Efficient Method to Develop a New Layer, Intersecting Multiple Layers
By Madhav Pai and Neelita Mopati

Abstract

Transportation system analysis begins with dividing a metropolitan region into traffic analysis zones (TAZ). A TAZ layer is built from multiple layers representing same or different feature classes. This makes it difficult and time-consuming to construct, especially for a person with limited GIS knowledge. Furthermore, socioeconomic data must be aggregated by TAZ; this requires building a correspondence between the TAZ layer and other layers.

This presentation will demonstrate how a person with limited GIS knowledge can efficiently develop a clean TAZ layer with existing tools. Examples will illustrate problems encountered and precautions to minimize them. This technique can be applied whenever one wants to create a new layer from multiple layers representing same or different feature classes.

Travel Forecasting Models and the Need for a TAZ Layer

Travel forecasting models are used extensively in transportation system analysis. A travel forecasting model is a series of mathematical equations that convert a given data set (land uses and network) into a forecast of when, where and how people will travel. Different approaches are used to develop these models. The most widely used approach in practice is the aggregate approach.

The aggregate approach analysis begins with dividing the study area into geographic units or traffic analysis zones (TAZ). The land uses and network are aggregated at the zonal level to model travel behavior at the TAZ level. Figure 1 shows the TAZ system for the City of Mountain View in Santa Clara County, California. This system has 133 TAZs. The analysis begins by aggregating parcel level land use (socio economic data) at the TAZ level.

The travel forecasting model forecasts traffic on roadway facilities and hence it is logical for roadway facilities to be TAZ boundaries. A TAZ represents group uses that have similar access to the street geography (network) coded in the model. Figure 2 shows TAZ #4 with streets California, Franklin, Mercy and Bryant as boundaries.

