Applications of ArcGIS in Transportation Planning

(Analysis of Downtown Austin Network as case study)

by: Moggan Motamed

1. Introduction

Depending on technical issues, growth rate, and available funding, building a road should take between 5 and 21 years from start to completion. The major phases in building a road include a feasibility study, obtaining initial funding, planning, design, purchasing right-of-way, and construction. Obtaining initial funding is critical in moving a road project from the Long-Range Transportation Plan (LRTP) to the Transportation Improvement Plan (TIP), where the project can then proceed through a planning process that involves environmental mitigation, traffic forecast, permit application, and public involvement.

Transportation planning is an important process in ensuring that transportation spending and policies are as effective as possible. As transportation engineers and researchers, we support this process by developing and running models which predict the impact of potential projects or policies- for instance, in Austin, what would be the impact on city traffic and emissions be if an extra lane was added on I-35? If the toll on SH-130 was reduced? If streetcar lines are installed downtown? In this way, the benefits of projects can be compared with their costs, and funding and implementation priorities established.

Analysis of different possible scenarios and find the best efficient solution is critical to obtain required fund at each level. One of the tools for analyzing is Geographic Information Systems (GIS), which widely have been used in the field of Transportation.

GIS for Transportation named GIS-T by the American Association of State Highway and Transportation Officials, has been used for diverse purposes:

- From modeling travel demand
- From analyzing the annual capital improvement plans to identifying noise regulation violations around airports
- From improving transit service throughout rejuvenated urban centers to planning scenic byways in recreational areas

GIS provides a framework to inform models, such as those used to forecast travel demand and plan capital improvements, and to support strategic decision-making. In addition, GIS applications for making environmental evaluations can shed light on the consequences of various transportation alternatives.

2. Project Purpose

The primary purpose of this term project is to investigate applications of ArcGIS in transportation planning in more depth. The primary idea is to implement “ArcGIS Network Analysis” tool box, which is the extension for transportation application, and investigate the methodology behind it.

Furthermore on this project, as a case study, I used dynamic traffic assignment (DTA) to model downtown Austin trips.

Construction activities and numbers of related work zones have grown significantly. The most problematic work zones occur on roads that are already fully loaded with traffic. The impact of work zones on mobility and safety makes success of the traffic control plan vital. As the next step, the purpose of this paper is to investigate driver route switching behavior during the construction (work zone) or incident using the base network model. For instance, here we assumed there is construction or incident on 2nd St. how it will effect on downtown network? By having this information we will be able to define more effective traffic control plans.

This report is organized as follows. **Next section** provides an overview of the existing traffic assignment methods in the industry. **Section 4** discusses traffic data utilized in this study. **Section 5** provides applications of "Network Analysis" extension in transportation. **Section 6** provides a description of the study area, scenarios developed for this study to analyze driving behavior during road closure, describe the study approach, and methodology and discusses the results. Finally, **Section 7** provides sumrry and limitation of this study and discusses opportunities for further studies.

3. Overview of Traffic Assignment Concepts and Methods

3.1. Network Terminology

A network consists of links and nodes. In transportation applications, a link usually represents a means of travel from one point to another: a road segment between two intersections (Figure1).

It is usually convenient to use a node to represent each zone; such nodes are called centroids, and all trips are assumed to begin and end at centroids (Figure 1).
In transportation planning and network analysis, it is customary to use centroid nodes to represent traffic analysis zones (TAZ), from/to which trips are assumed to have originated (Origins) or destined (Destinations). In reality, however, trip origins and destinations are much more distributed and can scatter throughout a traffic analysis zone. The use of TAZs is a matter of necessity because, although we may be able to know where precisely a trip originates from and heads to by a detailed survey, such individual trip origins and destinations are aggregated in traffic zones in the final trip table due to limited survey coverage and computational considerations. The centroid in each traffic zone thus "represents an aggregation of all the actual origins and destinations within its zone" (Sheffi, 1985). In order to load those trips on the network, each centroid is connected to the roadway network by centroid connectors. Those connectors usually do not have physical counterparts in the real network. In this way, trips are assumed to start from and end in those network nodes that are connected to the centroids, rather than the real origins (e.g. people's homes) and destinations (e.g., people's offices).When trip access/egress information is unknown and the TAZ is relatively large, a common way of generating connectors for each TAZ is to select several network nodes within the TAZ to represent trip access/egress nodes, and connect them to the centroid with

links having a constant travel cost(or travel time). The connector nodes are usually the closest n nodes near the centroid, but sometimes are chosen arbitrarily. This selection method is provided in most of the commercial transportation planning software. In addition, connectors may also over-estimate or under-estimate the travel times between traffic zones, and thus influence mode choices in the demand model, as well as the shortest paths in the assignment model. (4)

Links are often expressed by the nodes they connect as (i,j) where i is the upstream node (sometimes called the tail node) and j is the downstream node (also known as the head node). Associated with each link is its flow, denoted xij , representing the total number of vehicles wanting to use link (i; j) during the analysis period. The flow is also known as the volume or demand.

The travel time on link (i; j) is expressed as tij , and to represent congestion, we let this travel time be a function of xij , that is, we write tij(xij). Because of congestion effects, tij is typically increasing and convex, that is, its first two derivatives are typically positive. The function used to relate demand to travel time is called a link performance function. The most common used in practice is the Bureau of Public Roads (BPR) function, named after the agency which developed it:

$$t_{ij}(x_{ij}) = t_{ij}^0 \left(1 + \alpha \left(\frac{x_{ij}}{c_{ij}}\right)^\beta\right) \quad (1)$$

where t^0_{ij} is the “free-flow" travel time (the travel time with no congestion), c_{ij} is the practical capacity (typically the value of flow which results in a level of service of C or D), and α and β are shape parameters which can be calibrated to data. α=0.15 and β=4 are commonly used if no calibration is done.(3)

A path π is a sequence of adjacent links connecting two nodes i_0 and i_n. We can either write π as an ordered set of the nodes passed on the way with the notation [i_0, i_1, i_2, i_3,…, i_{n-1}, in].

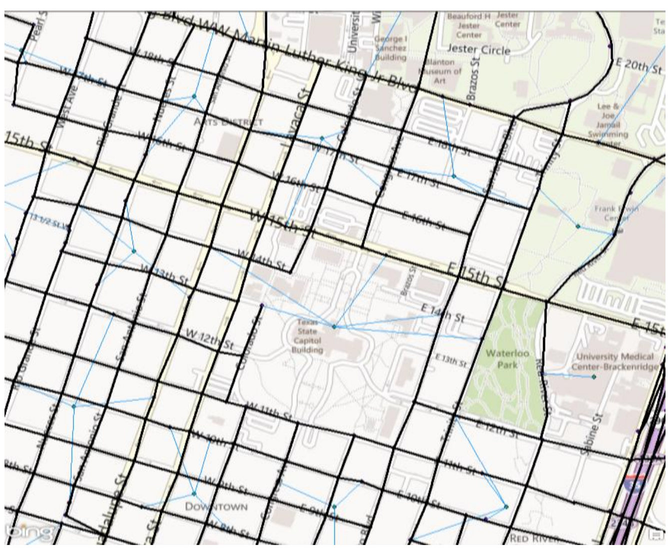

Figure 1: Network components

3.2. Traffic Assignment concepts and Methods

Depending on the models used, a variety of measures of effectiveness can be considered, and one may want to know the impacts of a project on mobility, congestion, emissions, equity, toll revenue, transit ridership, infrastructure maintenance needs, and any one of a vast pantheon of metrics.

To predict ridership on a new transit line with complete accuracy would require knowing how many trips every single possible rider makes, and the decision process each one of these potential riders uses when deciding whether or not to use transit.

The behavior of human beings is often impossible to predict, maddeningly inconsistent, and motivated by a variety of factors difficult to measure.

The purpose of a mathematical model is to translate a complicated, but important real-world problem into precise, quantitative language that can be clearly and unambiguously analyzed. Further, just because a model is useful does not mean it cannot be improved. Indeed, this is the goal of transportation researchers around the world. The usual pattern is to start with a model which is simple, transparent, and insightful. This simple model can then be improved in ways to make it more correct and useful.

There are many possible measures of effectiveness for evaluating the impacts of a transportation project or policy. Many of these can be calculated if one can predict the number of drivers on each roadway segment, the number of passengers on each bus route, and so forth. These are called link flows. Predicting link flows allows a city or state government to evaluate different options.

If link flows are the output of a planning model, the main input is demographic data. That is, given certain information about a population (number of people, income, amount of employment, etc.), we want to predict how many trips they will make, and how they will choose to travel. Census records form an invaluable resource for this, often supplemented with travel surveys. Commonly, a medium-to-large random sample of the population is offered some money in exchange for keeping detailed diaries indicating all of the trips made within the next several weeks, including the time of day, reason for traveling, and other details.

