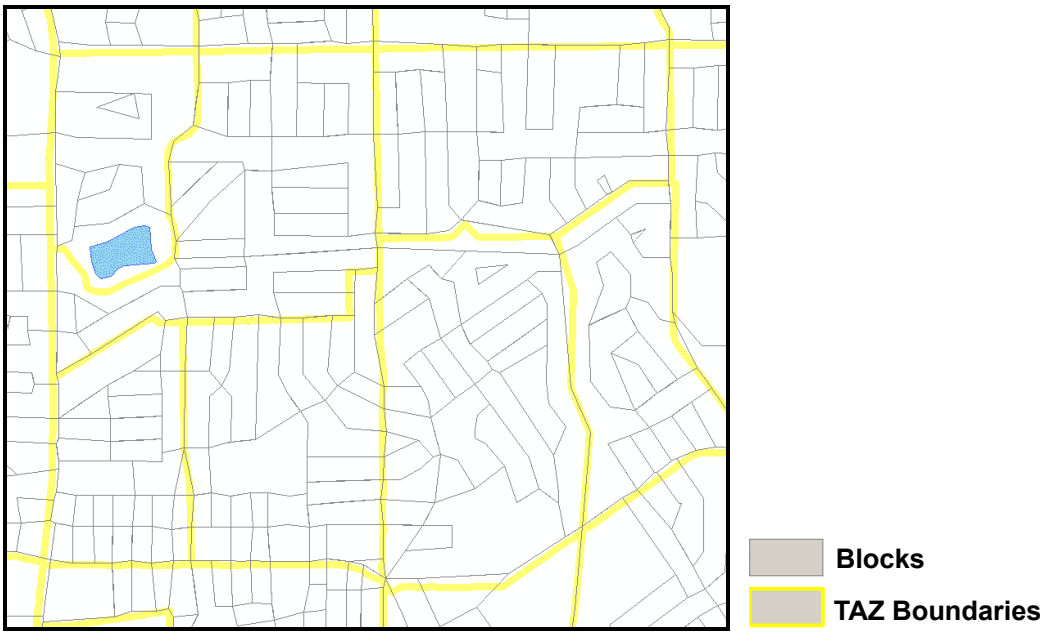
How to Use Census Geography

Data on Census geography is available as a public source for download at: http://www.census.gov/geo/www/cob/bdy_files.html.

Of all the Census geographies, the Census Bureau defines Census blocks as the smallest geographic entity for which the Bureau collects and tabulates 100 percent decennial Census data. **Census blocks** are defined as "areas bounded on all sides by visible features, such as streets, roads, streams, and railroad tracks; and by invisible boundaries, such as city, town, township, and county limits; property lines; and short, imaginary extensions of streets and roads."[13] These blocks can be used as "building blocks" for delineating TAZ boundaries. Once the analyst determines the area and extent of the TAZ using various criteria that are described in later sections, TAZ boundaries can be delineated using one or more of these building blocks. The size of a typical block varies from a well developed area to a sparsely settled area.

In Figure 3.5, the grey lines indicate the block boundaries, and the yellow ones indicate the TAZs. As seen in the figure, one can use blocks theoretically as building blocks to delineate TAZs, although reporting of select Census attributes is more limited at the block level.

Figure 3.5 Delineating TAZs Based on Block Boundary



[13]United States Census Bureau, *Appendix A. Census 2000 Geographic Terms and Concepts*, page A10, http://www.census.gov/geo/www/tiger/glossry2.pdf.

If the extent of the TAZ spans over a number of blocks, then one might consider using larger units of geography, the Census block group boundaries, to delineate TAZs. **Census block groups** are defined as "a cluster of Census blocks having the same first digit of their four-digit identifying numbers within a Census tract. For example, for Census 2000, BG 3 within a Census tract includes all blocks numbered between 3,000 and 3,999. The block group is the lowest-level geographic entity for which the Census Bureau tabulates sample data from the decennial Census."[14] So, if the extent of TAZs is fairly larger when compared to block sizes in an area, one can then check block groups to see if those can be used as references for delineating TAZ boundaries. As shown in Figure 3.6a, where the colored areas indicate various block groups, if the required size of a TAZ matches that of a block group, then one can delineate that TAZ over the block group boundary. Sometimes, if the TAZs need to span partially over multiple block groups, then one can still maintain the minimum unit of block as shown in the Figure 3.6b.

Figure 3.6 Delineating TAZs Based on Census Block Groups

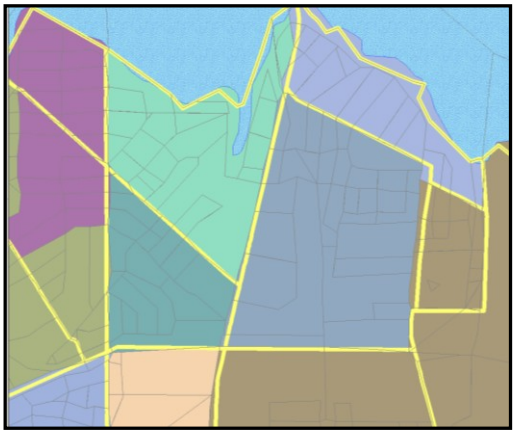


Figure 3.6a *indicates how a TAZ boundary can be delineated based on a block group boundary. Colored areas indicate block groups.*

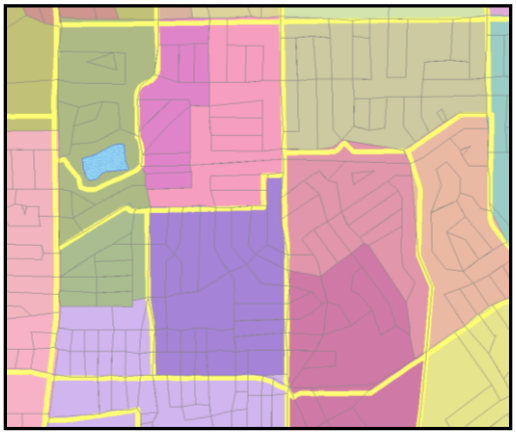


Figure 3.6b *shows how to delineate TAZ boundaries for areas traversing partially over multiple block groups. Colored areas indicate block groups.*

One can apply similar logic for TAZ areas that need to span across several block groups. In such cases, one can use the next larger unit of Census geography, the Census tract boundaries. **Census tracts** are defined as "a small, relatively permanent statistical subdivision of a county or statistically equivalent entity, delineated for data presentation purposes by a local group of Census data users

[14] United States Census Bureau, *Appendix A. Census 2000 Geographic Terms and Concepts*, page A8, http://www.census.gov/geo/www/tiger/glossry2.pdf.

or the geographic staff of a regional Census center in accordance with Census Bureau guidelines."[4]

For purposes of travel demand modeling, one should use tracts as the largest size of building blocks for delineating TAZ boundaries. According to the U.S. Census Bureau, these tracts are designed to be relatively homogeneous units with respect to population characteristics, economic status, and living conditions at the time they are established. This translates into homogeneity in terms of travel patterns inside each Census tract. Therefore, ensuring that the boundaries of the largest TAZs correspond to Census tract boundaries may assist with depicting travel patterns more accurately. Further, Census tract boundaries are delineated with the intention of being stable over many decades, so they generally follow relatively permanent visible features,[15] which meets one of the important criteria for delineating TAZs (as discussed in the next section).

Note that local agencies are provided the opportunity to review and suggest modifications for the delineation of block groups, census tracts, census county divisions, and census-designated places for the purpose of reporting data from the 2010 Census through the Participant Statistical Areas Program (PSAP). Modeling staff should participate in this process to learn what the new census tract and block group boundaries are.

3.2.3 Political Geography

Political geography refers to all politically delineated boundaries, such as cities, counties, MPOs, and states. Political geography also incorporates any other local or regional jurisdictional boundaries reflecting public entities.

Why Use Political Geography?

The primary purpose of delineating TAZ boundaries consistent with political geography is for subarea analysis of model outputs. Entities using travel demand models often need to analyze/evaluate travel patterns relevant to certain predefined political geographies, such as cities or counties. Nesting TAZs within this political geography facilitates easy grouping of TAZs that fall within that geography, and assists in aggregating outputs from the travel demand models. Having a TAZ structure consistent with political boundaries also assists in isolating and extracting certain sets of TAZs according to their location under political boundaries, and analyzing travel patterns relevant to each jurisdiction or within different political geographies. For example, if an MPO wishes to identify the magnitude of travel between each of its cities, having the TAZ boundaries consistent with city boundaries assists in the aggregation of data for

[15] United States Census Bureau, *Appendix A. Census 2000 Geographic Terms and Concepts*, page A11 to 12, http://www.census.gov/geo/www/tiger/glossry2.pdf.

each city, and then enables the modeler to conduct an intracity travel pattern analysis.

How to Use Political Geography

The first step in delineating TAZs based on political geography is to identify all political geography that is of interest for analysis. Upon deciding that, one should collect data depicting the relevant political geography either from a public source, if available, or through a process of digitization or georeferencing in software such as ArcGIS.

As in the case of physical geography, upon obtaining the political boundary data, make sure that no TAZ boundary partially overlaps with a political boundary (Figure 3.7a), and that the TAZ boundaries align with political boundaries (Figure 3.7b). If a TAZ boundary spans beyond the political boundary, then one can split that TAZ at the political boundary to form the required nesting (Figure 3.7b).

Figure 3.7 Delineating TAZs Based on Political Geography

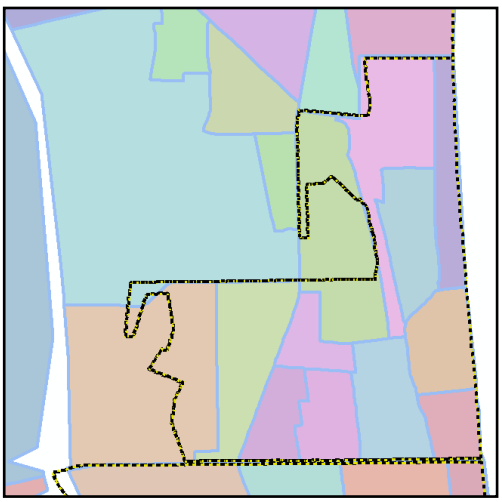


Figure 3.7a *indicates zone boundaries (in colors) crossing over city boundaries (in dotted lines).*

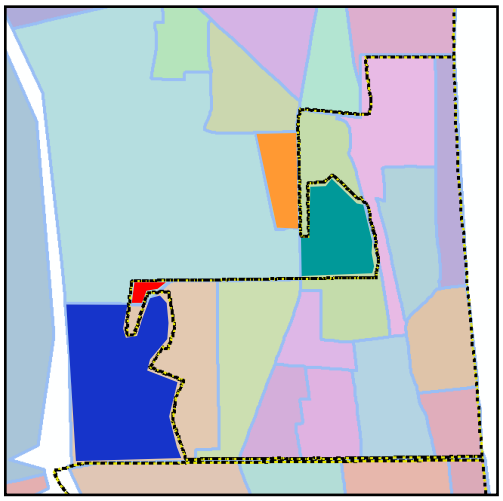


Figure 3.7b *indicates zone boundaries (in colors) adjusted through splitting process to nest within city boundaries (in dotted lines).*

Upon successful delineation of TAZs based on political geography, it might be helpful to assign all TAZs that fall within a certain political geography a logical series of numbers. For example, one can assign numbers ranging from 1 to 99 to all TAZs that fall within a given political boundary, such as a city. One can assign numbers ranging from 100 to 199, and so on, to all TAZs that fall within a different city. Following this procedure would greatly assist in easily querying and extracting all TAZs that belong to a particular city. Even if the city does not have 100 TAZs inside its boundary, for example, it has only 50 TAZs inside it, it would still be helpful to reserve TAZ numbers from 51 to 99 available for any

additional TAZs that might arise from future TAZ refinements in that city. Another option is to assign sector or geographic location codes to TAZs representing each of the cities.

3.2.4 Planning Districts and Sectors

Ideally, TAZs should be nested completely within planning district or sector boundaries. As noted above, this allows for easier reporting of data, such as demographics; productions and attractions; or trips, by planning district or sector. One can use zone-to-district equivalency tables to compress matrices, such as trip tables, to summarize statistics or trips by district.

In addition, one should nest TAZs within CBD boundaries, if at all possible.

3.2.5 Irregular Zone Geography

Irregular zone geography can cause the "lumping" of trips onto the roadway network unrealistically. For example, as illustrated in Figure 3.8a, if a TAZ is mostly rectangular in shape, the longer centroid connectors will not assign as many trips due to link distance. As a result, the trips most likely load from the centroid to the roadway network using the shorter centroid connectors; when in reality, the majority of the trips from the area within the TAZ may not be loading nearly as many trips at that one access point. To resolve this issue, one should split the TAZ to reduce the lengths of the centroid connectors and replicate real access to the roadways, as indicated in Figure 3.8b.