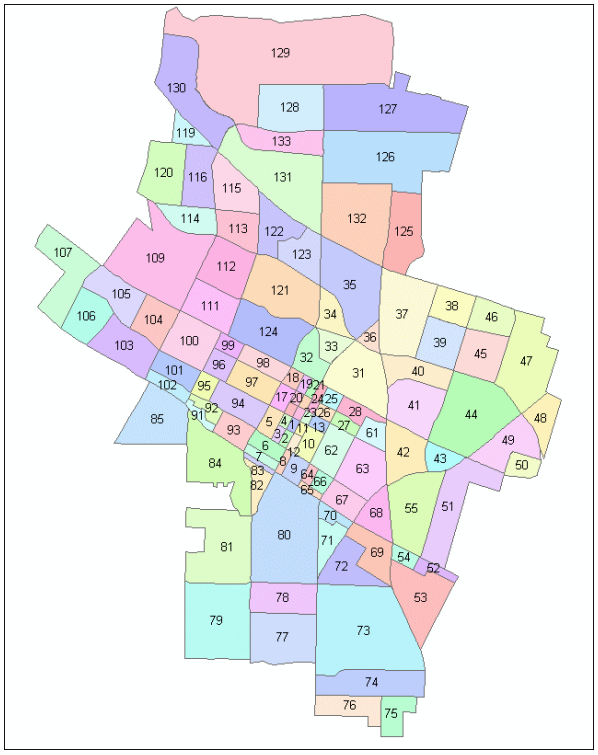

Figure 1: City of Mountain View, Traffic Analysis Zone System

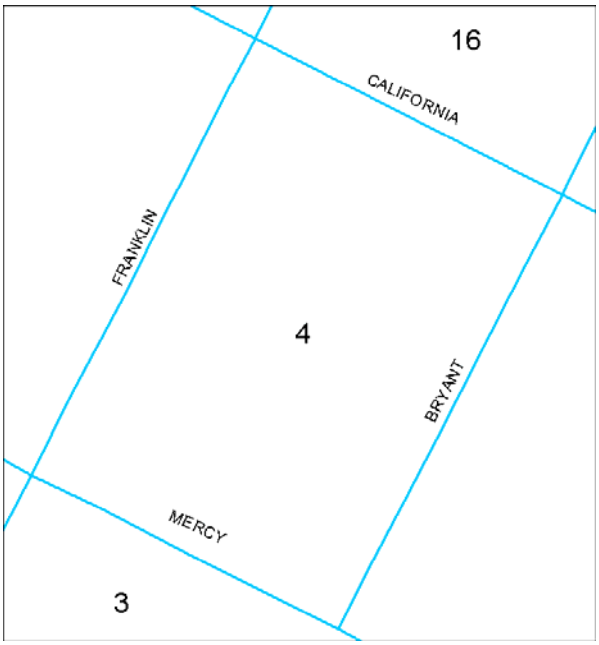

Figure 2: TAZ #4 Surrounded by Streets California, Franklin, Mercy and Bryant

Funding for Travel Forecasting Models

Regional MPOs, counties and cities own and maintain travel forecasting models. These agencies obtain their funding from federal agencies like FHWA (Federal Highway Administration) and FTA (Federal Transit Administration). Yet they do not have much money for developing travel forecasting models. A big portion of the budget is needed for calibrating and validating the travel model. Hence, building the TAZ layer is a task with little budget. This situation or "the lack of funds" makes it hard to hire GIS experts to do the job or to give agency staff any advanced GIS training.

Building a TAZ Layer

We started building TAZ layers by modifying the parcel or the census block polygon layer. With our limited knowledge about GIS and GIS tools we struggled to build clean TAZ layers with efficiency. We tried intersecting or merging layers from different feature classes before beginning edits. We ran into problems similar to the one shown in Figure 3. The display shows one selected feature from the merged polygon layer. This alien (as my colleague referred to it) had to be "hacked" at multiple locations in order to edit it. We were unsuccessful in cutting this feature at particular locations when zoomed in. It took us a while to realize that the feature was so big. We realized that working with line layers was easier and more efficient. We found ET GeoWizards[1] to be a great tool for conversions between polyline and polygon layers. In the process of building TAZ layers for various organizations, we developed a methodology to build TAZ layers within our financial and time commitments.

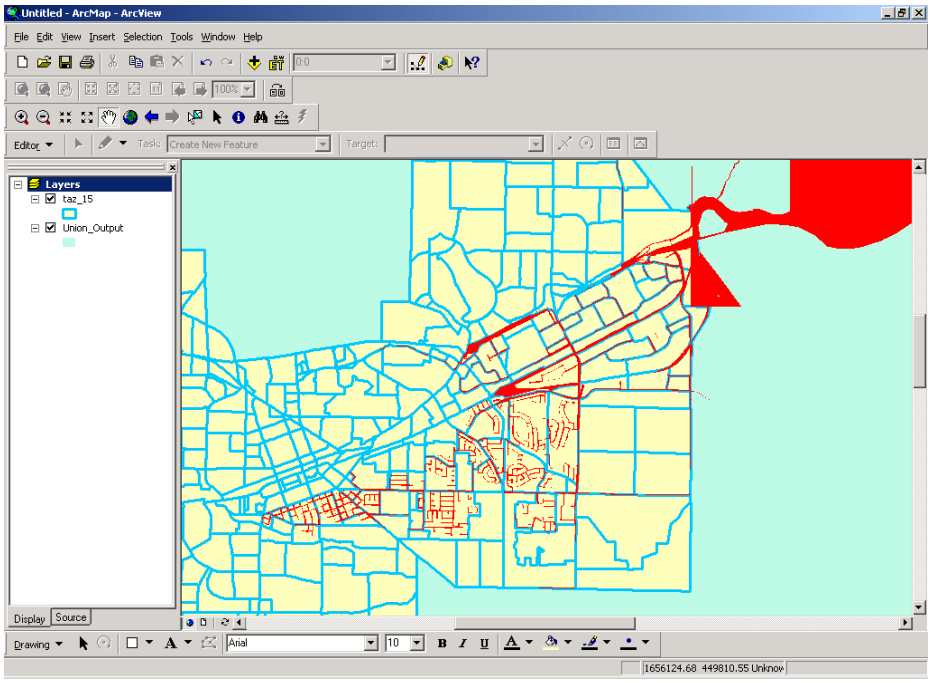

Figure 3: The "Big Alien" Feature -One Big Polygon Created during Layer Merge

[1] To learn more about ET GeoWizards go to http://www.ian-ko.com/

Our Seven Steps to building a TAZ layer

Step 1: Determine the layers you want to use to build your TAZ layer.