To get link flows from demographic data, most regions use the so-called four-step model (Figure1). The first step is trip generation: based on demographic data, how many trips will people make? The second is trip distribution: once we know the total number of trips people make, what are the specific locations people will travel to? The third is mode choice: once we know the trip locations, will people choose to drive, take the bus, or use another mode? The fourth and final step is route choice: once we know the modes people will take to their trip destinations, what routes will they choose? Thus, at the end of the four steps, the transition from demographic data to link flows has been accomplished.

Demographics are not uniform in a city; some areas are wealthier than others, some areas are residential while others are commercial, some parts are more crowded while other parts have a lower population density. For this reason, planners divide a city into multiple zones, and assume uniform conditions within each zone. Clearly this is only an approximation to reality, and the larger the number of zones, the more accurate the approximation. (At the extreme, each household would be its own zone and the uniformity assumption becomes irrelevant.) On the other hand, the more zones, the longer it takes to run each model, and at some point computational resources become limiting. For examples, the Austin model used in 2004 contains about 1000 zones, while the Chicago model contains about 1,800. Zones are often related to census tracts, to make it easy to get demographic information from census results.(4)

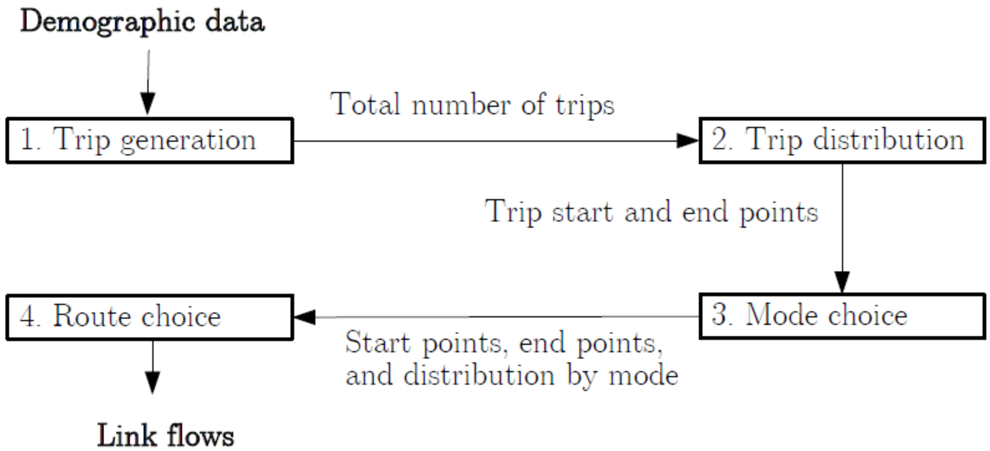

Figure 2: Schematic of the four-step process.

Let us assume we know the number of drivers traveling between each origin zone and destination zone (from CAMPO[1]). From this, we want to know how many drivers are going to use each roadway segment, from which we can estimate congestion, emissions, toll revenue, or other measures of interest. This is shown schematically in Figure 2. The shortest path problem is one of fundamental problem in network optimization. This problem can be stated as follows: given a graph G = (N,A) where each arc has a cost c_{ij} , an origin r ϵ N, and a destination s ϵ N, find the path P connecting r and s for which the sum of its arcs' costs is minimal. In general, if a segment of a path does not form the shortest path between two nodes, we can replace it with the shortest path, and thus reduce the cost of the entire path. There are two main approaches: Static Traffic Assignment (STA), and Dynamic Traffic Assignment (DTA).

In STA, the two most common approaches for solving shortest paths are *label setting* (Dijkstra's algorithm) and *label correcting*. The ArcGIS uses the Dijkstra's algorithm to find the shortest path. Dijkstra's algorithm finds the shortest path from the origin r to every other node, when every arc has a nonnegative cost. Furthermore, at each step it finds the shortest path to at least one additional node. It uses the concept of finalized nodes, that is, nodes to which the shortest path has already been found. Furthermore, it stores an n x 1 vector q, representing the previous node in the shortest paths, taking advantage of the treelike structure of the shortest paths.

1 The Capital Area Metropolitan Planning Organization (CAMPO)

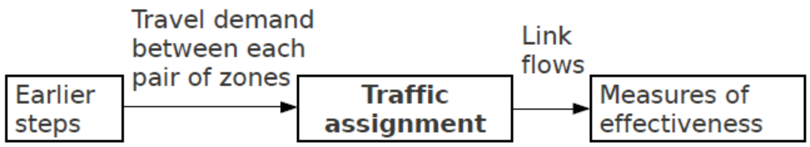

Figure 3: Inputs and outputs of traffic assignment.

Properly resolving the issue of the “steady state" assumption requires moving to a dynamic network model. Dynamic network models have the potential to more accurately model traffic, but are harder to calibrate, are more sensitive to having correct input data, and require more computer time. Further, dynamic models end up requiring very different formulations and approaches. While useful in a number of circumstances, they are not universally better than static models. The primary way DTA models differ from one another is in the underlying traffic flow model. There is no broad agreement on the best traffic flow model to use, and it largely depends on the application (as with static vs. dynamic, there is a tradeoff between level of detail and computational requirements).

The question of whether a static or dynamic model is more appropriate depends on the application at hand. Speaking broadly, dynamic models are often preferred when (1) we want relatively detailed information on the traffic flow itself (where congestion will be, how long queues are, etc.); (2) bottlenecks or dynamic traffic control are the central object of study (e.g., work zone studies, variable tolls, traffic signals); (3) our network exhibits a high level of congestion; or (4) our analysis period is long enough that both demand and congestion change significantly. On the other hand, static models tend to be preferred (1) if there are a large number of scenarios to study; (2) the input data are not known with a high degree of accuracy (e.g., long-range predictions); (3) our network is not highly congested; or (4) we have only a limited amount of computational resources to spend on traffic assignment. The additional realism of dynamic traffic assignment is highly attractive and, indeed, necessary for certain studies, but these advantages must be weighed against the greater data and computational requirements.

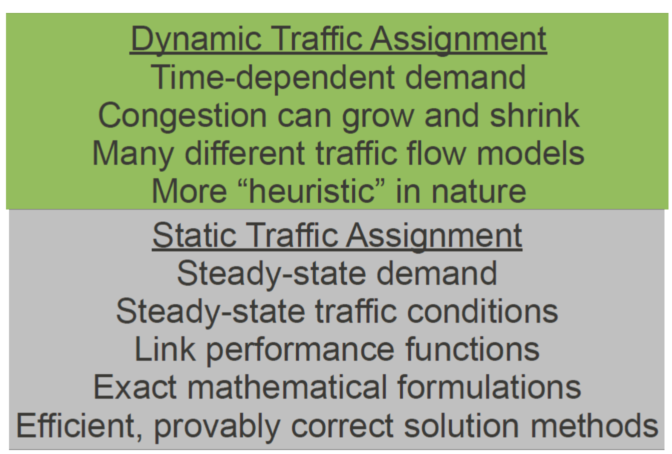

Figure 4: STA and DTA main facts

4. Description of Data

The data for application of network analysis tool box was available on ArcGIS Online. For different analysis purposes I used San Francisco, San Diego, and Paris data base.

To analyze driving behavior during road closure I used VISTA[2] to model downtown Austin traffic pattern. The VISTA is a comprehensive dynamic traffic assignment (DTA) system that integrates data warehousing and traffic analysis for transport applications via a client-server implementation. One of the advantages of this algorithm is predicting travel demand and supply by incorporating more behaviorally realistic methodologies. And it is an Internet based geographic information system (GIS) and incorporated it into the system.

The model inputs in this study include a 2004 network that covers Travis, Williamson, and Hays counties and was originally developed by the Capital Area Metropolitan Planning Organization (CAMPO). This input data which was available in text format includes directional link peak hour attributes which is used in directional peak period traffic analysis. The data provided in this input file include tail node number, head node number, directional peak hour capacity of the link, length of the links, free flow travel time, toll rates, and beta and alpha parameters that are used in the Bureau of Public Roads (BPR) function. The CAMPO model (and network) includes 1117 internal zones. Even though this information was sufficient for the purpose of this analysis, some difficulties were encountered while determining number of lanes and length of study period (e.g. AM peak hour capacity versus AM peak period capacity) as this information was essential in making correct improvement adjustments for the study scenarios. The output of VISTA is a text file which will provide us the data we need (Link travel time, and link flow) for analyzing the network by ArcGIS (Table 1).