Figure 3.8 Delineating TAZs Based on Irregular Zone Geography

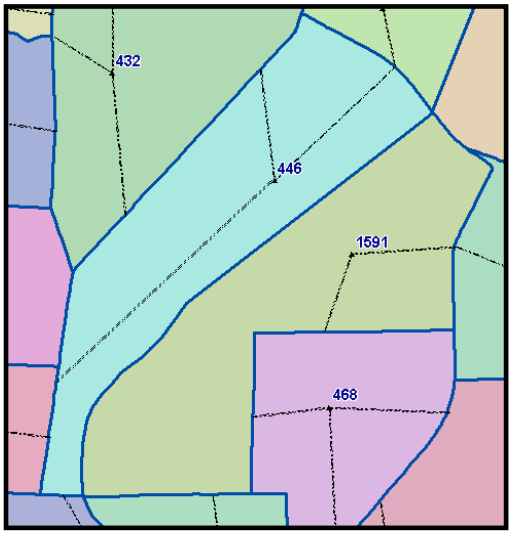


Figure 3.8a *Irregular zone boundaries.*

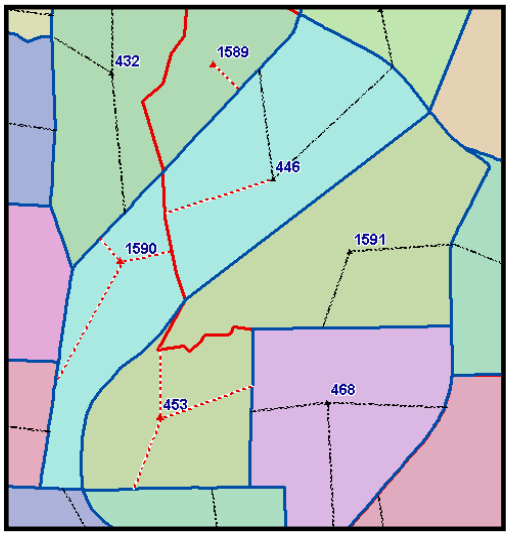


Figure 3.8b *Irregular zone boundaries split to better represent the center of activity and loadings (in red).*

3.3 SOCIOECONOMIC DATA

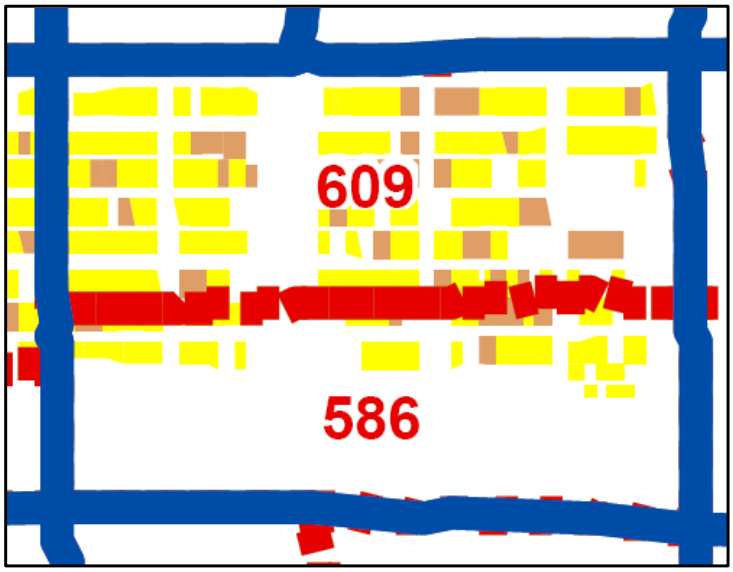
3.3.1 Homogeneous Land Uses

Land use refers to the manner in which portions of land or the structures on them are used, such as commercial, residential, retail, industrial, etc.[16] Homogeneous land uses are those that are similar in nature, such as TAZs that include mostly households or mostly employees.

Why Use Homogeneous Land Uses?

In areas with homogeneous development patterns, isolating activities in separate TAZs assists in analyzing and measuring the behavior of different activities (Figure 3.9). Also, as shown in the Figure 3.9, at places where activities are concentrated on only one side of the TAZ, one can isolate trip generation from such activity easily by delineating the zones based on land uses. In the example depicted in Figure 3.9, by overlaying parcel land use data, one can visually understand that Zone 609 has significant residential development (colored as yellow), and Zone 586 has very sparse development.

Figure 3.9 Usage of Land Use Data to Analyze and Isolate Effects of Different Kinds of Activities



Note that delineating TAZs based on homogenous land uses is not always feasible, such as in central business districts, smart growth developments, or any

[16]Planning Glossary, United States Department of Transportation, Federal Highway Administration.

other mixed use developments. Section 6.0 includes further discussion of this topic.

How to Use Homogenous Land Uses

One can use two primary data sources for the purposes of identifying existing or potential land use on a given parcel: 1) City's Master/Comprehensive Plan; and 2) County's Property Tax Appraisers parcel information. One can obtain master plans by contacting that particular city office. The plan generally contains maps depicting existing and future land uses for their jurisdiction. Most cities have electronic versions of these maps that one can use readily for the purpose. If the cities do not have an electronic version of these maps, one can either contact the county for the tax parcel information or reference the land use maps geographically in software programs such as ArcGIS. The county's tax appraisal office collects information for each parcel to place a value on each individual property. One of several attributes collected is the current land use for each property. One can readily use this information in delineating TAZs, and it is typically available on-line.

Upon successfully obtaining the data from either of the datasets or any other source, one can delineate TAZ boundaries based on clusters of similar land uses (Figure 3.10). One must use judgment to determine the logical groupings of land uses. It is not necessary to isolate each parcel with a distinct land use into a TAZ, but based on the required size of the TAZ, one can judge what constitutes a significant grouping of similar land uses. Figures 3.10a and 3.10b depict a few logical groupings of activities to delineate TAZ boundaries. In Figure 3.10b, Zones 519 and 1299 are separated based on predominant land uses. Though Zone 1299 contains other land uses besides commercial (in brown), as commerical activity is the most dominant land use for the required size of the TAZ, such a zone split seems reasonable.

Figure 3.10 Delineating TAZs Based on Clusters of Similar Land Uses

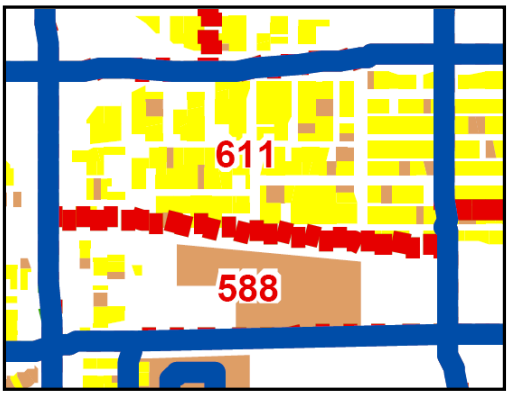


Figure 3.10a *indicates the grouping of commercial activity into the zone 588 and predominant residential activity into zone 611.*

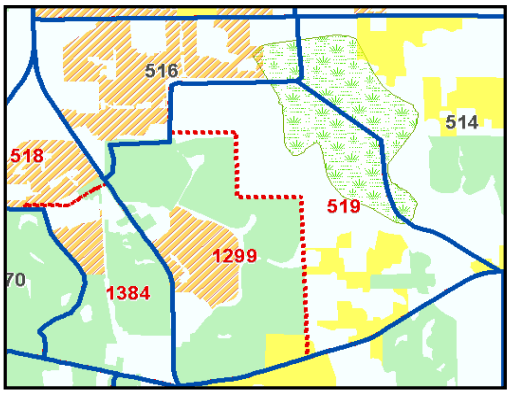


Figure 3.10b *indicates grouping of predominant activity into zone 1299.*

3.3.2 Special Generators

Special generators may be required when the normal trip generation equations produce extra productions or attractions, or produce fewer than expected for a specific trip purpose within a TAZ. These adjustments may be necessary if the trip generation rates applied to the socioeconomic data do not produce the correct number of trip ends. For example, parks and beaches normally have few workers and would produce very few attractions based on employment. By computing a value for the TAZ from some other source, such as the Institute of Transportation Engineers (ITE) Trip Generation Report, the planner can estimate a value for the recreation purpose. Table 3.1 below is a listing of special generators used in Florida.

Table 3.1 Examples of Special Generators

Common	Others
Universities	Hospitals
Community Colleges	Other Shopping Centers
Parks/Beaches	Government Buildings
Regional Shopping Malls	Tourist Attractions
Military Bases	Ports
Airports	
External Stations	
Group Quarters	

For the purpose of delineating TAZs, one should keep special generators as separate zones. An example is a university in a mostly residential area. Centroid connectors coded within the special generator zone should represent the true access point(s) of the special generator to the surrounding roadway network.[17]

3.4 ACCESS

3.4.1 Transit Access

A good estimate of transit ridership is sometimes directly related to a reduction in the size of TAZs. An ideal situation for travel demand modeling is to have zones as small as possible to minimize aggregation error. From a transit access

[17] Barton-Aschman Associates, Inc., and Transportation Research Board, *Report 365 – Travel Estimation Techniques for Urban Planning*, National Cooperative Highway Research Program, 1998.

standpoint, this means an average square zone with one-quarter to one-half mile edges. Many areas have dozens of zones larger than this, and Florida's high growth rates imply that a substantial amount of transit ridership would occur in these zones in future years.

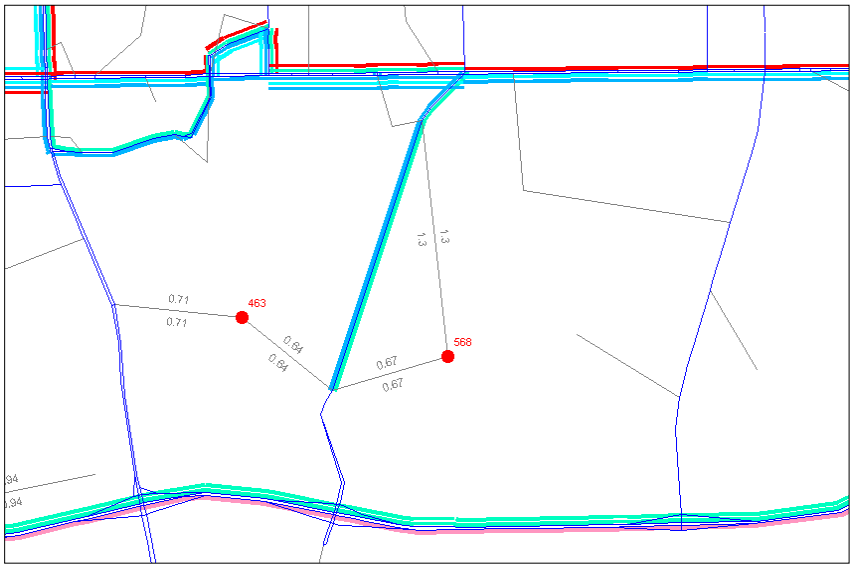
This necessitates a mechanism to evaluate the percentage of the zone having the ability to walk to transit. This reflects the fact that, although transit service may directly service certain portions of the zone (via walk access), some of the zone may not be served at all. This mechanism is known as percent walk to transit or simply "percent walk." The maximum distance is currently set to one-half mile.

Percent walks are carried into the mode choice utilities, expressed as different access markets. Smaller zones with good transit service are likely to be "100 percent walk," when all activity has the ability to walk to transit. By contrast, large zones with isolated transit service are likely to be "25 percent walk." Such zones are reflected in the mode choice model as 75 percent given only drive-transit and nontransit modes, and 25 percent given a (marginal) chance of walking to transit and all other modes.

The PT Module

Zone sizes and connectors take on a heightened sensitivity with the conversion of Florida models to Florida Standard Urban Transportation Model Structure (FSUTMS) Cube-Voyager, as the Public Transport (PT) module strongly relies on a well-developed zone system with centroid connectors truly representative of access/egress capabilities. The new transit standards, recently developed by FDOT, use PT to generate all walk- and transfer-access connections (or access legs). Unlike its TRANPLAN-oriented predecessor, PT uses <u>only</u> the centroid connectors when generating the access legs. The new one-half mile maximum for walk-access effectively requires that zones served by transit need to have connectors less than one-half mile. Zones with longer connectors are not connected to transit, regardless of the frequency of the transit service. Figure 3.11 shows two zones (463 and 568) with hourly bus service. However, PT will not create any walk-access legs, because all the connectors for both zones are longer than one-half mile.

Figure 3.11 Two Zones with Bus Service, But Excessive Connector Length Prevents Walk-Access Connections



The following two sections describe common problems that arise during forecasting studies when zone areas are not properly sized for the desired level of analysis. The final section describes an easy method to evaluate the effectiveness of zone sizes. Note that an individual examination of transit service and connectors for each zone is the best way to determine when they are too large for transit analysis.