The parcel or census block data is usually the source for socio economic (land use) data. The land use data would then be aggregated/disaggregated to the TAZ level. The street (street centerline) layer is used mostly as TAZ boundaries. If there is a parent jurisdiction (e.g. county or metro region) TAZ system then the TAZ system has to nest into it. TAZ boundaries should always confirm to natural features like rivers, streams or railroad lines and so a railroad layer or water bodies layer also might be used.

Step 2: Convert all polygon layers to polyline layers.

All polygon layers like the parcel layer, the census block layer or the TAZ layer for parent jurisdiction should be converted to polyline layers. We used ET GeoWizards to convert the polygon layers to polyline layers.

When you convert a polygon layer to a polyline layer all it attributes are lost. We used TransCAD (GIS based travel demand modeling software) to avoid this inconvenience. TransCAD allows you to retain attributes from the polygon layer. Though not necessary, this later proves to be useful. The advantages are discussed in step 4.

The manuals indicate that Arcinfo/Arceditor has wizards that can be used to perform the same functions but we have not been able to experiment with this functionality since we only have an ArcGIS license.

Step 3: Create a new layer by intersecting all the layers deemed necessary to build the TAZ layer.

Once we assimilated all the necessary input polyline layers, we used the “Clip Feature” in ET GeoWizards to combine the various polyline layers into a single polyline layer. This feature creates an intersection of the polyline layers. If an attribute about the origin of a line is retained during conversion, a color coding scheme can be used to display the new merged layer. For example, if the merged layer is an intersection of the parcel layer converted to a polyline layer and the street centerline layer, we would add a numeric field to both the layers and fill the parcel layer with ones and the street centerline with twos. This categorization can then be used to define symbology by categories -> unique values.

The merge feature in ArcGIS Tools -> Geo Processing Wizard can be used to perform the same task; however, it only retains attributes from one layer.

Step 4: Clean the line layer.

The cleaning process of the line layer is the most involved and important step. We have found “Creates a line to split line features” tool in Arc View 3.2 as the most convenient

tool to perform this task. Unfortunately this functionality has not been included in ArcGIS 8 and other subsequent updates. Figure 4 shows the cut feature in ArcView 3.2.