Table 1: Input data to ArcGIS

link_ttime_base_project_AUSDT - Microsoft Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	LinkID	count	avg_ttime(sec)	LinkID	from_sec	to_sec	count	avg_ttime	LinkID	from_sec	to_sec	count	avg_ttime	LinkID	from_sec	to_sec	count	avg_ttime(s
2	1E+05	2723	6	105088	3600	7200	2714	6	105088	3600	7200	2736	6	105088	3600	7200	2750	6
3	17613	180	21.81666667	17613	3600	7200	180	21.9333	17613	3600	7200	181	21.9282	17613	3600	7200	178	21.7753
4	17612	2317	19.03323263	17612	3600	7200	2317	18.9814	17612	3600	7200	2316	19.0557	17612	3600	7200	2318	19.0677
5	17615	37	26.35135135	17615	3600	7200	33	27.2727	17615	3600	7200	39	25.6923	17615	3600	7200	38	26.1316
6	17614	440	12.525	17614	3600	7200	449	13.3831	17614	3600	7200	351	13.0855	17614	3600	7200	400	13.215
7	17616	404	17.42079208	17616	3600	7200	428	17.1098	17616	3600	7200	332	15.7229	17616	3600	7200	392	15.6429
8	17618	670	16.01641791	17618	3600	7200	670	16.3657	17618	3600	7200	638	14.5909	17618	3600	7200	623	15.6404
9	17620	684	12.64035088	17620	3600	7200	686	12.809	17620	3600	7200	659	13.6571	17620	3600	7200	658	13.8511
10	17621	531	22.1299435	17621	3600	7200	531	21.9153	17621	3600	7200	514	20.3463	17621	3600	7200	527	20.7609
11	17622	365	8.78630137	17622	3600	7200	368	9.09783	17622	3600	7200	397	8.70529	17622	3600	7200	368	8.95924
12	17624	579	15.11398964	17624	3600	7200	566	14.8039	17624	3600	7200	611	14.4452	17624	3600	7200	582	14.9072
13	17626	86	6.523255814	17626	3600	7200	93	6.51613	17626	3600	7200	117	6.48718	17626	3600	7200	101	6.56436
14	1E+05	365	15	105119	3600	7200	365	15	105119	3600	7200	365	15	105119	3600	7200	365	15
15	1E+05	706	7.992917847	105125	3600	7200	687	7.62445	105125	3600	7200	679	7.73638	105125	3600	7200	678	7.96903
16	1E+05	530	46.95849057	105135	3600	7200	516	47.2093	105135	3600	7200	519	44.3931	105135	3600	7200	537	47.3017
17	1E+05	52	6	105131	3600	7200	52	6	105131	3600	7200	52	6	105131	3600	7200	52	6
18	1E+05	708	12	116672	3600	7200	701	12	116672	3600	7200	716	12	116672	3600	7200	693	12

link_ttime_base_project | Sheet1

[2] Visual Interactive System for Transport Algorithms (VISTA)

5. Applications of ArcGIS in Transportation

"Network Analysis" toolbox extension is developed for transportation application. The ArcGIS Network Analyst extension allows us to build a network dataset and perform analysis on a network dataset. This extension is composed of a number of parts, which I go through some of them.

As a first step, we need to create a network data set. It is not possible to just add a streets feature class to ArcMap and start finding shortest routes or perform other network analyses. Simple features, like the line features that represent streets, are not aware of one another. They don't inherently know what they are connected to—and connectivity is indispensable for network analysis. Network datasets, however, store the connectivity of features. Therefore, instead of using street features directly, we need to create a network dataset in ArcCatalog from the streets, and then the ArcGIS Network Analyst extension can reference the network dataset for everything it does.

The ***Network Analyst*** toolbar in ArcMap provides some general-purpose information and functionality. For example, it lets us know which network dataset, if any, is active; it allows us to inspect the attributes of network elements on the map with the ***Network Identify*** tool ; and it allows us to choose the network analysis we want to perform and creates the corresponding network analysis layer for us. Other useful buttons on the toolbar include the ***Directions*** button , which opens turn-by-turn instructions for routes; the ***Network Analyst Window*** button , which shows or hides the ***Network Analyst*** window; and the **Solve** button , which generates the results for our network analysis.

The Network Analyst extension developed based on ***Dijkstra algorithm***.

5.1. Find the quickest route to visit a set of stops

Whether finding a simple route between two locations or one that visits several locations, people usually try to take the best route. But "best route" can mean different things in different situations.

The best route can be the quickest, shortest, or most scenic route, depending on the impedance chosen. If the impedance is time, then the best route is the quickest route. Hence, the best route can be defined as the route that has the lowest impedance, where the impedance is chosen by the user. Any valid network cost attribute can be used as the impedance when determining the best route.

San Francisco network were used for this part. First I created the network dataset. As a second step, we need to active the Network Analysis. Then Click ***Network Analyst*** on the ***Network Analyst*** toolbar and click New Route. After the route analysis layer is added to the ***Network Analyst*** window, we can add the stops to be visited by a route. Then Network Analyst calculates the nearest network location and symbolizes the stop with the *located* symbol. All stops have a unique number, which represents the order in which the stop will be visited by the route. The sequence of the stops can be changed by clicking a stop in the ***Network Analyst*** window and dragging it to another position in the list. If a stop is located on the network but in the wrong location, we can move the stop to the correct position. By click the Solve button on the ***Network Analyst*** toolbar. A route feature appears in the map display and in the Network Analyst window under ***the Routes class*** (Figure 5). We can also add a barrier on the route to represent a roadblock, and we will find an alternate route to our destination (Figure 6). Barriers are feature classes in network analysis layers that restrict or alter impedances of the underlying edges and junctions of the associated network dataset. Barriers are split into three geometry types (point, line, and polygon) and are designed to model temporary changes to the network.

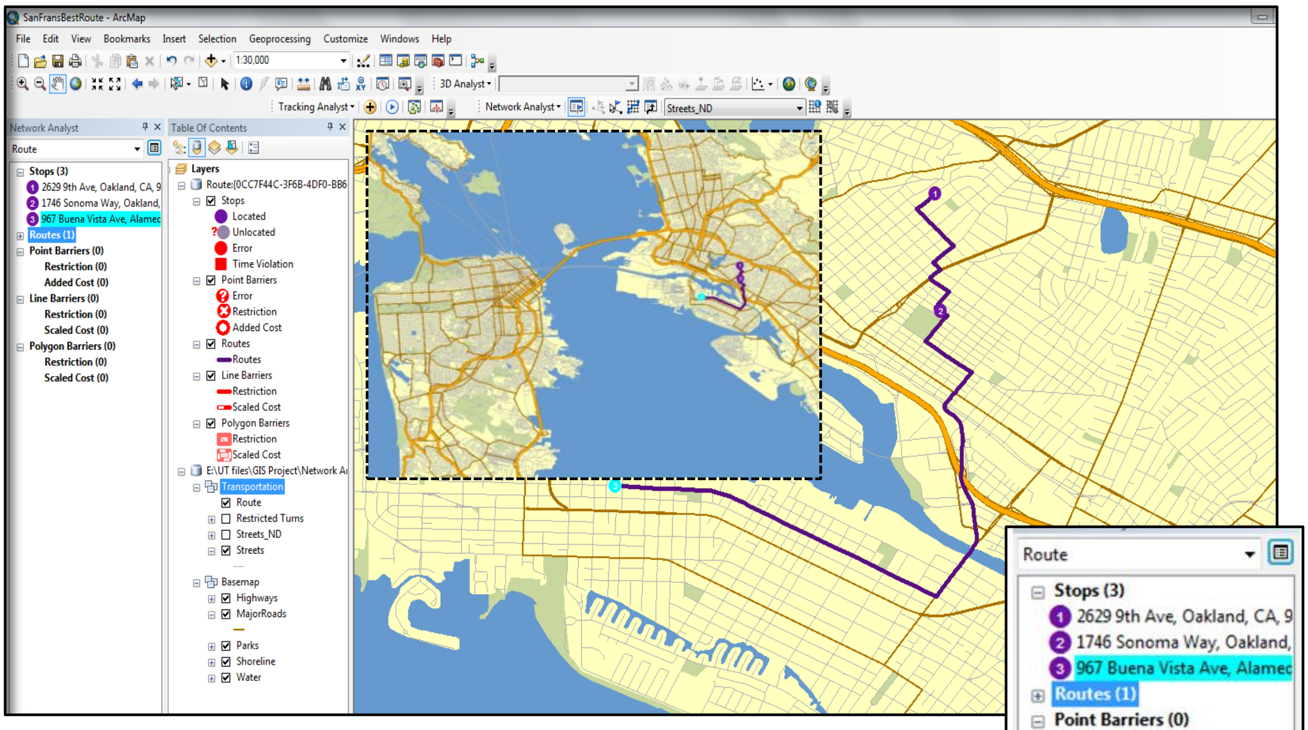

Figure 5: The quickest route to visit a set of stops

We have to be careful about saving the route analysis layer. After we create the layer, it will be stored in memory, so if we exit ArcMap without saving, the analysis is lost. However, if we save the map document, the analysis layer is saved with it. We can also export data. One option is to export the entire analysis layer to an LYR file. The analysis properties and objects are stored within the LYR file. Another option is to save the sublayers of the analysis as feature classes using the ***Export Data*** command.