The "Large Zone/Single Station" Problem

Figures 3.12 and 3.13 provide a good example of how large zones can impact transit accessibility and ridership. They represent a situation that arises in Alternatives Analysis called the "large zone/single station" problem. A large zone on the fringe of the suburbs contains one large development located in a quadrant of the zone. Assume no other development exists. The left side of Figure 3.12 shows a rail station (shown in red) on the western zone boundary. The percent walk computation determines that one-third of the zone is within one-half mile to the station. Although the development is more than one-half mile away, the mode choice model is told that 33 percent of the development's residents have walk access to transit. As a result, the transit market is 33 percent of the development's residents. The right side of Figure 3.12 illustrates the same conditions, but a subzoning process has been completed. In this case, the percent walk computations determine that 0 percent of the development's zone has access to transit. The effective transit market is 0 percent, which is a more accurate representation.

Figure 3.12 Overestimating Walk Access to Transit

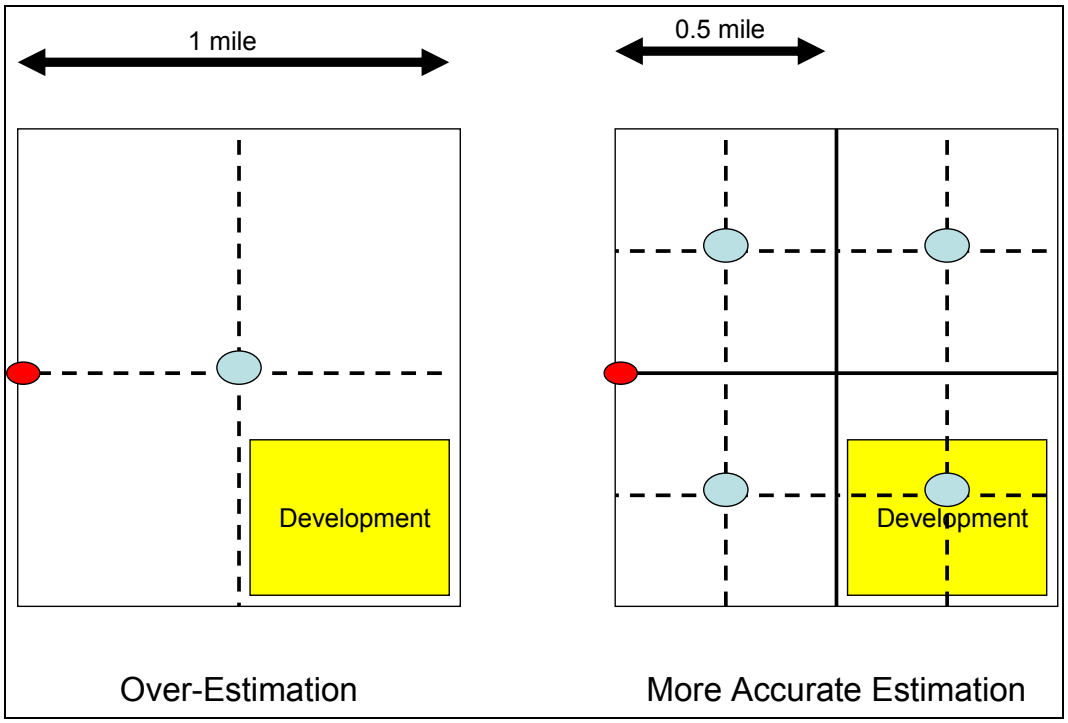
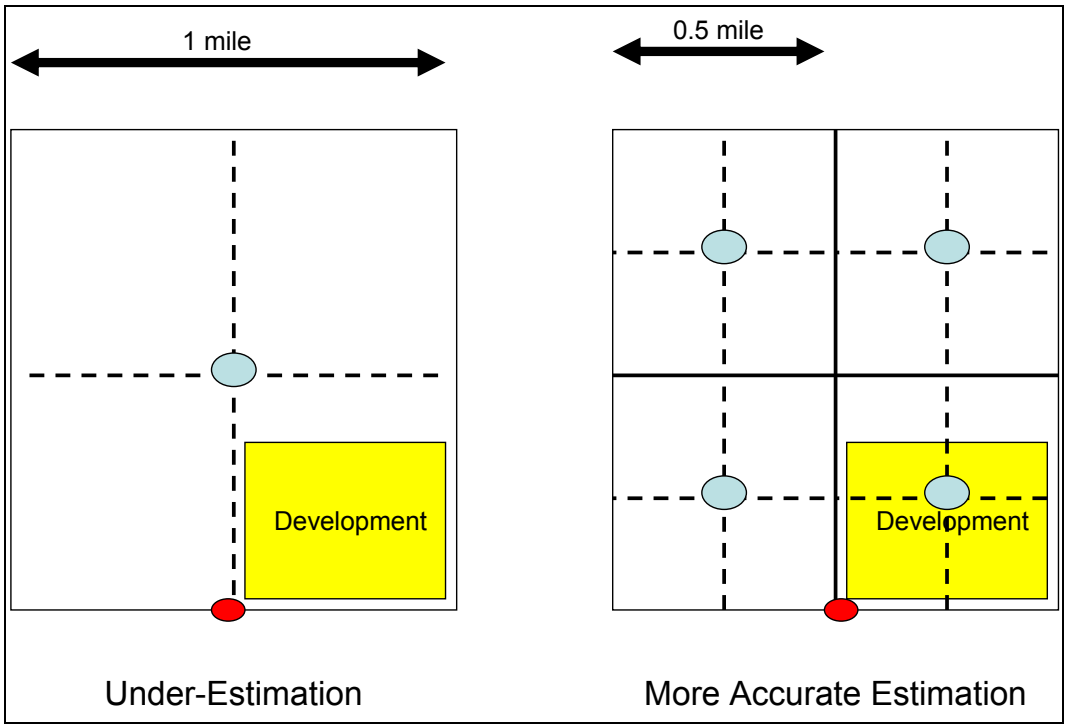


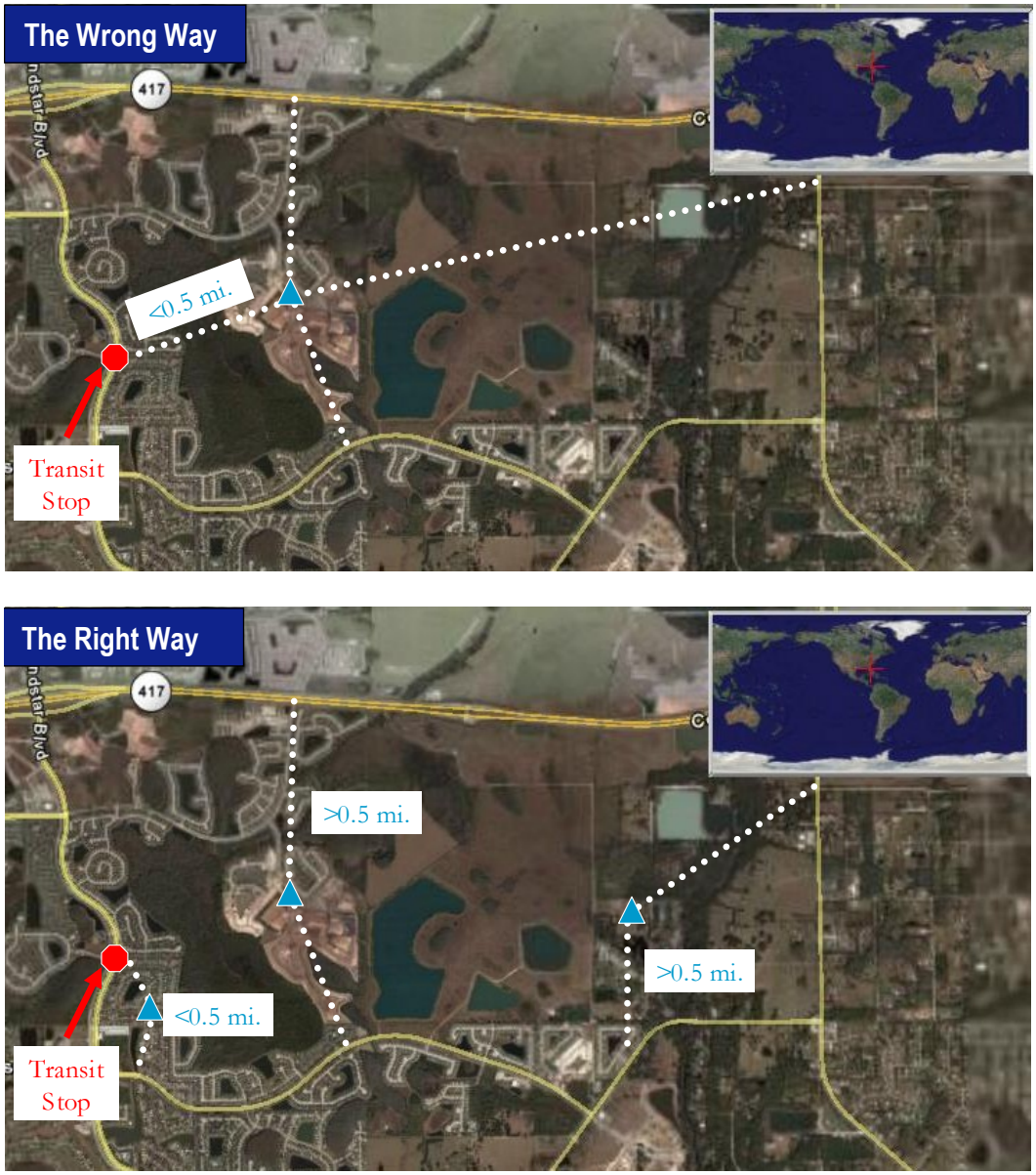
Figure 3.13 illustrates the same zone and development assumptions, but with the rail station much closer to the development. The left-side conditions would result in the transit market underestimated. Assume the entire development is within one-half mile of the station. The percent walk computations would determine that only 33 percent of the zone is near the station. So the transit market is underestimated by two-thirds. The right side of Figure 3.13 illustrates a much more accurate estimation of the transit market, as the percent walks and actual distance to the station should match exactly.

Figure 3.13 Underestimating Walk Access to Transit



A similar example is illustrated in Figure 3.14. Using Google satellite imagery, the larger zone assumes that anyone living or working in the TAZ has access to the transit stop on the western boundary since the centroid connector is less than 0.5 miles long. However, in reality, those located on the eastern side of the TAZ, as well as those located on the northern and southern sides of the TAZ, are not within a 0.5-mile walking distance. Additionally, the example assumes that people are walking across the lake which obviously is not the case. The Right Way, also illustrated as part of Figure 3.14, demonstrates the correct way to delineate TAZs based on transit access, as people are not crossing the lakes to get to the transit stop. In addition, it does not assume the larger number of people have access to transit based on the distance of the centroid connectors within each TAZ. Barriers can also be coded separately in the barriers file to eliminate the possibility of transit access connectors being generated across these barriers.

Figure 3.14 Delineating TAZs Based on Transit Access



The "Large Zone/Small Activity Area" Problem

Zone sizes are also important for large parcels having a relatively small activity area that receive transit service. Airports and universities are classic examples. Figure 3.15 shows an example of this problem. Zone 463 is largely university property with a small area of concentrated activity. The activity area is within the black circle in the figure. A bus enters this zone and circulates within the activity area. However, since the zone is quite large, the bus routing cannot be better represented, and the transit market is underestimated for similar reasons as in previous examples.