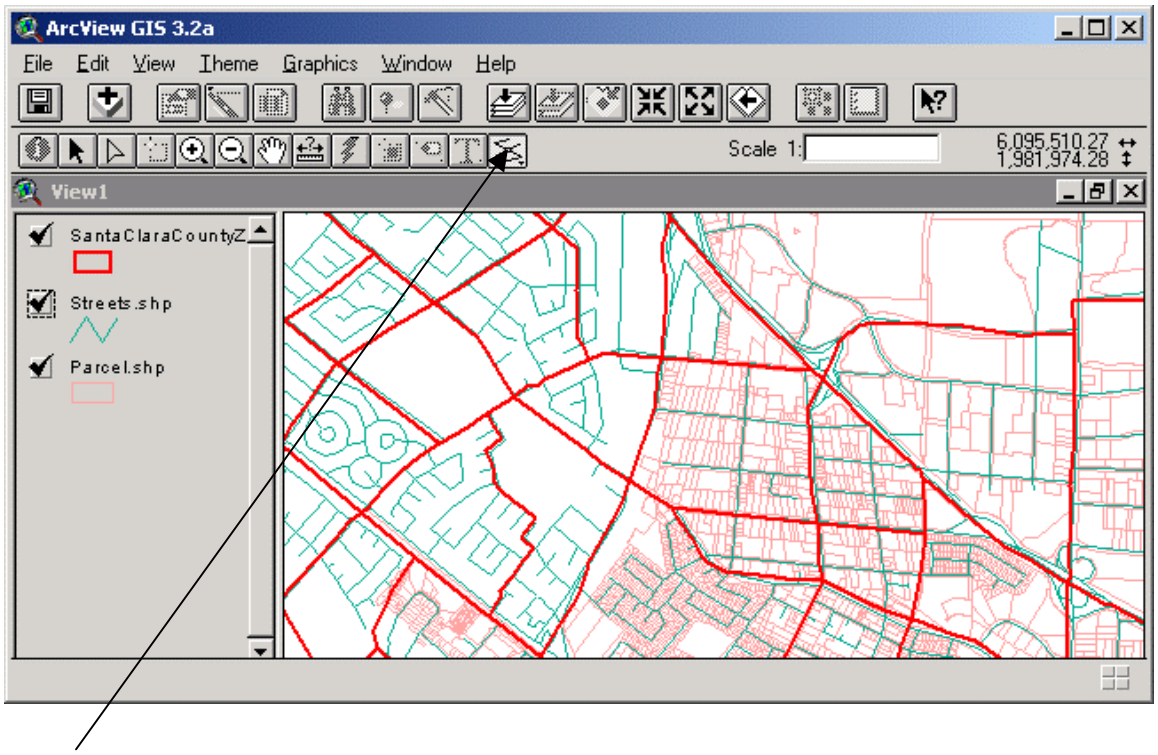

Figure 4: Shows the "Creates a line to split line features " tool in Arc View 3.2

Figure 5 shows a merged layer of the parcel layer and the street centerline layer created using Step 3. To create a TAZ #96 we need to delete all the parcels enclosed between streets Escuela, Villa, California and Chiquita. To delete Higdon Street, which runs down the middle of the TAZ, we apply the following steps in ArcView 3.2:

- Zoom into the location as shown in Figure 6 ;
- Zoom further into the location to the level of detail shown in Figure 7;
- Higdon Street is connected to Villa and so if you delete Higdon Street then Villa Street would also be removed. Thus, a cut has to be made at the intersection;
- Select Theme -> Start Editing;
- Select the cut feature as shown in Figure 4;
- Draw a cut along the black line in Figure 7;
- The cut tool intersects Villa and Higdon at two points
- We can now select and delete the portion of Higdon Street within TAZ #96; and
- The TAZ layer will look as shown in the Figure 8. The small bump is insignificant once you zoom out. See Figure 9.