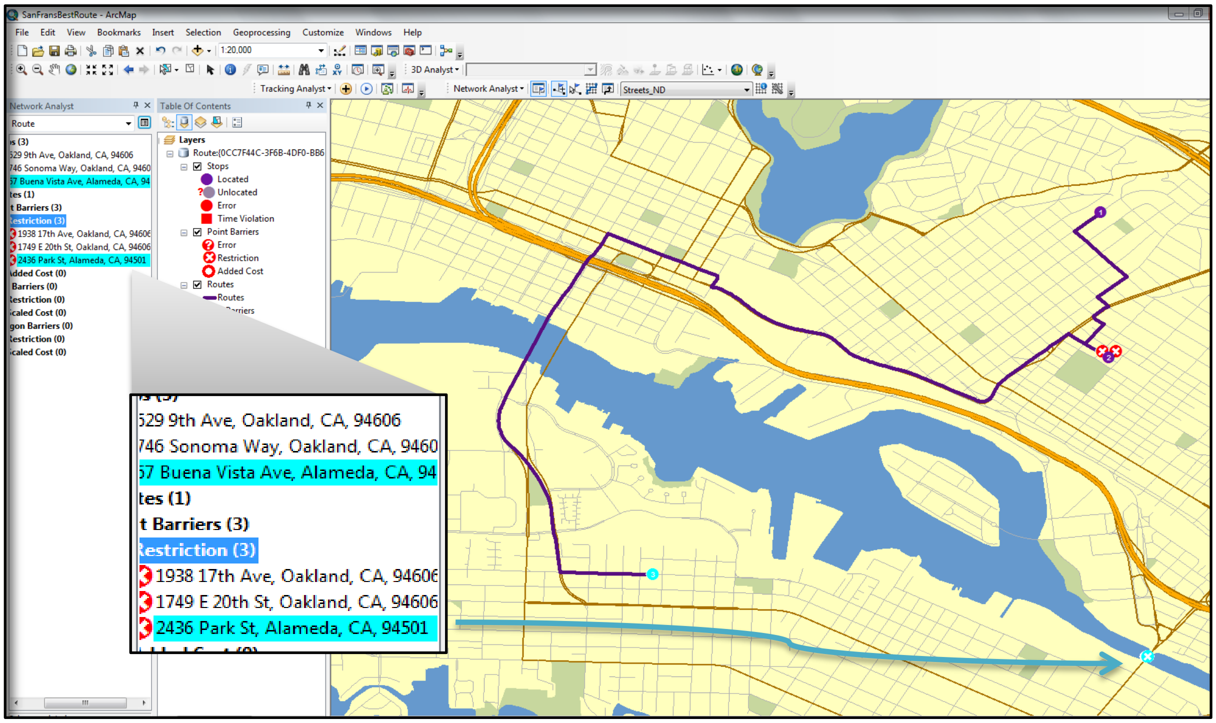

Figure 6: The quickest route to visit a set of stops with barriers

5.2. Find the closest facility (fire stations)

Finding the closest hospital and fire stations to an accident, the closest police cars to a crime scene, and the closest store to a customer's address are all examples of closest facility problems. While finding closest facilities, we can specify how many to find and whether the direction of travel is toward or away from them. Once we have found the closest facilities, we can display the best route to or from them, return the travel cost for each route, and display directions to each facility. Additionally, we can specify an impedance cutoff beyond which Network Analyst should not search for a facility. For instance, we can set up a closest facility problem to search for hospitals within 15 minutes' drive time of the site of an accident. Any hospitals that take longer than 15 minutes to reach will not be included in the results. Network Analyst allows performing multiple closest facility analyses simultaneously. This means we can have multiple incidents and find the closest facility or facilities to each incident.

I used the available data (San Francisco) to work with this feature. I created a closest facility analysis layer from the ***Network Analyst*** toolbar by clicking **Network Analyst** > **New Closest Facility**. Then it appears in the ***Network Analyst*** window, along with its six network analysis classes: Facilities, Incidents, Routes, Point Barriers, Line Barriers, and Polygon Barriers.

Analysis parameters are set on the ***Layer Properties*** dialog box for the analysis layer. After setting all the parameters it will give us the information of the closest fire station to the location of incident. (Figure 7)

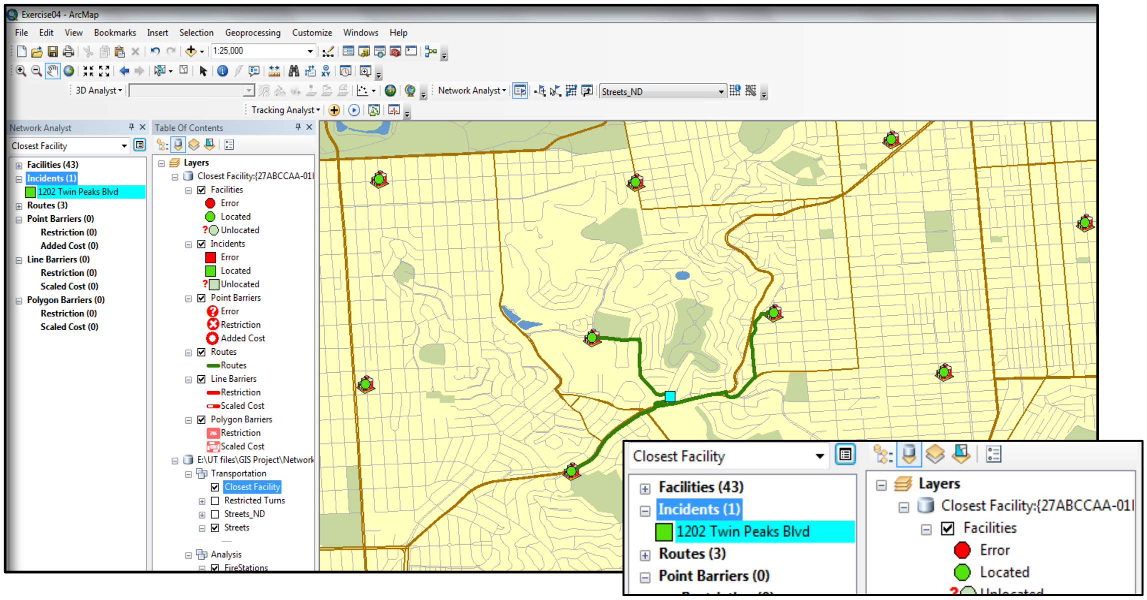

Figure 7: the closest fire stations

5.3. Create a model for route analysis

A dispatcher managing a fleet of vehicles is often required to make decisions about vehicle routing. One such decision involves how to best assign a group of customers to a fleet of vehicles and to sequence and schedule their visits. The objectives in solving such vehicle routing problems (VRP) are to provide a high level of customer service by honoring any time windows while keeping the overall operating and investment costs for each route as low as possible. The constraints are to complete the routes with available resources and within the time limits imposed by driver work shifts, driving speeds, and customer commitments.

Network Analyst provides a vehicle routing problem solver that can be used to determine solutions for such complex fleet management tasks. Consider an example of delivering goods to grocery stores from a central warehouse location. A fleet of three trucks is available at the warehouse. The warehouse operates only within a certain time window—from 8:00 a.m. to 5:00 p.m.—during which all trucks must return back to the warehouse. Each truck has a capacity of 15,000 pounds, which limits the amount of goods it can carry. Each store has a demand for a specific amount of goods (in pounds) that needs to be delivered, and each store has time windows that confine when deliveries should be made. Furthermore, the driver can work only eight hours per day, requires a break for lunch, and is paid for the amount spent on driving and servicing the stores. The goal is to come up with an itinerary for each driver (or route) such that the deliveries can be made while honoring all the service requirements and minimizing the total time spent on a particular route by the driver.

To use this application we need to create the model first. For this part I found Paris network data on ArcGIS Online. First I created the route layer in the model. Next, I added the network locations (stops) to be used as inputs. Then, I solved and displayed the results (Figure 8,9).