Figure 3.15 University in Zone 463 Suffers from the Large Zone/ Small Activity Area Problem

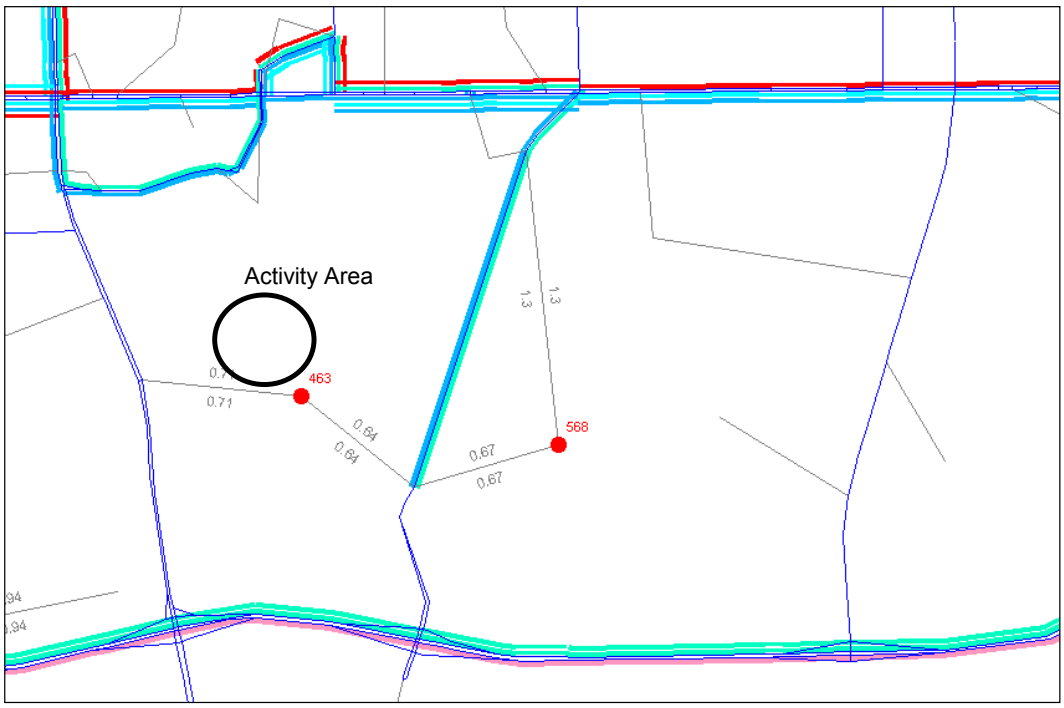
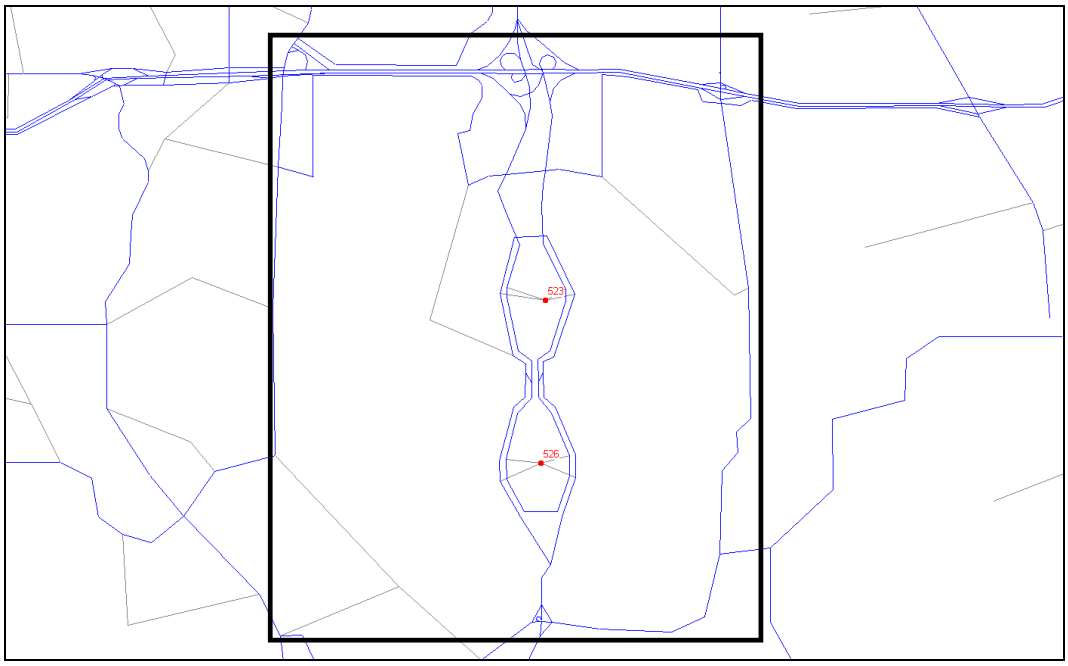


Figure 3.16 shows a good example of how to correct this problem. In the Orlando model, the two major terminals of the Orlando International Airport (the entire property is bounded by a black rectangle) are given separate zones. Transit service to the airport can be coded very accurately, circulating through the microcoded streets and stopping only at the terminals.

Figure 3.16 Good Solution to Large Zone/Small Activity Area Problem



Evaluating Zone Sizes

Zone sizes should be relative to the amount of activity being represented. However, gauging zone size and activity levels can be difficult, especially for future years when growth levels are abstract. A simple evaluation measure is to compare base and future year trip activity to zone size on a cumulative frequency distribution plot. Follow the following steps to create these plots:

1. In Excel, develop a record for each zone that has fields for zone number, zone count, base year population, base year employment, future year population, and future year employment. The zone count is a cumulative count of non-dummy zones. Do not use dummy zones for this analysis.
2. Compute base and future year activity levels for each record. Estimate trip activity by adding population to two times employment.
3. Sort the records in ascending order based on zonal area.
4. Compute cumulative totals of number of zones, zonal area, base year activity, and future year activity for each record. Also, compute the cumulative percent of the totals.
5. Using Excel's charting tools, create a line graph of the four fields. The X-axis should be zonal area. Cumulative percent should be on the Y-axis.

An example of the final plot is shown in Figure 3.17. From a transit perspective, all three lines should be close together and a majority of the zones should be less than a square mile. Figure 3.17 illustrates that slightly less than 50 percent of the

zones are less than one-half square mile. Base and future year activity levels are divergent from zonal area. Only about 55 percent of base year activity occurs in zones less than a square mile. Approximately 42 percent of future year activity occurs in the same zones. The results indicate that zone refinements are desirable.

Figure 3.17 Graph Comparing Zone Size to Activity Levels

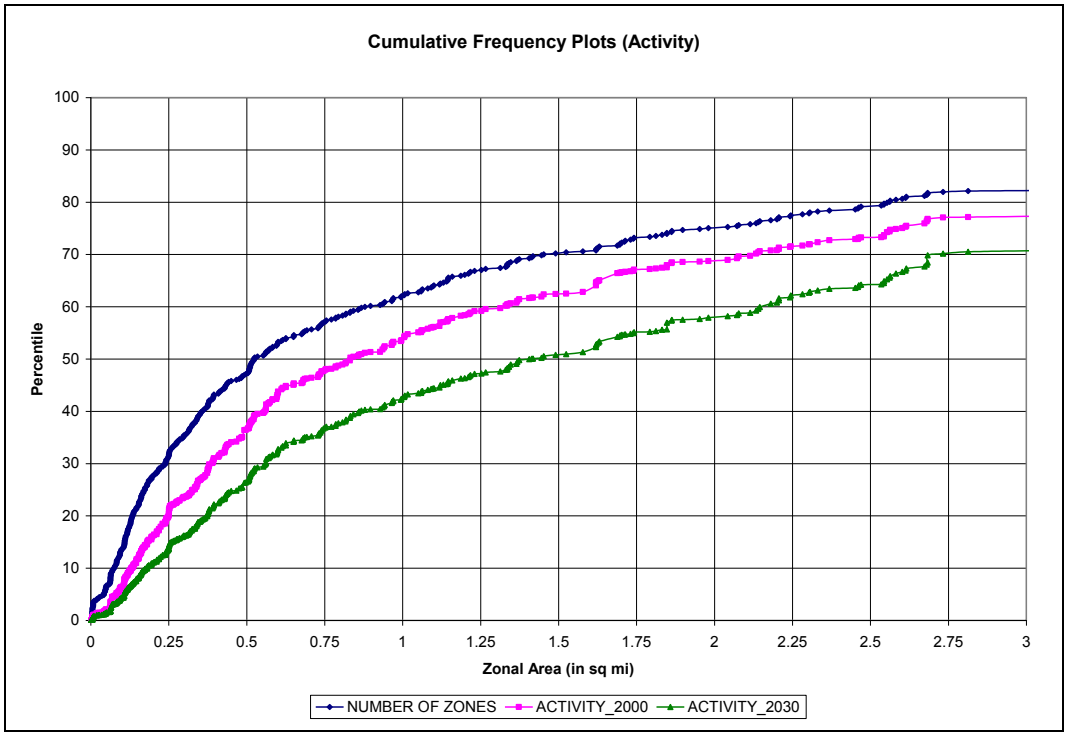
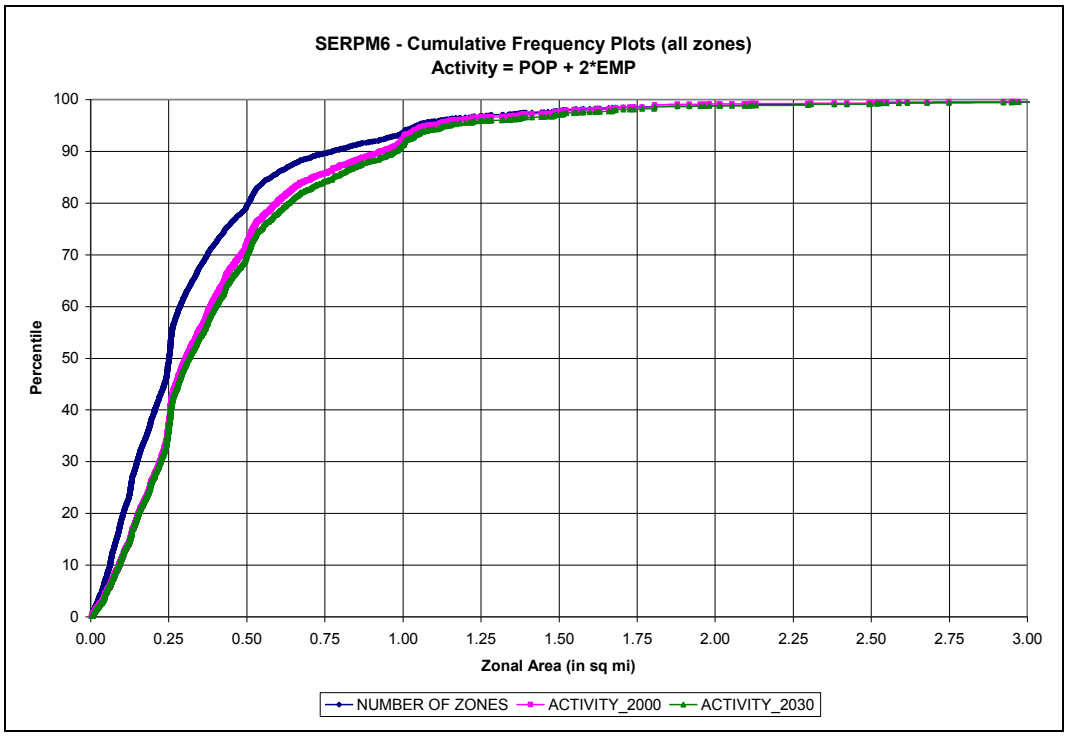


Figure 3.18 is the same plot for a different modeling area, the latest version of the Southeast Florida Regional Planning Model (SERPM). This graph implies a good zone area-activity balance, as over 90 percent of the zones are less than a square mile. Activity levels for the base and future years correlate very well with zone area.

Figure 3.18 SERPM6 Graph Comparing Zone Size to Activity Levels



3.4.2 Freight/Intermodal Needs

Using methods included in the Federal Highway Administration's (FHWA) Quick Response Freight Manual, one can calculate the number of commercial vehicle trip ends by TAZ. The following facilities typically generate and attract a large amount of daily truck activity:[18]

- Seaports;
- River docks;
- Truck-rail intermodal terminals;
- Airports;
- Major manufacturing plants; and
- Wholesale, retail, warehousing and redistribution, and extractive industry sites (dependent upon the level of freight/truck activity).

It would be ideal to isolate these truck generators/attractors into separate TAZs.

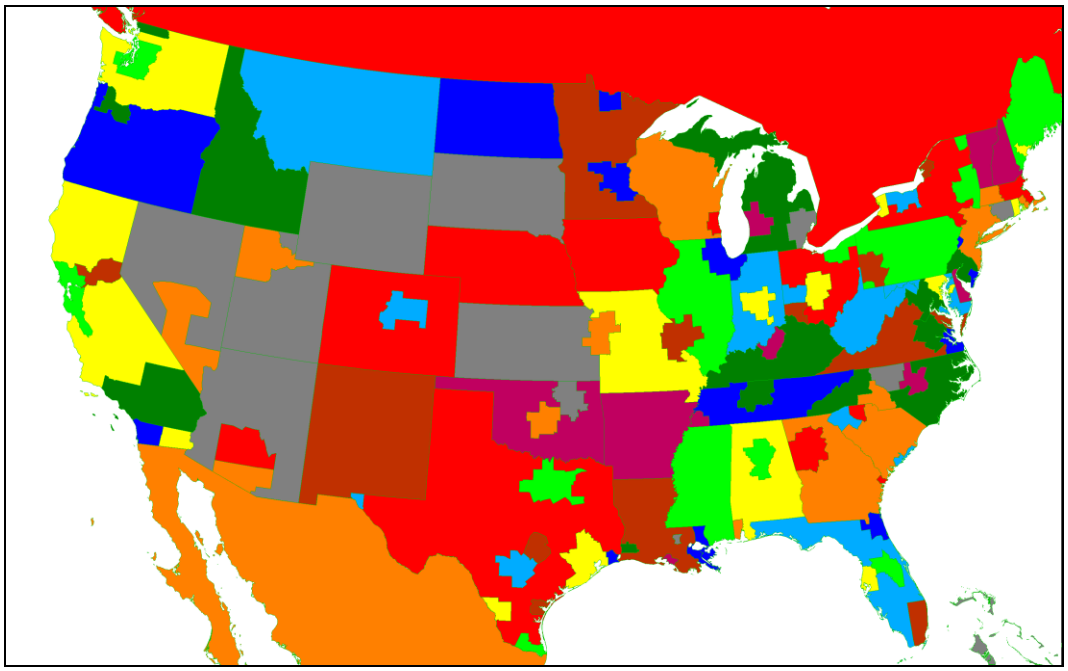
[18] *Freight Analysis Framework Highway Capacity Analysis Methodology Report*, Office of Freight Management and Operations, Federal Highway Administration.