Figure 5: Merged Parcel layer and Street Centerline layer

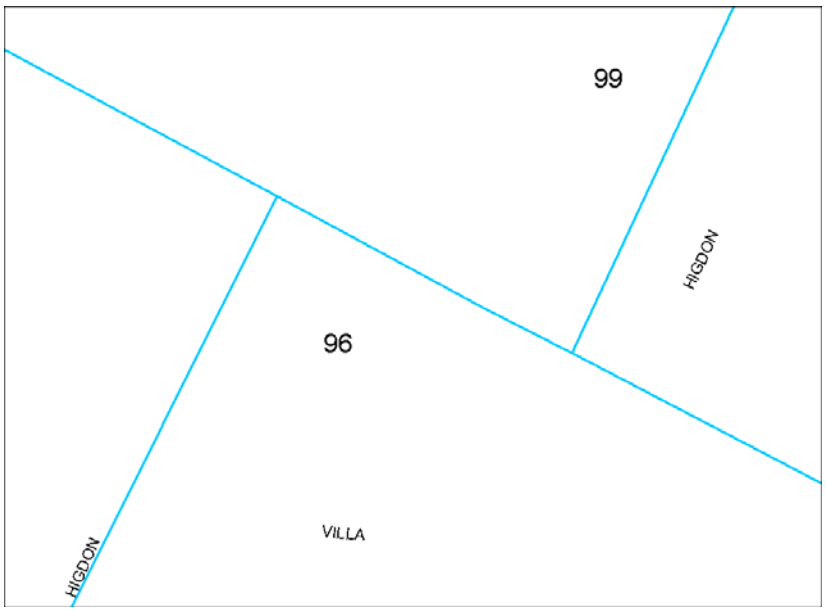

Figure 6: Shows Higdon Street to be Deleted

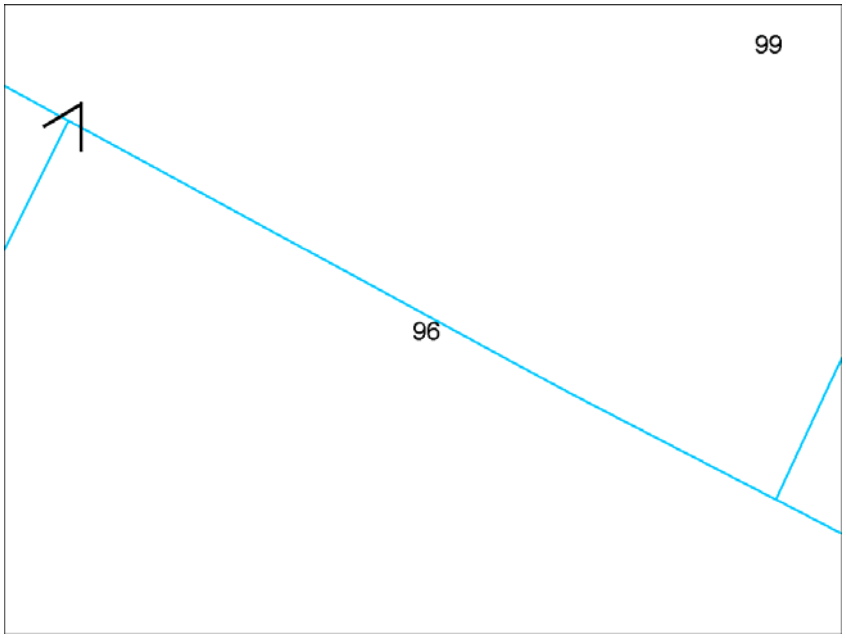

Figure 7: Shows the Cut Drawn at the Intersection of Higdon and Villa

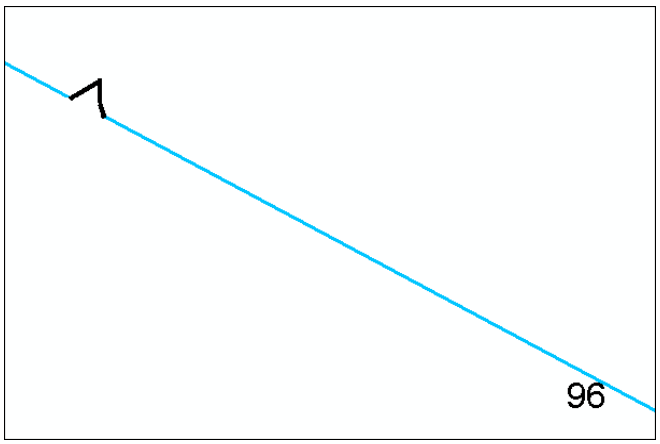

Figure 8: Villa Street After Higdon Street Deletion

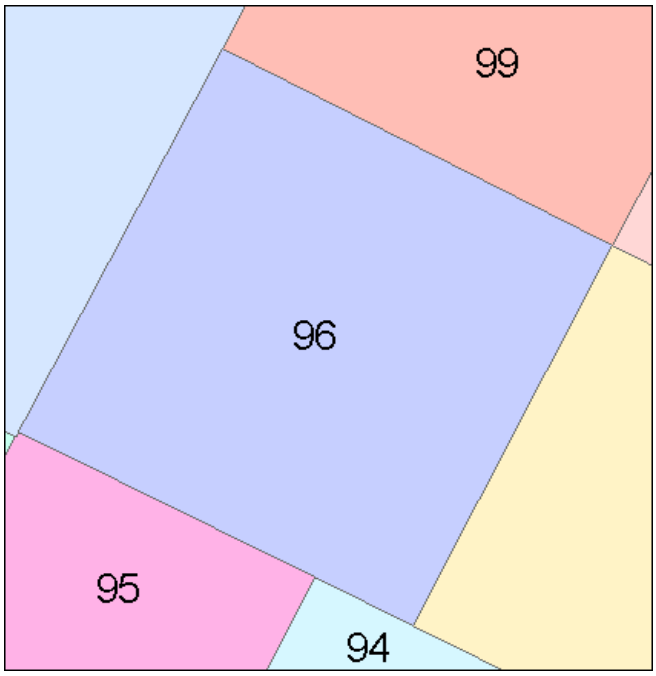

Figure 9: TAZ Layer After Higdon Street Deletion

Step 5: Clean the polygon layer.

Convert the clean polyline layer to a polygon layer using ET Geo Wizards. Inspect the polygon layer for slivers (small polygons created due to errors in the polyline layer). Edit the polyline layer to prevent creation of the identified slivers. Once you think the layer is reasonably clean use ET Geo Wizards to reconvert it to a polygon layer. The new polygon layer should have exactly the same number of records as TAZs.
Usually on the first pass you will discover slivers as shown in Figure 10.