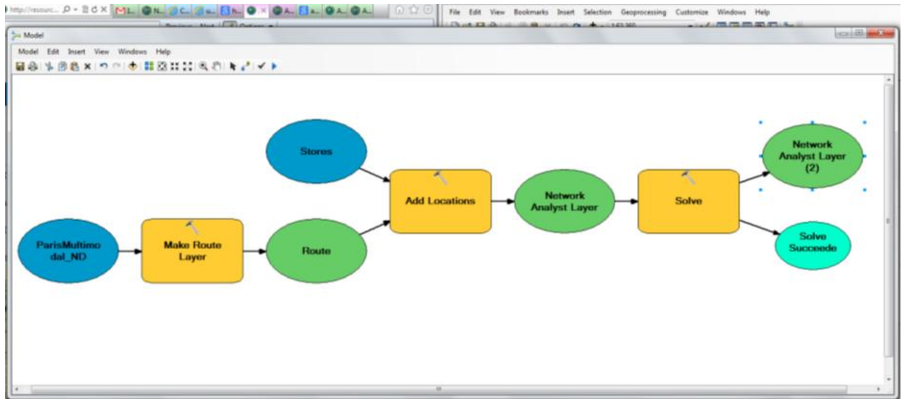

Figure 8: a model for route analysis

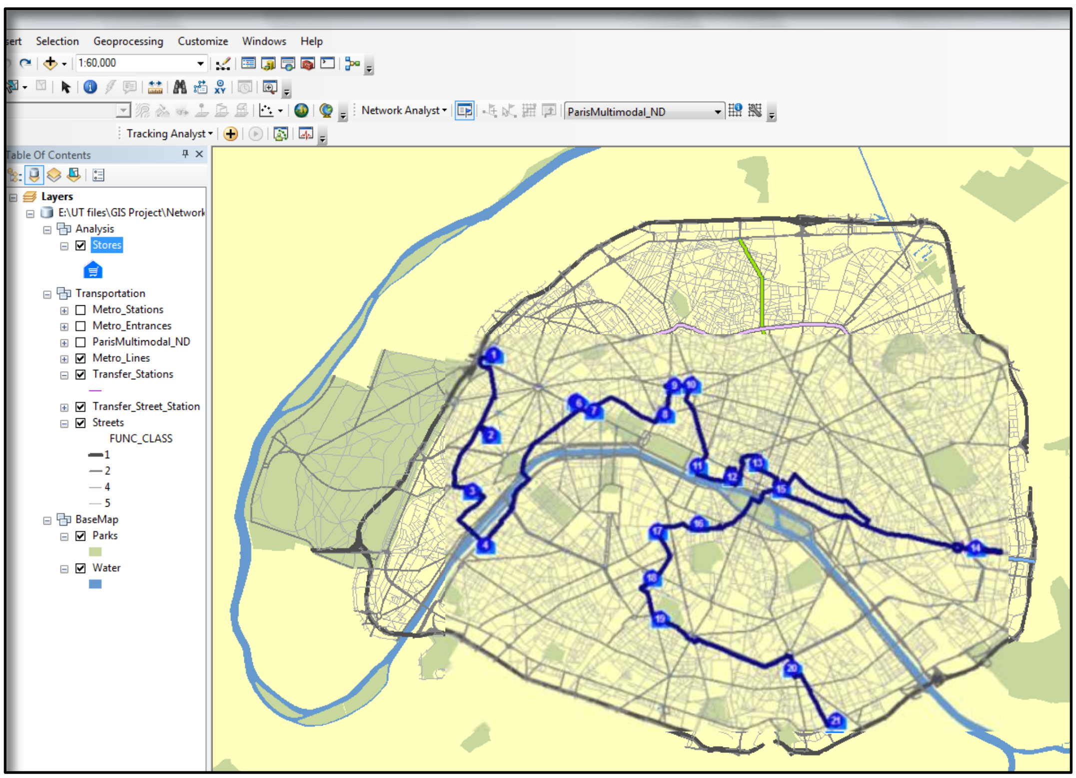

Figure 9: vehicle routing problems (VRP) in Paris

5.4. Configure live traffic on a network dataset

We can perform network analyses and access live traffic feeds through ArcGIS Online services. Look at Figure 10 to see the areas in which these services are provided.

Any country colored in green, yellow, or orange indicates ArcGIS Online provides services for performing network analyses. Green indicates live and historical traffic data are available for that region, which means our analyses can take into account changing traffic conditions based on current and past observations. Yellow indicates historical traffic is available, so our analyses can also account for changing traffic conditions, but the travel speeds are based on past observations only. Orange indicates static travel speeds are available.

The green fill symbol also indicates ArcGIS Online provides live traffic feeds within the area. By linking a properly-configured network dataset to one of the feeds, we can incorporate live traffic data into any network analysis layer we create on the network dataset.

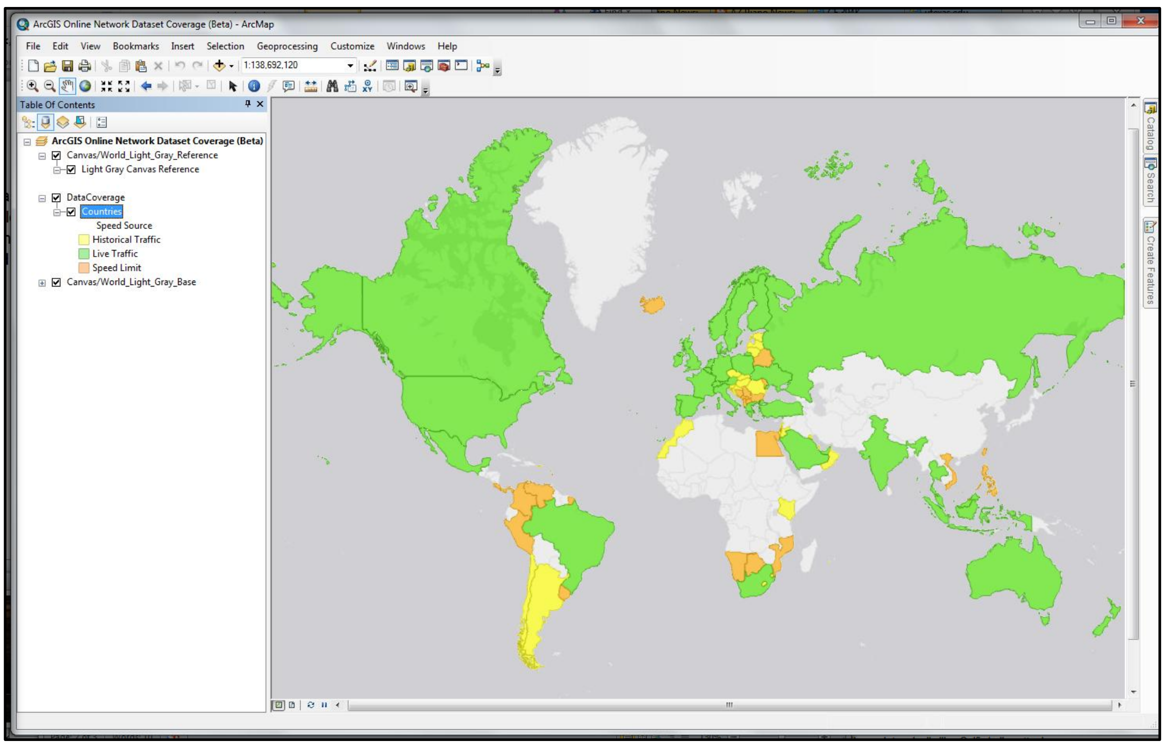

Figure 10: ArcGIS Online Network Dataset Coverage (Beta) [From ArcGIS Online]

I created a network dataset in a geodatabase using San Diego Street, turn, and signpost features. The network dataset will also include historical and, optionally, live traffic data, which makes it possible to view travel speeds for different times of day and solve time-dependent network problems. We can configure historical and live traffic data with this page of the wizard. Configuring historical traffic data is required to set up live traffic data.

The SanDiego geodatabase contains two tables that store historical traffic data: Patterns and Streets_Patterns.

The Patterns table acts as the Profiles table for the network dataset. Each profile describes the variation of travel speeds in 15-minute intervals over the course of a day.

The Streets_Patterns table functions as the Streets-Profiles table. The records in the table link edge source features with profiles in the Patterns table. A representative profile can be specified for each day of the week for each digitized direction of a source feature. By linking street source features with traffic profiles, the streets' varying traffic speeds can be described for an entire week.

The travel speeds in the Patterns table are relative to a free-flow speed so that many different source features with different free-flow speeds can share the same profile. This design minimizes storage requirements.