The FHWA Freight Analysis Framework (FAF) data provides commodity flow estimates between states, regions, and major international gateways. FAF^2 provides commodity flow estimates for 2002 and the most recent year plus forecasts through 2035 and addresses seven modes: truck, rail, water, air, intermodal, pipeline, and other multiple modes. As an alternative to the FHWA Quick Response Freight Manual method, TRANSEARCH data is often used to convert the FAF commodity flow data to commercial vehicle trips. The old version, FAF^1, provided commodity flow data at the county level. However, the new version, FAF^2, provides data at the Commodity Flow Survey (CFS) zone level. As illustrated in Figure 3.19, there currently are 114 CFS zones in the United States, five of which are in Florida (statewide, Jacksonville, Tampa, Orlando, and southeast Florida).[19] The FDOT currently is disaggregating the FAF^2 data further into smaller freight analysis zones (FAZs) for the state of Florida. It is anticipated that these FAZs will be based largely on the current year 2000 Florida Statewide Model TAZ structure. It is recommended that modelers consider the statewide model TAZ structure not only for the purposes of being consistent with the FAF^2 zone geography, but also to assist with delineating TAZs in more rural areas.

In addition, some areas in Florida, such as Tampa and Orlando, have collected local truck trip-making data to use in their truck models, as the level of aggregation in the Florida Statewide Model may not suit their needs. One should use local freight/truck data, if available, instead of the statewide model truck data. However, note that although many areas may have collected local truck count data, truck count data alone is not sufficient to develop truck trip patterns in a truck model. A truck trip diary survey is necessary to calculate truck trip attraction rates and replicate truck trip-making patterns.

[19] Tang, Tianjia, *Freight Analysis Framework Update Presentation*, Office of Freight Management and Operations, Federal Highway Administration, Florida Model Task Force Meeting, December 2006.

Figure 3.19 Freight Analysis Framework CFS Zones



Source: Office of Freight Management and Operations, Federal Highway Administration.

3.5 CENTROID CONNECTORS

In addition to defining the actual boundaries of TAZs, representing realistic access to and from the zones with the use of centroid connectors is also important. The following is a summary of guidelines already discussed that one should consider when coding centroid connectors:

- Centroid connectors should represent realistic roadway and transit access;
- Centroid connectors should not cross man-made or natural barriers, such as lakes, rivers, railroad tracks, limited access highways, etc.;
- Include a sufficient number of centroid connectors to avoid the loading of too many trips onto one roadway network link;
- Do not connect centroid connectors at intersections or directly to interstate ramps, as illustrated in Figure 3.20a (The Wrong Way) and Figure 3.20b (The Right Way); and
- When two centroid connectors are connected to the same roadway segment, the access points should be separated by a certain distance, as illustrated in Figure 3.21a (The Wrong Way) and Figure 3.21b (The Right Way).

Figure 3.20 Placement of Centroid Connectors Relative to Intersections and Interstate Ramps

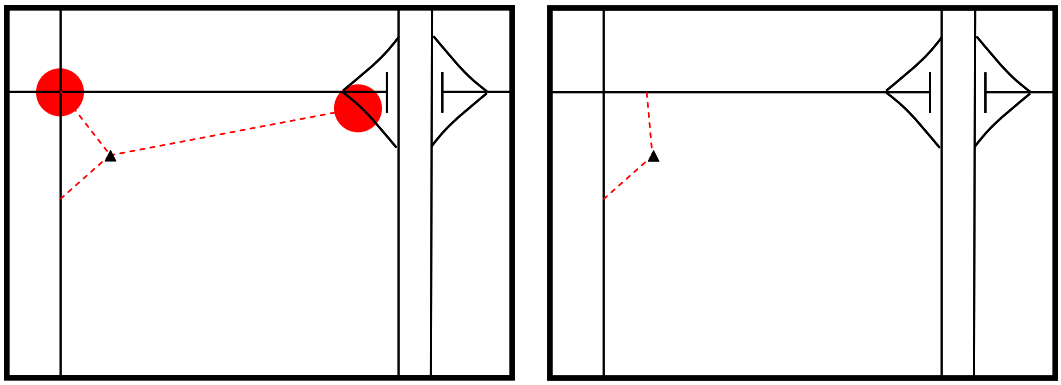


Figure 3.20a *The Wrong Way* ***Figure 3.20b*** *The Right Way*

Figure 3.21 Offsetting Centroid Connectors at Access Points

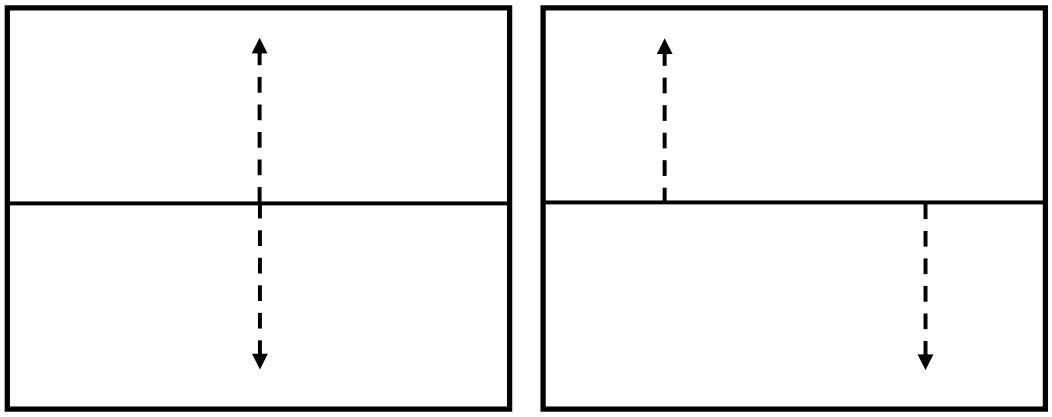


Figure 3.21a *The Wrong Way* ***Figure 3.21b*** *The Right Way*

3.6 EXISTING TRANSPORTATION FACILITIES

Much like physical geography, the location of existing transportation facilities is among the most common considerations for TAZ delineation. In terms of highway facilities, only freeways, expressways, and arterials are considered access barriers, as local and collector streets do not necessarily restrict movement across them. Even for major roads, understanding grade separations is helpful in determining and potentially filtering out the street segments that might impose physical barriers. Data on minor roads, though they do not provide barriers, can be useful in determining whether or not any access is possible from a given TAZ to the model network (earlier Figure 3.1c).

The following transportation facilities should always form TAZ boundaries:

- Rail lines;
- Limited access highways;
- Arterial streets and roadways; and
- Collector streets and roadways.

Matching the boundaries of TAZs with roads assists in more accurate loadings of trips onto each street segment, and minimizes coding of centroid connectors that cross over major roads. Having the knowledge on how minor roads link to major highway facilities is useful in determining logical boundaries for TAZs. In the earlier figures, delineating four separate TAZs based on underlying roads isolates the effect of the area serviced in each quadrant on the model network; however, TAZ splitting, as displayed in Figure 3.2c, would only be necessary if this were a location of high-density development.

One-way streets provide a different set of challenges in delineating TAZs. If major one-way streets are used as TAZ boundaries, this results in somewhat small zones lying between the two parallel streets that comprise a one-way pair. One-way streets are often present in CBDs. In the interest of minimizing streets bisecting zones, some CBDs have separate TAZs for every downtown block. The downside of this is that persons often park in a different zone from where they work, causing some inaccuracies in highway modeling. Conversely, transit modeling requires access from the buildings.

3.7 TAZ NUMBERING

Although not required, it is recommended that TAZ numbers begin with one and be consecutive. However, it is not uncommon for regional models to set aside a specific range of TAZ numbers for both TAZs and dummy zones for each county. For instance, County A may use numbers 1 to 100, of which 81 to 100 are dummy zones. County B may use numbers 101 to 200, of which 171 to 200 are dummy zones. This allows the model users to differentiate between counties or other political boundaries. Another way to flag counties is through the location code, which is often used in Florida. Other areas throughout the country may actually sequence the zone numbering within and outside the CBD or along a perimeter roadway (i.e. beltway).

In addition, one should create TAZ equivalency tables to provide a list of the new zone numbers that were split from the original zone numbers. One can use these TAZ equivalency tables to further aggregate or disaggregate the corresponding socioeconomic data.

4.0 Future Year TAZ Considerations

In addition to reviewing existing data, future year data should also be considered when delineating base year TAZs. Once the base year TAZ structure has been finalized and the model validated, future year socioeconomic data and trip forecasts should be reviewed as part of model sensitivity testing. It is important that TAZ boundaries and centroid connectors generally remain the same between model years with a few exceptions, as changing them impacts the model validation. These exceptions include the following:

- Future planned transportation corridors (both highway and transit);
- Developments of regional impact (DRIs); and
- Construction within previously vacant areas that would result in increased densities.

Further detail is provided below.

4.1 Planned Transportation Corridors

When defining the TAZ structure in the base year, one should also consider planned future transportation corridors. The Long-Range Transportation Plan (LRTP) for the study area should be used to identify planned highway and transit corridors. If a planned highway or transit corridor bisects a TAZ, the modeler should consider splitting the TAZ in the base year if feasible. Figure 4.1a provides an example of how the base year zone structure and centroid connectors may look without considering a future corridor. Figure 4.1b illustrates what the base year zone structure would look like if the planned corridor were considered; however, the future corridor is not depicted in the base year network. Figure 4.1c illustrates the future year zone structure with both the planned corridor and additional centroid connectors included. One can consider this same process when conducting subarea studies that require further refinement within the travel demand model.

4.2 Developments of Regional Impact

In addition to network changes, one should also consider future socioeconomic data, especially new DRIs in the study area. The modeler should consider the study area's Comprehensive Plan future year land use map and any amendments when delineating TAZs in the base year, as it can have a significant impact on the delineation of TAZs. Figure 4.2a illustrates the base year TAZ

structure based on existing land use, whereas Figure 4.2b illustrates the base year TAZ structure considering future year land use and providing a placeholder for the planned DRI.

Figure 4.1 Defining the TAZ Structure Based on Future Corridors

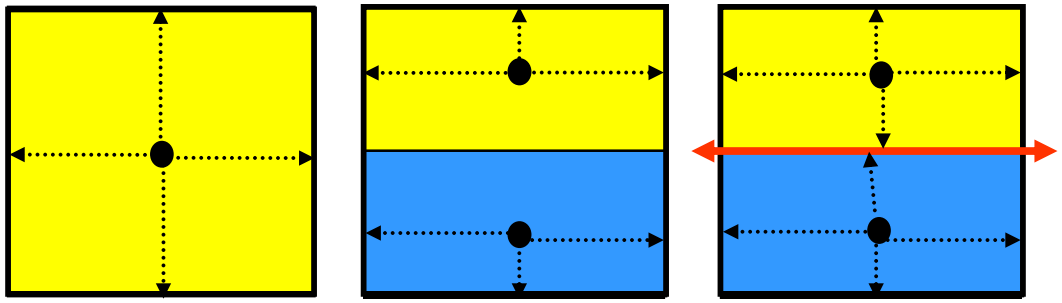


Figure 4.1a – *Base year zone structure without considering future corridor.*

Figure 4.1b – *Base year zone structure considering future corridor.*

Figure 4.1c – *Future year zone structure incorporating future corridor and additional centroid connectors.*

Figure 4.2 Defining the TAZ Structure Based on Future DRI

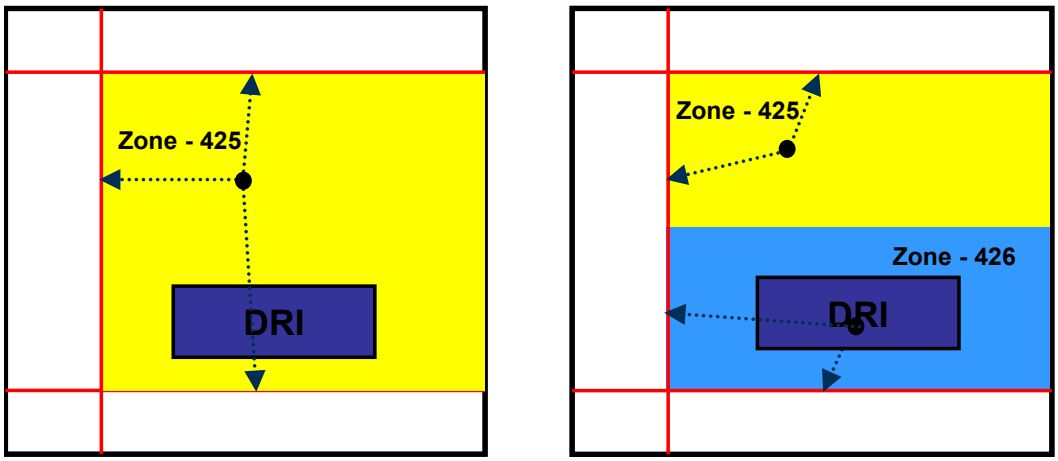


Figure 4.2a – *Base year zone structure without considering future DRI.*

Figure 4.2b – *Base year zone structure considering future DRI.*

4.3 POPULATION AND TRIPS PER ZONE

As mentioned in Section 3.0, anything more than 15,000 trips per day or 1,200 to 3,000 people per TAZ exceeds the recommended zone size. Often times, a TAZ may not have as many people or generate that many daily trips in the base year.