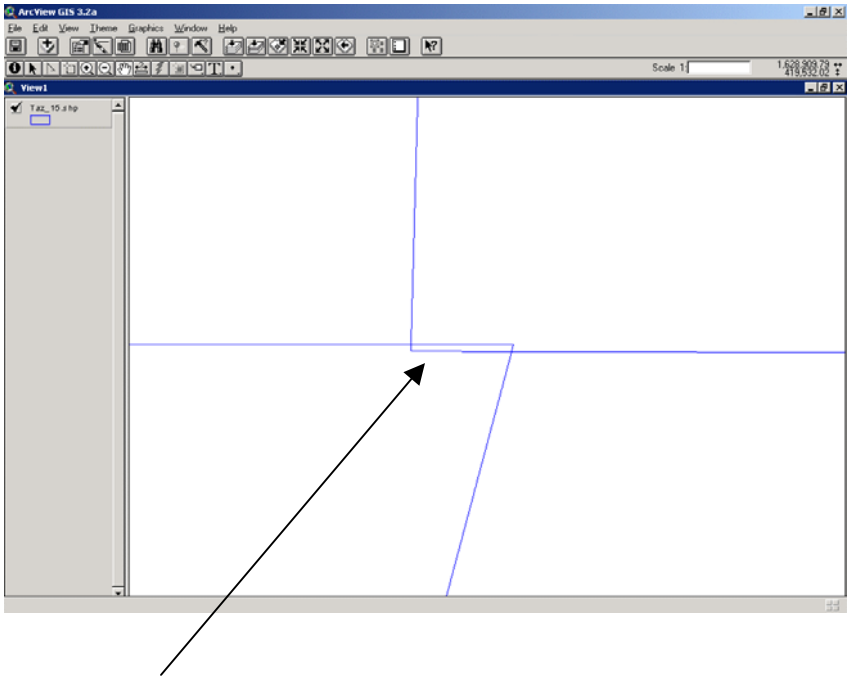

Figure 10: Shows a sliver polygon that needs to be cleaned

Try to locate all the slivers. Go back to the polyline layer to clean them. We have found "Creates a line to split line features" tool works best for this purpose. You follow the same steps described in step 4 to delete the extra lines that create the sliver. In ArcView 8.3 the Trim and Extend features also have proven resourceful for this task.

Based on our experiences in building a TAZ layer using this process, we have found that it is most efficient to do about ninety percent of the clean up in the polyline layer. The last bit of clean up can be done in step 6.

Step 6: Accuracy checks and edits on the polygon layer.

By following Steps 1 to 5, the polygon layer created may still need to undergo error checks and editing. Add all the layers used to create the polygon layer in a map along with the TAZ layer. Check for locations where polygon boundaries have been incorrectly coded.

If the edits are huge such as modifying a large polygon boundary to match a highly curvilinear mountainous road as shown in Figure 11, it is simpler to convert the polygon layer back to a polyline layer and then edit it rather than trying to edit the polygon layer directly.

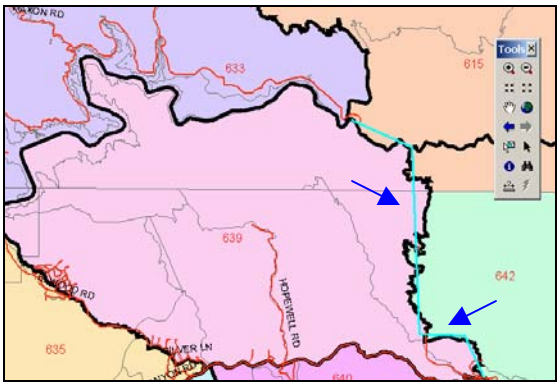

Figure 11: A Zone with Incorrect Boundary

However, if the edits are fairly simple and not too many, ArcMap8.3 has a few new tools that make our task easier. For example, consider the Traffic Analysis Zones #210 and #211 shown in Figure 12. The boundary between these two zones needs to be modified to follow the canal boundary exactly.