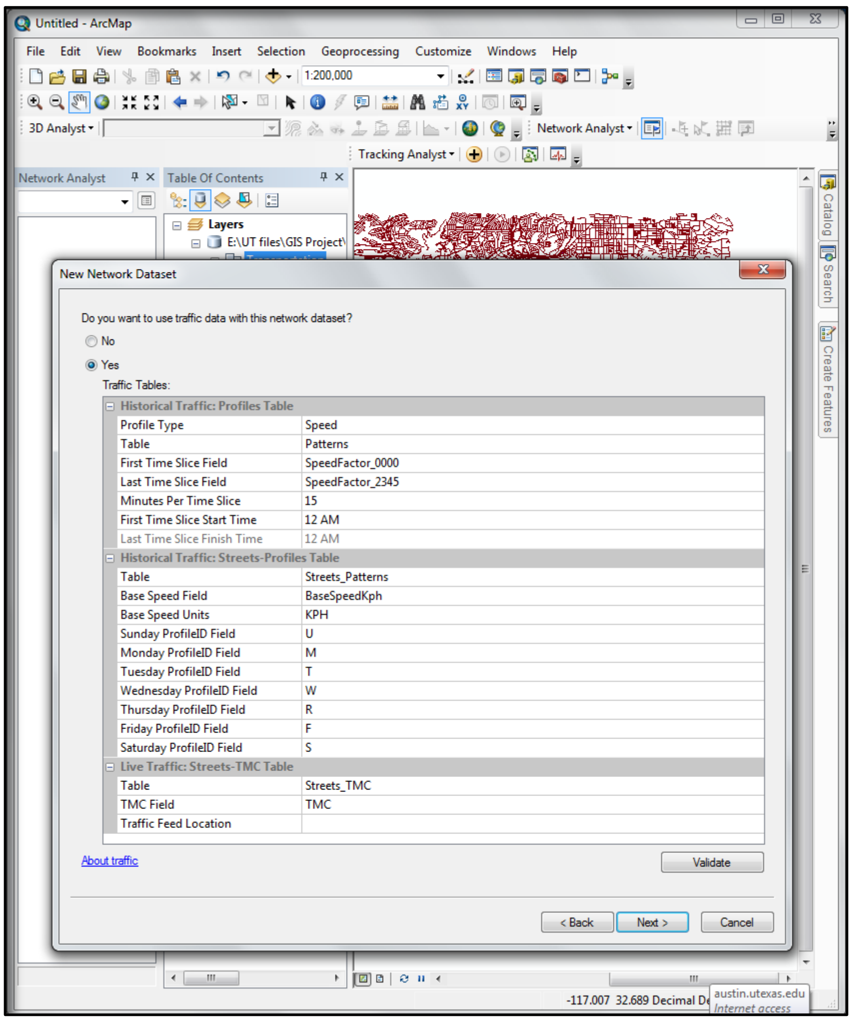

Figure 11: San Diego Network Dataset

The Streets-TMC table is used with live traffic data. It links source features with standard traffic message channel (TMC) codes, which in turn relate to live travel speeds stored in the dynamic traffic format (DTF) files. DTF files are designed specifically for network datasets to read and understand. The Update

Traffic Data tool creates DTF files by connecting to a data provider's traffic feed, reading the data, and converting it to the dynamic traffic format.

The ArcGIS Network Analyst extension recognizes the schema of the tables and automatically configures the historical traffic sections of this page in the wizard. It also configures the table for the live-traffic section, but not the Traffic Feed Location property.

For this project I observed downtown San Diego network on Friday afternoon for couple of hours (November 30th).

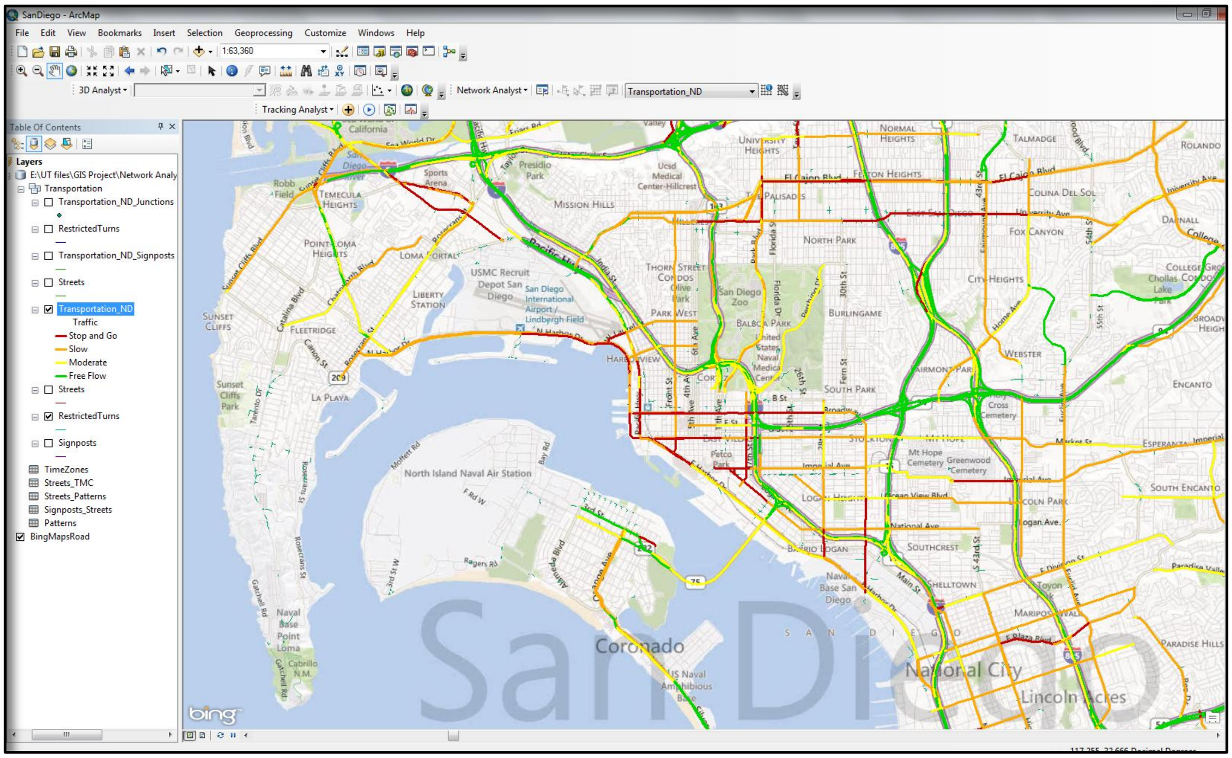

Figure 12: Downtown San Diego Live traffic 11/30/12 at 3:55 PM

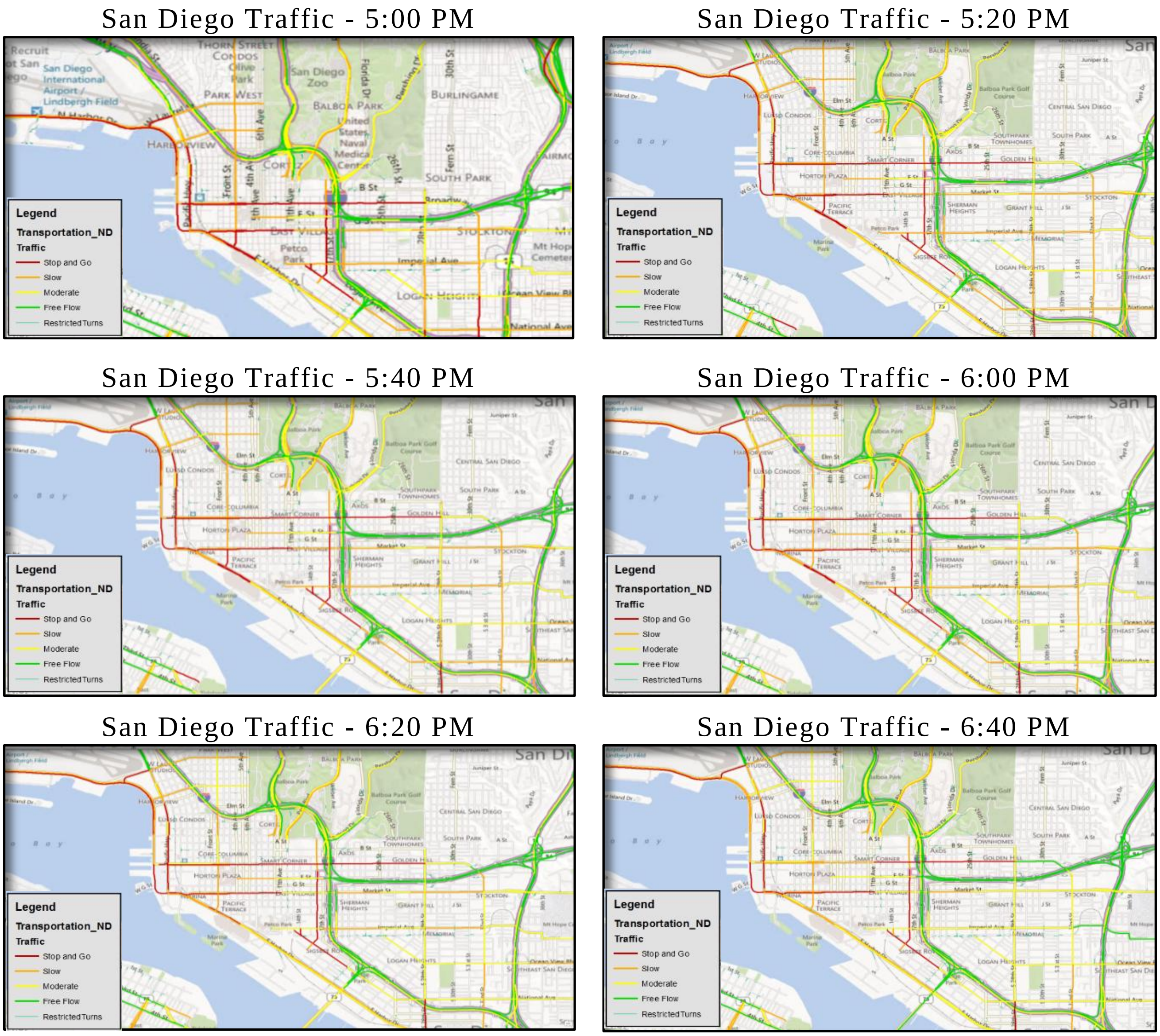

Figure 13: Downtown San Diego Live traffic changes

6. Driving behavior changes through different cases

As briefly described previously, this study's main objective is to reduce traffic congestion around the downtown Austin (Figure 14) and provide a safer environment for those who live, study, and work near downtown. The first step to achieve this objective is to evaluate existing traffic conditions within an area of interest. Initially, I utilized the DTA software VISTA to identify links flow and link travel time. After importing data into ArcGIS and visualizing link flow in network. It appears there are some links with no traffic flow (shown in Figure 14).