However, with the future year land use, it may very well push the population or daily trips over the thresholds noted above. As a result, one should also consider future year socioeconomic data when delineating base year TAZs.

5.0 Splitting TAZs

Section 5.0 discusses how to split TAZs and their respective socioeconomic data once you have decided how to split them using the guidance provided in Sections 3.0 and 4.0.

5.1 NETWORK DATA IMPACTS

As discussed in Section 3.0, when one splits a TAZ, one needs to update the highway network to reflect the new TAZ structure. For instance, one may split a TAZ as a result of a minor arterial road being added to the model that now bisects the zone. The minor arterial that split the zone now serves as the new border of two split zones. Note that in some cases, adding a link in the highway network to reflect a new road or additional network detail may require the splitting of a highway link. If the model also includes a transit network, the user should activate the transit route files in FSUTMS-Cube Voyager in order for the transit route files to be automatically updated if the link being split occurs on a transit route. If the split link occurs on a transit route and the transit route files are not updated, the transit step fails when running the model as a result of the erroneous node sequencing in the transit route file due to missing node(s).

In addition to updating the highway network roadway links, centroid connectors also require updating as a result of new TAZs or TAZ splits. As discussed in Sections 3.0 and 4.0, centroid connectors should represent realistic access points.

5.2 SOCIOECONOMIC DATA IMPACTS

5.2.1 Household Data

Splitting household data into new TAZs can be the most time-consuming aspect of zone splitting, dependent upon whether TAZ boundaries are consistent with Census or political geography. Having TAZ boundaries consistent with Census geography enables practitioners to readily access the Census data for apportioning the data after a TAZ has been split. If the boundaries are not consistent, the process might be tedious and may require local-area knowledge to apportion the data properly.

As mentioned earlier in this document (Section 3.1.2), the U.S. Census Bureau only collects household data on a decennial timeframe, although each state's clearinghouse agency estimates and forecasts county-level population for a number of future years. The Bureau of Economic and Business Research (BEBR) at the University of Florida serves as Florida's official agency for population projections.

The data elements that the Census Bureau collects vary for different Census geographies. At the block level, the Census Bureau collects and tabulates 100 percent decennial Census data. At the block geographic level, one can obtain information on age, number of households, and whether the residence is owned or rented. The Census Bureau collects this information from all people and housing units in the Census SF1 and SF3 databases. In terms of household data for modeling purposes, though information on population and dwelling units is offered at the block level, details such as the type of dwelling unit (single-family or multifamily) and population levels for each type of dwelling unit, are not available. The Census Bureau provides these details at the block group level, at which the Census Bureau tabulates sample data from the decennial Census. The Census Bureau collects the sample data from one in six people, and then weights the sample data to represent the total population. Block group data contain additional information on population and housing, including auto availability and income.[20]

In cases where the new zone structure (after TAZ splits) is consistent with Census block groups, data for the new zones can be derived directly from the underlying block groups without exceeding the totals of the original zone's data. Although the new zone structure is consistent with the Census block group structure, the relative proportions must be derived from the Census block group data rather than directly using the Census data itself. This is as a result of the base year in question not being the same as that of Census data. For example, assume that Zone 425 has a population of 1,000 and is split into three zones, renumbered as 425, 495, and 501, and the geography of the new zone structure matches that of the Census block groups (Figure 5.1a). Based on the Census block group data, one can compute relative proportions for all three new zones using the following formula:

$$\text{Relative proportion of population for zone 495 (Pr1)} = \frac{\text{Population in the block group that new zone 495 corresponds to}}{\text{Total Population of all block groups that correspond to original zone 425}}$$

These proportions can then be applied to the original zone's data to derive data for the new zone structure. In our example, population for new zone 495 will be equal to 1,000 x Pr1. Upon assigning data to these new zones, it is important to verify that the total from the new zone structure is equal to the original zone's data. As we are applying proportions to the original's total, there may be instances where there is a loss of data due to rounding errors. For example, the total of the original zone 425 may be 1,000, where as the total from the new zones 425, 495 and 501 may be 1,001 due to the rounding errors from calculating the

[20] United States Census Bureau.

proportions. Hence, verifying the totals after assigning the data based on relative proportions is important.

One can adopt a similar process described above in instances where the new zone structure does not match the block group geography but it does match block geography (Figure 5.1b). One can derive data for the new Zones 425 and 495 (shown in Figure 5.1b), which are consistent with block geography, using relative proportions of general household data from Census blocks (rather than block groups) and one can apply the remaining portion of the original zone's data to 501.

There might be situations where TAZ splits are inconsistent with all Census geography. In such cases, one can use alternate data sources that provide information on land uses (e.g., parcel data), in addition to Census data. In many cases, one must use deductive reasoning to identify the most likely distribution of socioeconomic data across the TAZ splits. Local knowledge would play a key role in determining the most accurate data splits possible based on the data available.

Figure 5.1 Splitting Household Data into New TAZs

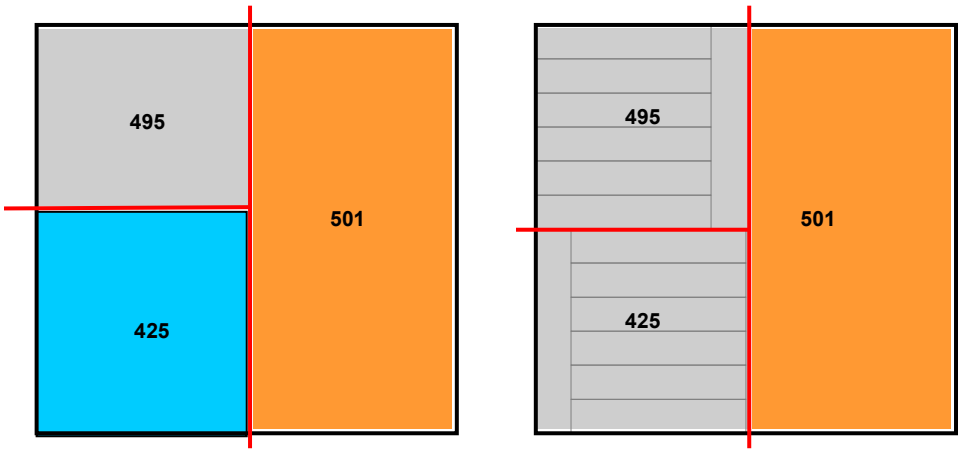
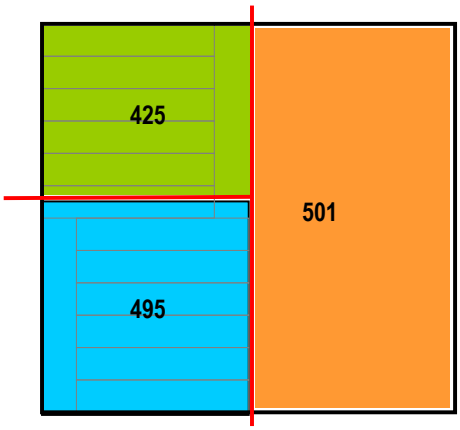


Figure 5.1a *indicates the original zone 425 (in black) split (at red lines) into three zones 495,425 and 501 based on block groups (colored areas).*

Figure 5.1b *indicates the original zone 425 (in black) split (at red lines) into three zones 495,425 and 501 based on blocks (gray lines). Colored areas indicate block groups.*

As shown in Figure 5.2, there might be a scenario where the split intersects one or more block geographies. In such instances, one can use land use and parcel information over and above the mathematical operations to make best judgments on household data distributions over these multiple block geographies. Only the dwelling unit and population data were split according to the above methods.

Figure 5.2 Household Data Splits Intersecting One or More Census Geographies



5.2.2 Employment Data

Splitting employment data might not be as complicated as household data, as long as employment is available in latitude/longitude. To split employment data, one needs a dataset similar to the Census that provides employment information by various industrial sectors, such as InfoUSA.

InfoUSA is a proprietary database that provides spatially enabled employment data (latitude/longitude information) with information related to the classification and size of the business establishments. FDOT purchased 2007 InfoUSA data for the entire state of Florida and intends to distribute these data to each of the FDOT district offices for public-sector use. Each business establishment in the InfoUSA dataset is flagged with both a Standard Industrial Classification (SIC) code and a North American Industry Classification System (NAICS) code specifying its industry classification.

The **Standard Industrial Classification Code** is a four-digit code used to categorize various employment industries. The official listing and descriptions of these codes are available on the Securities and Exchange Commission's web site at: http://www.sec.gov/info/edgar/siccodes.htm. The **North American Industry Classification System (NAICS) Code** is a six-digit code used to categorize various employment industries, which was released in 1997 and has since replaced the SIC code. The official 2002 U.S. NAICS Manual, which includes definitions for each industry and tables showing the relationship between 2002 and 1997 NAICS codes that were changed, are available on the Census web site: http://www.census.gov/epcd/www/naics.html. One can use these classifications to identify the type of employment, such as industrial, retail, or service, that are needed for allocating industry-specific employment data input into the travel demand model.

In addition to providing SIC and NAICS codes for each establishment, the InfoUSA database also provides information with regard to the size of the establishment. This information is provided on a categorical scale in Table 5.1 below.[21]

Table 5.1 InfoUSA Categories for Number of Employees

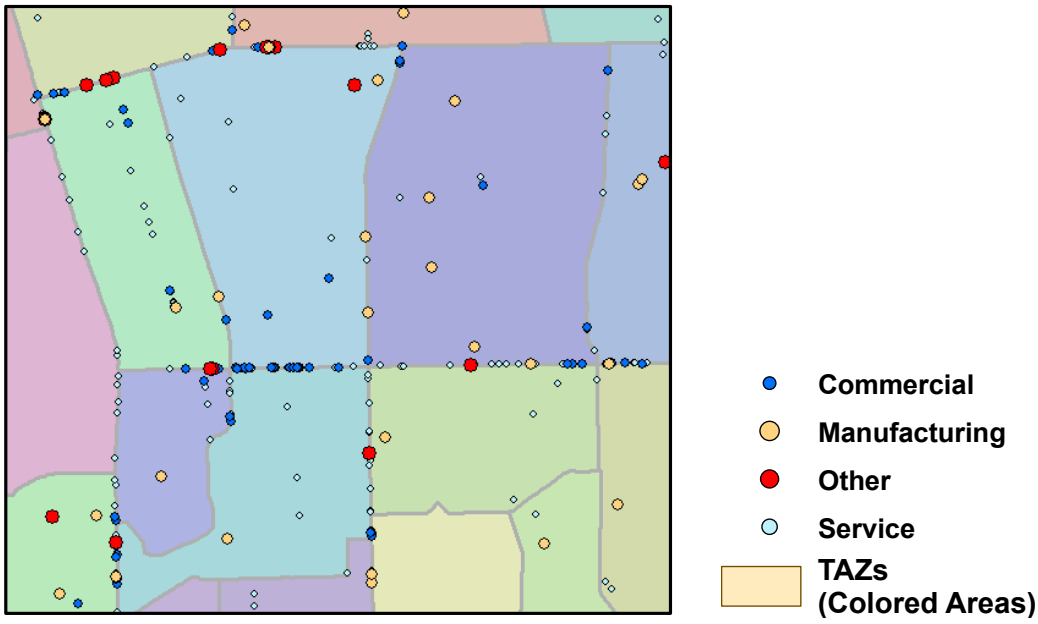
Code	Number of Employees	Code	Number of Employees
A	1 to 4	G	250 to 499
B	5 to 9	H	500 to 999
C	10 to 19	I	1,000 to 4,999
D	20 to 49	J	5,000 to 9,999
E	50 to 99	K	10,000 or more
F	100 to 249		

Though InfoUSA does not provide the exact amount of employment for all employers in the InfoUSA database, one can use median values in these ranges to derive approximate employment at each establishment. The InfoUSA dataset provides the data elements, employment type, and size that are required for the TAZ splitting process. One can also use any other dataset that provides similar information, assuming it is comparable to the InfoUSA data.