The first step to do this is to cut polygon #210 along the street polyline by using the "Snap to Vertex/Edge/Endpoint tool". This feature was not available in the older versions and so a line had to be manually drawn to cut the polygon thus introducing a large margin of error.

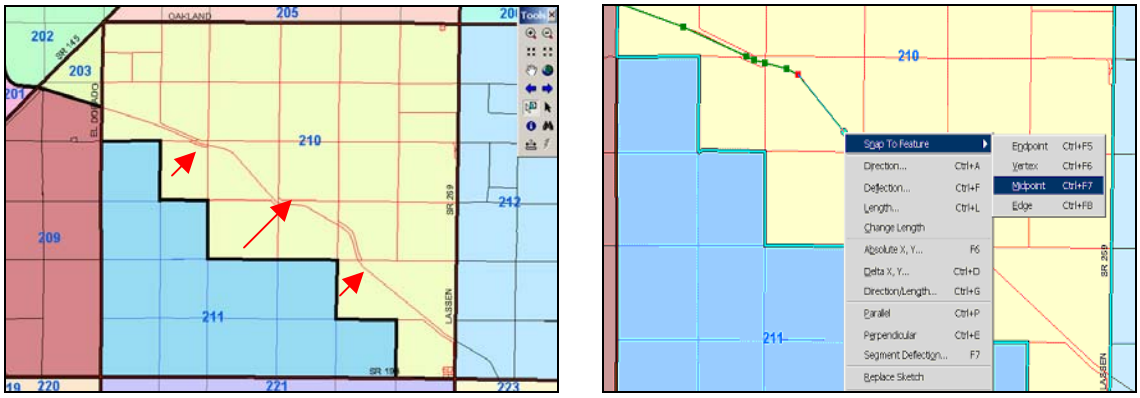

Figure 12: Simple Boundary Edits Using the "Snap To" Feature

Finally, the appropriate polygons created by the cut are combined using the "Merge" Feature. This same process can be carried out easily in the polyline version of the layer. However, converting the polygon layer to polylines, editing it and converting it back may be inconvenient for small edits like this.

Step 7: Create a correspondence between the TAZ and other layers.

Convert your parcel or census block layer to a point layer. Right click on the newly created point layer. Go to Join and Relates -> Join. Select "Join data from another layer based on spatial location" from the dropdown. Choose the TAZ layer as the layer to join. The TAZ field will be attached to each record on the point layer. Now you can aggregate

your land use data by TAZ, using Microsoft Excel, Microsoft Access, ArcGIS 8.3 or any other software of your choice.

Conclusions

The first part of the paper brings us to the following conclusion

- Building a TAZ layer is necessary for a travel demand model
- Travel Demand Modeler may have limited GIS knowledge and experience
- Budget allotted to the task is limited

We have successfully used this methodology of editing and cleaning a merged polyline layer to build TAZ layers for the City of Livermore, the City of Mountain View, Fresno Council of County Governments and Amador County. It is important to assess the extent of clean up needed during Step 4 (Clean the polyline layer). We have found doing about ninety percent of the clean up work on the polyline layer and doing the last bit of clean up on the polygon layer proves to be most efficient.

Overall, this methodology has met with great success. We have cost effectively completed our projects within the allotted time. Staff with limited or no prior GIS experience has been able to complete the task successfully by following the above steps.

Acknowledgements

We would like to thank Ianko Tchoukanski for developing a wonderful product ET GeoWizards. ET GeoWizards is user friendly and easy to use. Ianko has been very prompt in responding to questions and queries about the product and GIS. We also would like to thank our supervisors Mike Aronson, Kym Sterner and Damian Stefanakis for letting us experiment with this technique on their projects and our colleagues Allen Huang and Gail Payne for using the technique and giving us their valuable comments.

Author Information

Madhav Pai
Associate Transportation Planner
Dowling Associates Inc.
180, Grand Avenue,
Suite 250,
Oakland CA – 94612
510.839.1742 x122
FAX – 510.839.0871
mpai@dowlinginc.com

Neelita Mopati
Associate Transportation Planner
Dowling Associates Inc.
180, Grand Avenue,
Suite 250,
Oakland CA – 94612
510.839.1742 x125
FAX – 510.839.0871
nmopati@dowlinginc.com