The animation of vehicles simulated on the network and the VISTA output were checked and it appears consistent with the output. In other words, VISTA is saying that no vehicles are using these links, consistent with the output. This tells us that the java code that creates the output file doesn't appear to be doing something wrong or at least inconsistent with the DTA model. The next question naturally is does it make sense that no one is using these links? Looking at the location of centroids and connectors around the network, it does appear believable that, in the model, no one would be using these links. This is based on the location of the connector links, which input and output vehicles on the general network. If a vehicle can get to a connector, accessible to its origin or destination, without using a link in a particular area, it won't use the link. If you look at the location of links with zero volume, you will see that many are near centroids/connectors. Also, I found some vehicles using links on campus, just not necessarily in both directions (therefore, it would appear nothing is using the link in the selection due to the fact the links in both directions are on top of each other). It is also a product of the equilibrium convergence. Since vehicles are assigned to the shortest path, sometimes that means nothing is assigned to a path/link for a particular iteration - so at whatever iteration we stop, there might not be an associated volume. Therefore, if we want a value for travel time for those links with zero volume, assuming that at most you would have maybe 5-10 vehicles using them, we can input the free-flow travel time (link length divided by link speed limit), as that would be the value for even a small number of vehicles using the link. The level of service then for these links would be estimated at "A".

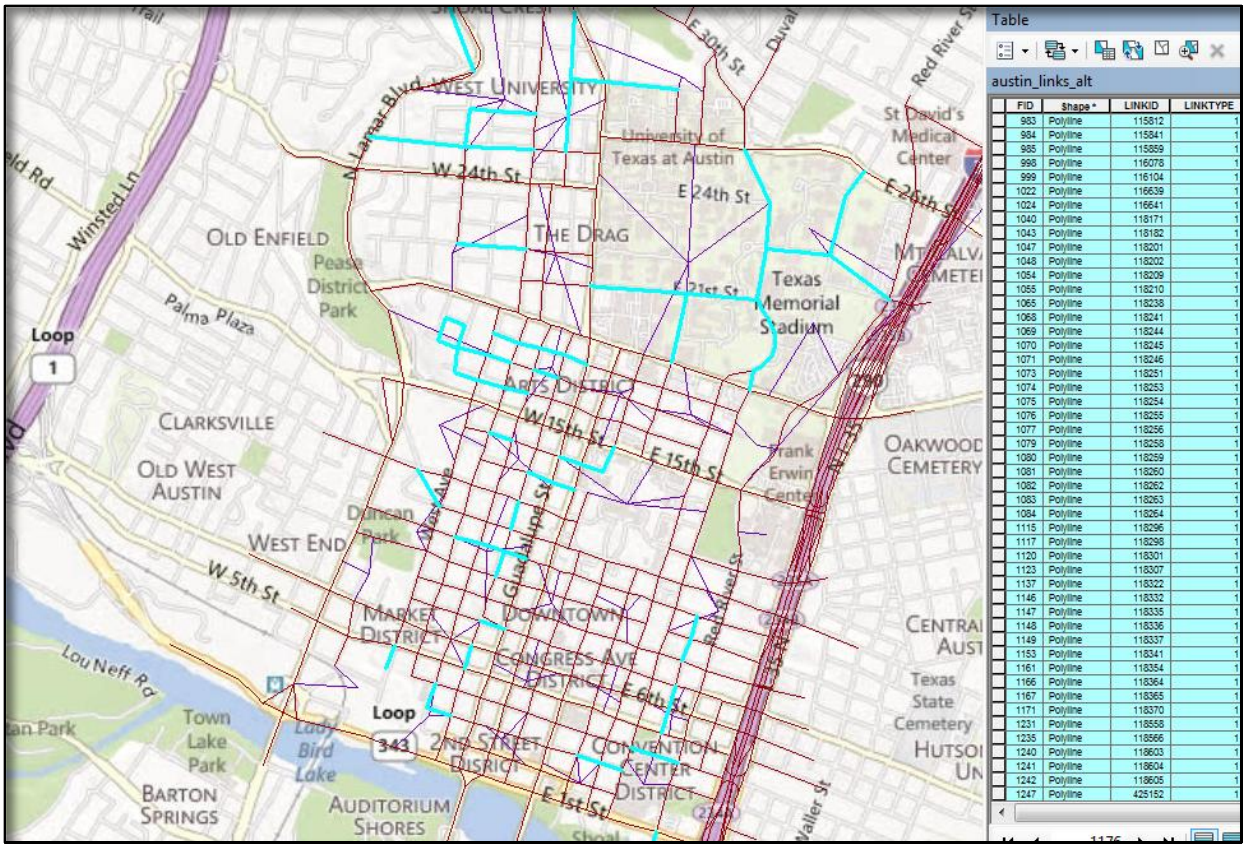

Figure 14: Downtown Austin network with selected zero link flow

Different case scenarios were defined to evaluate the driving behavior. Initially, three different scenarios are defined. These scenarios include:

> Scenario 1: There is a work zone on east bound of 2nd Street (Between Colorado St. and Congress Ave.) and drivers are aware of road closure.
>
> Scenario 2: Incident happens on east bound of 2nd Street (Between Colorado St. and Congress Ave.) and drivers are not aware of road closure.
>
> Scenario 3: There is a work zone on east bound of 2nd Street (Between Colorado St. and Congress Ave.) and half of drivers are aware of road closure.

These three scenarios will later be compared with the base scenario.

The Base Scenario (Figure 15 and 16) was conducted for year 2004. Because of the limited scope of this study, the model inputs were not examined for quality which is an important step in modeling to ensure model results best represent real-world traffic conditions. A limited validation of traffic assignment volumes was performed to evaluate the accuracy of model results. Therefore, further calibration and validation efforts are recommended but not within the scope of this study.

Link flow by itself does not give much information about traffic condition. One way to scale it to have more insightful measure is to divide link flow by capacity which is named v/c or flow rate. It is necessary to note that the V/C ratios developed and discussed in this report are not equivalent to V/C ratio in traffic operations since the final results of traffic assignment methods are not flows or volumes, but rather actual demands. Therefore, V/C ratios larger than one are common in this study and are only used in evaluation of traffic conditions as a relative rather than an absolute measure. Furthermore, V/C ratios are used with caution in this study as these measures would be less significant at lower volumes/capacities and are often used in combination with other measures such as travel time and link demands.