For splitting the employment data, each new zone should be geographically overlaid with the master employment data (i.e., point locations from InfoUSA). Based on the employment classifications required by the travel model, one must aggregate data for all locations that fall inside any new TAZ for each of the classifications to obtain total employment by industry in each zone (see Figure 5.3). One can use this information to derive relative proportions of employment using the employment database. One can then apply these relative proportions to the original zone's employment data to obtain data for all new zones.

[21] InfoUSA Documentation – U.S. Field Decode Sheet.

Figure 5.3 Master Employment Data Categorized Into Classifications (Color-Coded) Required by the Model



For example, original Zone 425 was split to obtain three new zones that were numbered as 425, 499, and 501. For a spatial overlay of master employment data onto these new zones, 50 employees in the manufacturing sector might yield estimates of 12, 20, and 18, respectively. One would then use these values to obtain relative proportions as:

12 InfoUSA Employees/50 Total InfoUSA Employees = 0.24 or 24 percent of Original TAZ 425;

20 InfoUSA Employees/50 Total InfoUSA Employees = 0.40 or 40 percent of Original TAZ 425; and

18 InfoUSA Employees/50 Total InfoUSA Employees = 0.36 or 36 percent of Original TAZ 425.

If the original TAZ had a total employment of 60 in the manufacturing sector, then employment is allocated by conducting the following computations:

0.24 x 60 Original TAZ Employees = 14 Employees in New TAZ 425;

0.40 x 60 Original TAZ Employees = 24 Employees in New TAZ 499; and

0.36 x 60 Original TAZ Employees = 22 Employees in New TAZ 501.

One can write scripts using Visual Basic for ArcGIS to automate the methodology of splitting the employment data and for quality control processes, thus saving significant time and effort in manual computations.

5.2.3 Other

Besides household and employment data, there are other data elements that need to be distributed during a TAZ split process. Some of these elements include schools, hotel/motel units, and special generators, such as universities, DRIs, or regional shopping malls. The methodology for all these data elements is grouped under one heading, as there are no universal datasets that would facilitate these data splits. Data splits for most of these elements would require human judgment beyond the use of available data.

Travel demand models typically require total school enrollment by school location. Some models may even require additional details in terms of different types of schools, such as primary school, high school, colleges, and school zones. Unlike the Census and InfoUSA, it might be challenging to obtain a school database with all the required information. If a geographic file encompassing all school data is available, then one can follow a procedure similar to that of splitting employment data. One can overlay the master school data with the new zones resulting from the split, and data in each new zone can be aggregated and classified by the type of school (if that data is available) to obtain school statistics for each zone. One can then derive relative proportions based on master school data and applied to each zone's data. In most cases, the density of school locations is less than that of employment data locations.

Sometimes a simple visual analysis of geographic data can assist in splitting the school data. As shown in Figure 5.4, if Zone 265 has to be split at the red-dotted line, then through visual analysis, one can easily attribute all school data to the bottom half of the TAZs, where the all schools seem to exist. If the model area is considerably small, then one can even consider obtaining a list of school addresses from the State's Department of Education and geocoding these addresses to locate them geographically. If no school data are available or if the accuracy of the available data is questionable, then land use data can be obtained from the City or County's Comprehensive Plan, or from the tax appraisers office (Figure 5.5), to locate zones where schools may exist based on education or institutional land uses. Local knowledge of land use can definitely assist in conducting visual analysis and deciding how the school data needs to be split.

Similar to schools, models require information related to number and occupancy of hotel/motel units. Geographic data on hotel/motel units are much more tedious to obtain from a public source than that of schools. If such data are directly available, then a procedure similar to that explained for schools can be used. If such data are not available, then one might consider using InfoUSA data (based on Industrial Classification codes) or geocoding sites (as in schools); or even searching through map engines, such as Google Maps or Yahoo Maps, to identify locations of hotels/motels in a given area. Though these might not be the most efficient processes, these sources often provide valuable information. The information provided on some of these web sites link to the actual hotel web sites, wherein information related to number of rooms is readily available. In either case, land use information can further assist in visually locating zones that may

contain all or none of the hotel/motel land uses and distribute data accordingly. For example, in Figure 5.5 below, parcel data, symbolized according to its land use, violet being hotel/motel units, is overlaid with the zones. If a split is being proposed at the red-dotted line on Zone 454, underlying land use data helps in identifying that all the hotel/motel units would end up in the bottom half of Zone 454.

Figure 5.4 Schools Overlaid with TAZ Boundaries

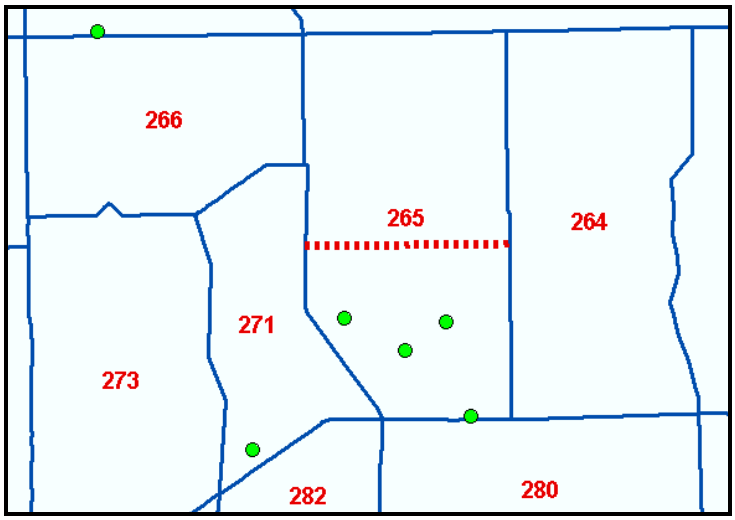
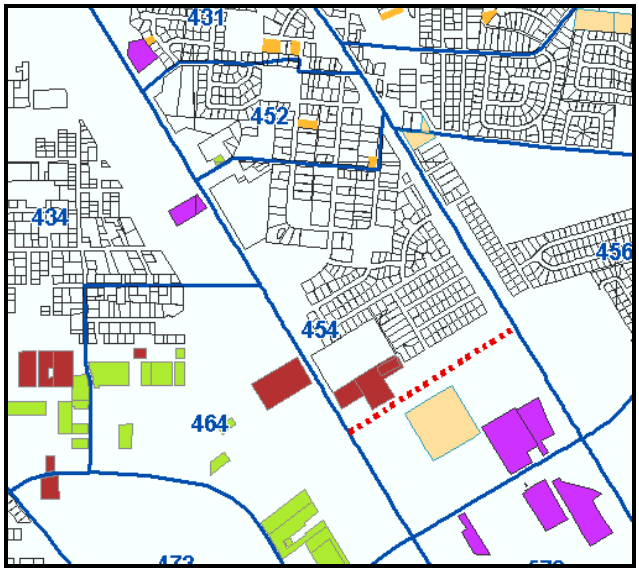


Figure 5.5 Parcel Data Overlaid with TAZ Boundaries



Special generators relate to any major activity center that can potentially generate a large number of trips. Generally, these generators include major universities, regional shopping malls, DRIs, etc. Geographic data on these facilities may not

be readily available, but is very easy to generate. As there is a minimal number of such facilities in a given model area, when compared to schools or hotels, obtaining information on these facilities should not be as time consuming. Most of these facilities should be well known and can be mapped with ease.

Information regarding DRIs is generally available from city/county or regional planning council web sites. As the number of these generators is fewer, it is best to visually identify them and assign the data accordingly. It is not typical that a given TAZ would have two special generators, and hence the process of relative proportions may not be required here. In cases where there are multiple generators located in a single zone and that zone had to be split, then one can obtain or assess data on the sizes of these generators based on professional judgment/knowledge to determine the distribution. Again, as with the other two data elements, one can use land use information in conjunction with any available data to make an informed decision.

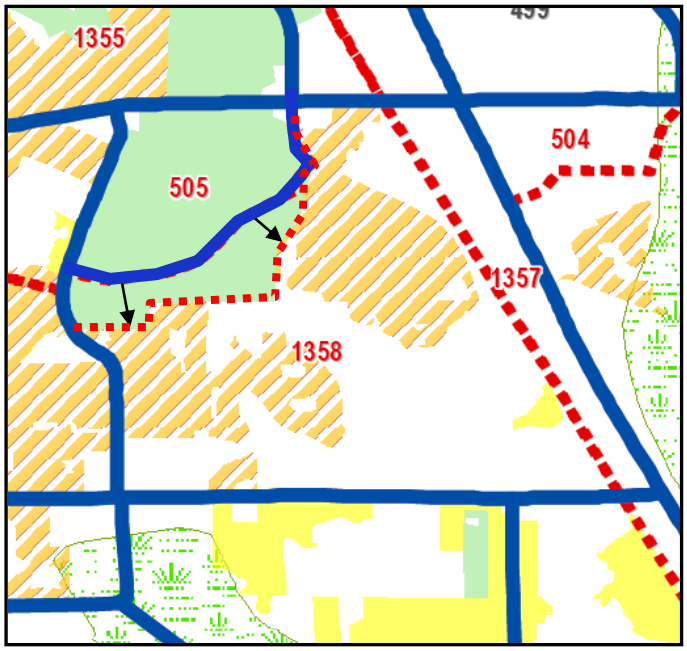
5.3 HANDLING BOUNDARY SHIFTS AND ZONE AGGREGATIONS

Besides simple zone splits, there might be instances where the zone refinements include boundary shifts, zone aggregations, or sometimes a combination of splits, shifts, and aggregations. The methodology of distributing data in such an instance can sometimes be a challenging task. As discussed earlier, the complexity of this process depends on how well the model data geographically corresponds to any external datasets, such as the Census, InfoUSA, or others.

Boundary Shifts

A shift in the boundary of a TAZ may be necessary for several reasons. Primarily, if the existing boundary of a TAZ does not correspond completely with the Census, political, or any other relevant geography, and if through slight modification to the TAZ boundary, the TAZ can be better represented in terms of travel characteristics, then a boundary shift is most relevant (see Figure 5.6). Figure 5.6 provides an example where one must alter the boundary to include all residential activity (in green) into one TAZ (505). Splitting the TAZ would result in tiny TAZs of no significant meaning. A boundary shift is extremely helpful, especially if the model has constraints in terms of total number of TAZs, as a boundary shift does not require any additional dummy zones to be used.

Figure 5.6 Land Use Data Overlaid with TAZ Boundaries to Demonstrate a Scenario Where Boundary Shift May be Valid



The procedure for splitting data during boundary shifts is similar to that of general TAZ splits. All TAZs that are affected by a boundary shift need to be identified first. For example, in Figure 5.7, TAZs 276, 283, and 299 are affected by the boundary shift. The data for all the affected zones then need to be aggregated and considered as a single zone. In our example, all data from Zones 276, 283, and 299 needs to be aggregated and viewed as a temporary single larger zone (e.g., 2000). The process from here is similar to that of splitting TAZ data, except that the original zone is now our larger zone (2000 in our example). The data from this larger zone should be split based on the assumption that the new boundaries of the original zones (276, 283, and 299) are to be split based on the larger single zone.

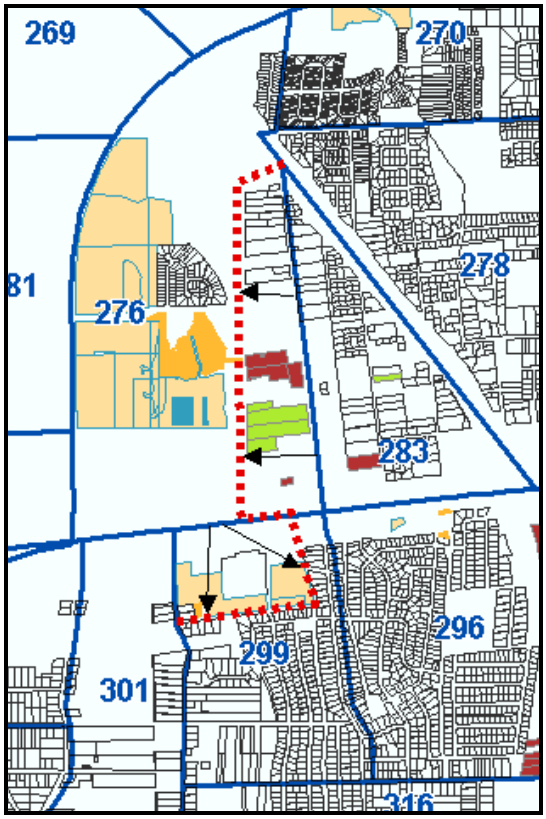
Based on a combination of relative proportions, human judgment, and land use data, as explained in the TAZ splitting section, data from the larger zone (2000) can be split into its constituent zones. In our example, if the population for Zones 276, 283, and 299 is 100, 100, and 100, respectively, the larger zone has a population of 300. We would then compute the relative proportions based on the new zone boundaries. In this example, that results in the following proportions: 0.1 for TAZ 276; 0.6 for TAZ 283; and 0.3 for TAZ 299. The data distribution is as follows:

0.1 x 300 Original Population = 30 People in New TAZ 276;

0.6 x 300 Population = 180 in New TAZ 283; and

0.3 x 300 Population = 90 in New TAZ 299.

Figure 5.7 Parcel Data Overlaid with TAZ Boundaries to Demonstrate Data Distribution in Case of a Boundary Shift

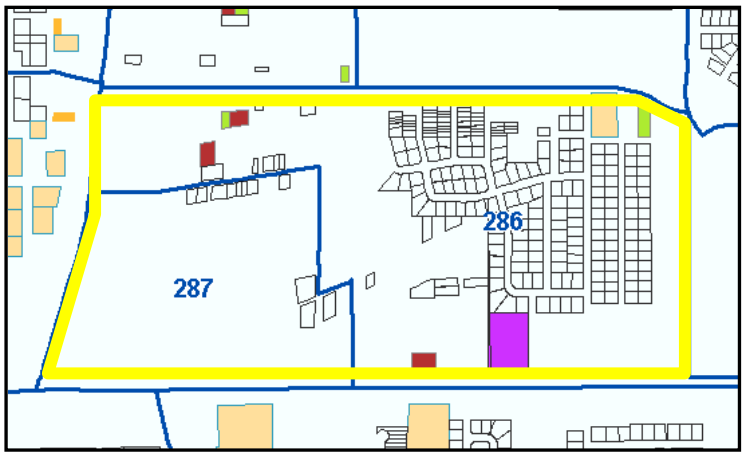


Zone Aggregations

Aggregation of zones is sometimes required when a given zone area is much smaller than what is necessary for purposes of the model. In other words, if any given zone does not have distinct travel characteristics from that of its neighboring zones, then a zone aggregation could be a valid process. Also, as in the case of boundary shifts, zone aggregation does not consume any additional zones and, in fact, results in the creation of a new dummy zone that can be used at any other relevant location in the model area. As a result, if zone splits are needed in one part of the model (e.g., downtown) to better represent travel patterns, and the model has a limited number of available dummy zones, one may conduct zone aggregations in less dense areas to free up additional dummy zones that are necessary for zone splits elsewhere in the model.

The process of distributing data for zone aggregation is fairly straightforward. The methodology constitutes a simple data aggregation of all the zones involved in the aggregation process. In the example shown in Figure 5.8, if Zones 286 and 287 need to be aggregated, then the data are simply added together. If the new zone, shown in yellow, is assigned the number 286, then the Zone 287 is now available for usage at any other location in the model area.

Figure 5.8 Parcel Data Overlaid with TAZ Boundaries to Demonstrate Aggregation Process



Situations might arise wherein one must conduct multiple refinements, such as splits, shifts, and aggregations. In such instances, one can readily adopt procedures previously explained for these individual processes. Using Figure 5.7 as an example, Zones 276, 283, and 299 need to be aggregated and split to form new Zones 276 and 283. To redistribute the data, all attributes from these three zones must be first aggregated and then using processes described earlier, split the data from this larger zone into Zones 276 and 283. If a boundary shift is needed for Zone 283, the data from new Zones 276 and 283 then needs to be aggregated and split accordingly.

5.4 Zones Beyond Model Boundary

Model boundaries are periodically expanded to incorporate additional counties and other transitioning areas. In many cases, this involves adding areas to the model that do not already have TAZs designated. Therefore, rather than splitting TAZs, one must develop new zones from scratch. Discussions earlier in this report provide sufficient guidance on considerations for establishing TAZ boundaries. Data availability is a significant concern in these new areas, so the initial boundaries should reflect readily available geographic divisions, such as Census block groups. Depending on development density, it might be acceptable to have larger-sized TAZs in outlying counties.

5.5 Revalidation

Once the TAZ structure has been refined, one must revalidate the model against the original model to ensure that the model is performing as well as or better than the original model. One should compare statistics from each step in the model process, including trips per TAZ, trips per purpose, and intrazonal trips, at a minimum. As a reasonableness check, one should overlay the TAZ

boundaries with freeways, bridges, water, railroads, military bases, etc. One should overlay TAZ boundaries with household, employment, population, and income data to verify patterns of homogenous land use are properly represented.[22]

[22] Chen, Ho-Chuan, and Hossein Barahimi, King County DOT, *Guidelines for Local Travel Demand Model Development*, 14th Annual EMME/2 Users Conference, Chicago, Illinois, 1999.

6.0 Topics Requiring Further Research

This white paper has focused on the conventional approach to delineating TAZs. Two emerging but related topics will need to be addressed in the near future, which include:

1. Mixed land uses; and
2. Dynamic subzoning.

Delineating TAZs based on homogenous land uses is not always feasible especially with the future direction of land use patterns. Downtown areas, or CBDs, as well as smarth-growth developments and any other mixed-use developments are not homogenous and cannot be isolated within a TAZ using existing practices. One potential solution to address mixed land uses in a travel demand model is dynamic subzoning.

Dynamic subzoning refers to the inclusion of multiple centroids within one TAZ, one to represent employment and one to represent households. The purpose of dynamic subzoning is to allow different access points onto the transportation network by having one set of centroid connectors for employment, and one second set of centroid connectors for households (one set per centroid). Some details merit further evaluation, including the numbering system of subzones, to facilitate implementation.

Appendix A. List of Data Sources

Table A.1 below provides a list of data and their respective sources for modelers in Florida.

Table A.1 Data Sources

Data	Data Source
Physical Features	• Census Tiger/Line Data (http://www.census.gov/geo/www/tiger/tiger2006se/tgr2006se.html) • Florida Geographic Data Library (FGDL) (http://www.fgdl.org/) • Florida DOT-Planning GIS Data Directory (http://www.dot.state.fl.us/planning/statistics/gis/default.htm) • National Transportation Atlas Database (NTAD) (http://www.bts.gov/publications/national_transportation_ atlas_database/2006/)
Census Blocks, Block Groups and Tracts	• Census web site (http://www.census.gov/geo/www/cob/bdy_files.html; http://www.census.gov/geo/www/tiger/tiger2006se/tgr2006se.html) • ESRI – Census Tiger datasets (http://arcdata.esri.com/data/tiger2000/tiger_download.cfm)
Political Boundaries	• Census web site (http://www.census.gov/geo/www/cob/bdy_files.html) • Florida Geographic Data Library (FGDL) (http://www.fgdl.org/) • Florida DOT-Planning GIS Data Directory (http://www.dot.state.fl.us/planning/statistics/gis/default.htm) • National Transportation Atlas Database (NTAD) (http://www.bts.gov/publications/national_transportation_ atlas_database/2006/) • State DOTs
Land Use Data	• City/County master plans, Florida Geographic Data Library (FGDL) (http://www.fgdl.org/)
Parcel Data	• County Tax Appraisers Office, Florida Geographic Data Library (FGDL) (http://www.fgdl.org/)
DRIs	• MPOs, County Plans, Regional Planning Councils, Florida Geographic Data Library (FGDL) (http://www.fgdl.org/)
Demographic Data	• Census web site (http://www.census.gov/main/www/cen2000.html)
Employment Data	• InfoUSA, Woods & Poole, and Dun & Bradstreet
Future Year Population Data	• Census web site (http://www.census.gov/population/www/projections/popproj.html) • Bureau of Economic and Business Research (http://www.bebr.ufl.edu/)

Appendix B. Glossary of Terms

Attraction – The pull or attracting power of a zone. For nonhome-based trips, attractions in a zone can be considered synonymous with trip destinations in that zone.

Block – Areas bounded on all sides by visible features, such as streets, roads, streams, and railroad tracks; and by invisible boundaries, such as city, town, township, and county limits, property lines, and short, imaginary extensions of streets and roads.[23]

Block Group – A cluster of Census blocks having the same first digit of their four-digit identifying numbers within a Census tract. The block group is the lowest-level geographic entity for which the Census Bureau tabulates sample data from the decennial Census.[24]

Census Tract – A small, relatively permanent statistical subdivision of a county or statistically equivalent entity, delineated for data presentation purposes by a local group of Census data users or the geographic staff of a regional Census center in accordance with Census Bureau guidelines.[25]

Centroid – Represents the center of activity within a zone.

Centroid Connector – Connects the centroid within the zone to the roadway facilities, usually representing access via local roads.

Demand – Used in an economic sense and based on the theory and methodology of consumer demand, a schedule of the quantities of travel consumed at various levels of price or levels of service offered by the transportation system. Demand is not a fixed amount of travel, but a function of level of service. Nearly all urban travel forecasting methods are based on the concepts of travel demand and transportation facility supply interacting in a transportation network as the market to produce an equilibrium flow pattern.

Destination – Location to which trips are made, variously identified as a zone of specified area (in aggregate travel forecasting) or a location with a specified "attraction power," measured by things, such as employees (for work trips) or square feet of sales area (for shopping trips).

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[23] United States Census Bureau, *Appendix A. Census 2000 Geographic Terms and Concepts*, page A10, http://www.census.gov/geo/www/tiger/glossry2.pdf.

[24] United States Census Bureau, *Appendix A. Census 2000 Geographic Terms and Concepts*, page A8. http://www.census.gov/geo/www/tiger/glossry2.pdf.

[25] United States Census Bureau, *Appendix A. Census 2000 Geographic Terms and Concepts*, page A11. http://www.census.gov/geo/www/tiger/glossry2.pdf.

EE Trips – External-External trips represent trips that have both trip ends outside the model study area.

External Zone – Those zones outside the study area along the model boundaries (also known as **external stations)**.

Forecasting – The process of determining the future values of land use, socioeconomic, and trip-making variables within the study area.

IE Trips – Internal-External trips represent trips that have one end inside the model study area and one end outside the model study area.

II Trips – Internal-Internal trips represent trips that have both ends inside the model study area.

Intrazonal Trip – A trip with both its origin and destination in the same zone.

Internal Zone – TAZs inside the study area or model boundaries.

Land Use – The manner in which portions of land or the structures on them are used, such as commercial, residential, retail, industrial, etc.[26]

NAICS Code – The North American Industry Classification System (NAICS) **Code** is a six-digit code used to categorize various employment industries, which was released in 1997, and has since replaced the SIC code.

Network – Set of nodes and connecting links that represent transportation facilities in an area. Normally associated with links are distances, levels of service, capacities, and volume requirements.

Node – A point where two links join in a network, usually representing a decision point for route choice, but sometimes indicating only a change in some important link attribute.

Origin – The location of the beginning of a trip or the zone in which a trip begins.

Productions – The number of home-based trip ends in the zone of residence. For all nonhome-based trips, productions are synonymous with origins.

SIC Code – The Standard Industrial Classification (SIC) Code is a four-digit code used to categorize various employment industries.

Socioeconomic Data – Demographic data, such as household, population, and employment characteristics, that are input into the model to determine the impact on trip-making patterns.

Special Generators – Concentrations of activities of such size or unusual nature to warrant special consideration in trip generation analysis.

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[26]Planning Glossary, United States Department of Transportation, Federal Highway Administration.

TAZ (Traffic Analysis Zone) – Geographic areas dividing the planning region into relatively similar areas of land use and land activity. Zones represent the origins and destinations of travel activity within the region, and serve as the primary unit of analysis in a travel forecasting model.

Transportation Model – A mathematical description of a transportation system's characteristics, including traffic volumes, land use, roadway type, and population. After a mathematical relationship is established, the model is used to predict traffic volumes based on anticipated changes in the other characteristics.

Trip End – Either a trip origin or a trip destination.

Trip Generation – A general term describing the analysis and application of the relationships, which exist among the trip-makers, the urban area, and trip-making. It relates to the number of trip ends in any part of the urban area.

Trip Purpose – The reason for making a trip, normally one of several possible purposes. Each trip may have a purpose at each end; (e.g., home to work), or may be classified by the purpose at the nonhome end (e.g., home to shop).

Trip Table – A table showing trips between zones – either directionally or total two-way. The trips may be separated by mode, by purpose, by time period, by vehicle type, or other classification.

Trip Rate – The average number of trips per household for specific trip purposes. In Florida, trip rates are usually applied by household size and auto availability within each zone by trip purpose.