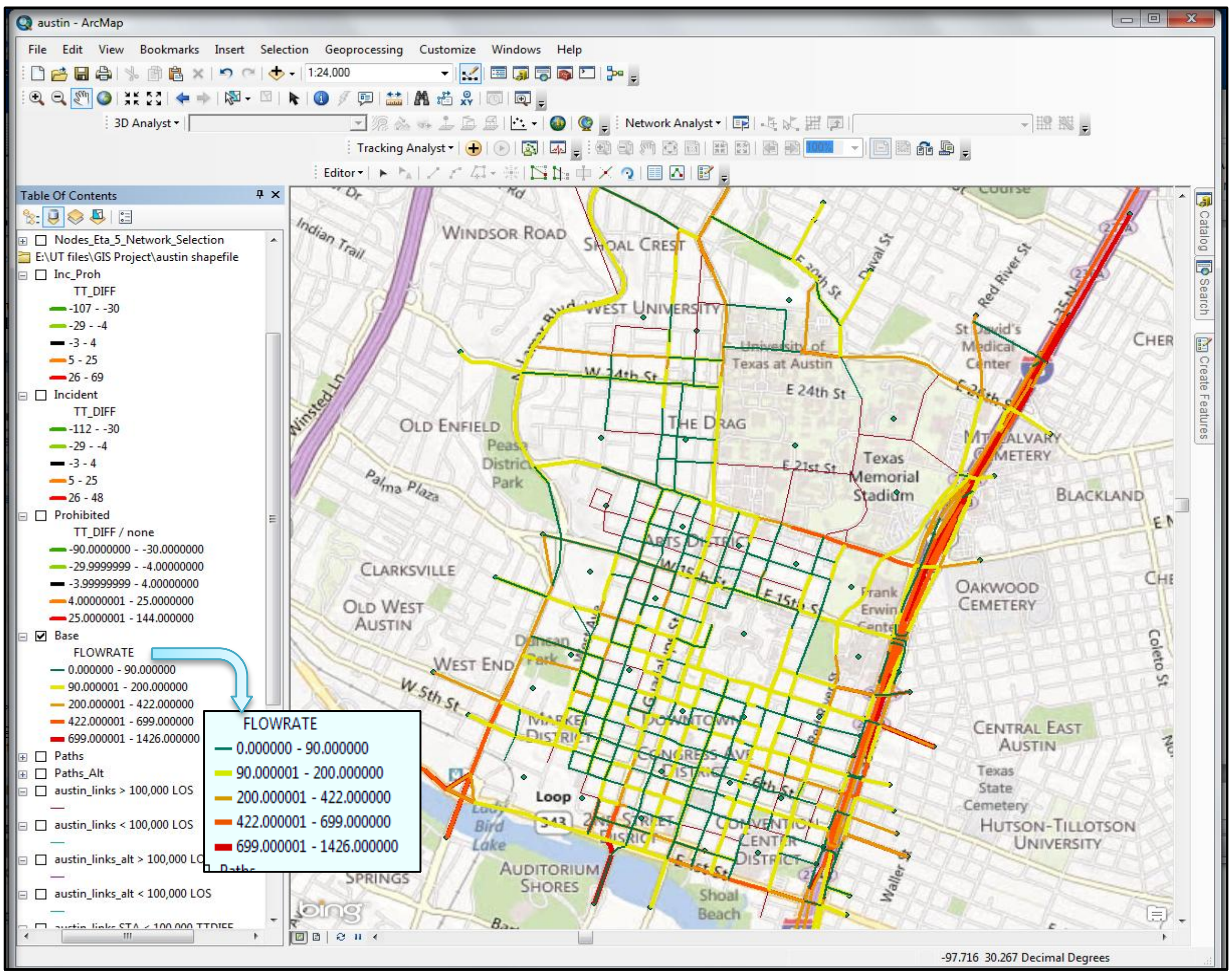

Figure 15: Base Network traffic condition based on 2004 traffic data

As a first changes, I assumed there is a work zone on east bound of 2nd Street (Between Colorado St. and Congress Ave.) in which provided prior notice to travelers about the closures hoping to reduce numbers of unnecessary trips and stimulate path changes during the closure.

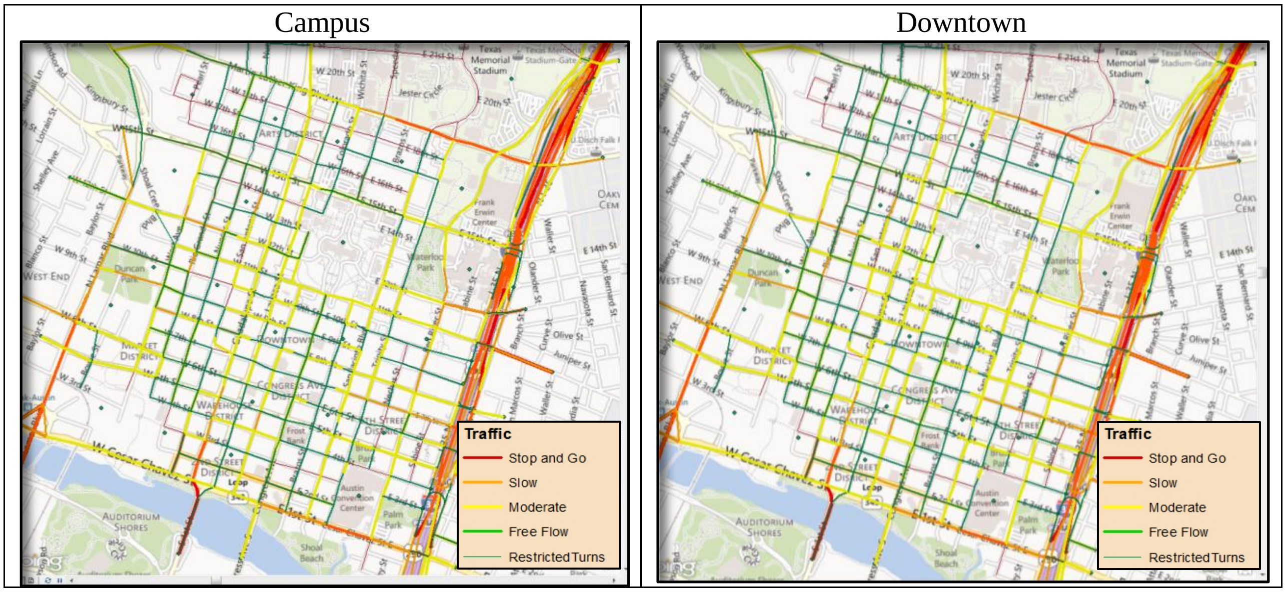

Figure 16: Traffic Flow in base scenario

As a matter of comparison, one robust measure is link travel time. To compare different scenario with the base scenario, I used the link travel time differences.

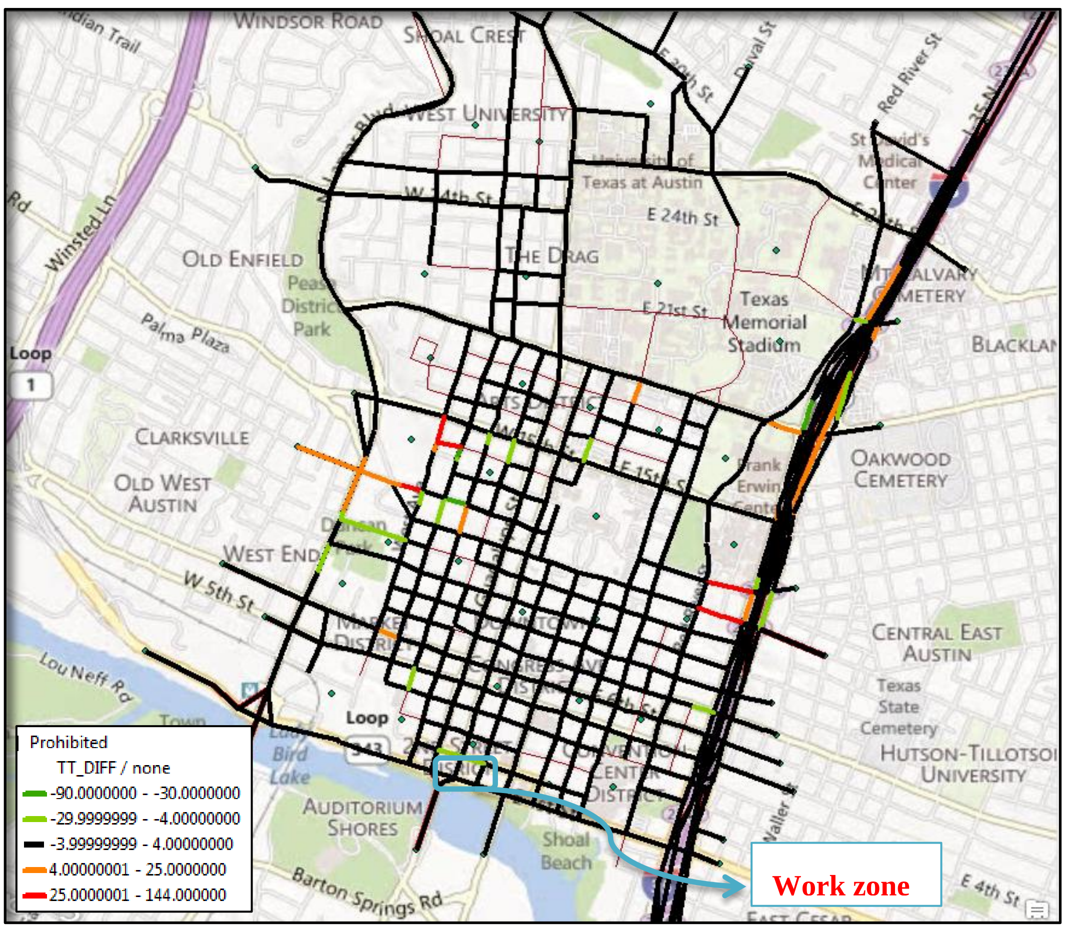

Figure 17: Travel Time Difference during construction with base network

The black color in all map scenarios represents negligible changes. The green color shows travel time reduced in that link. That means less traffic exist. Red and orange color shows traffic situation is getting worse (more traffic).

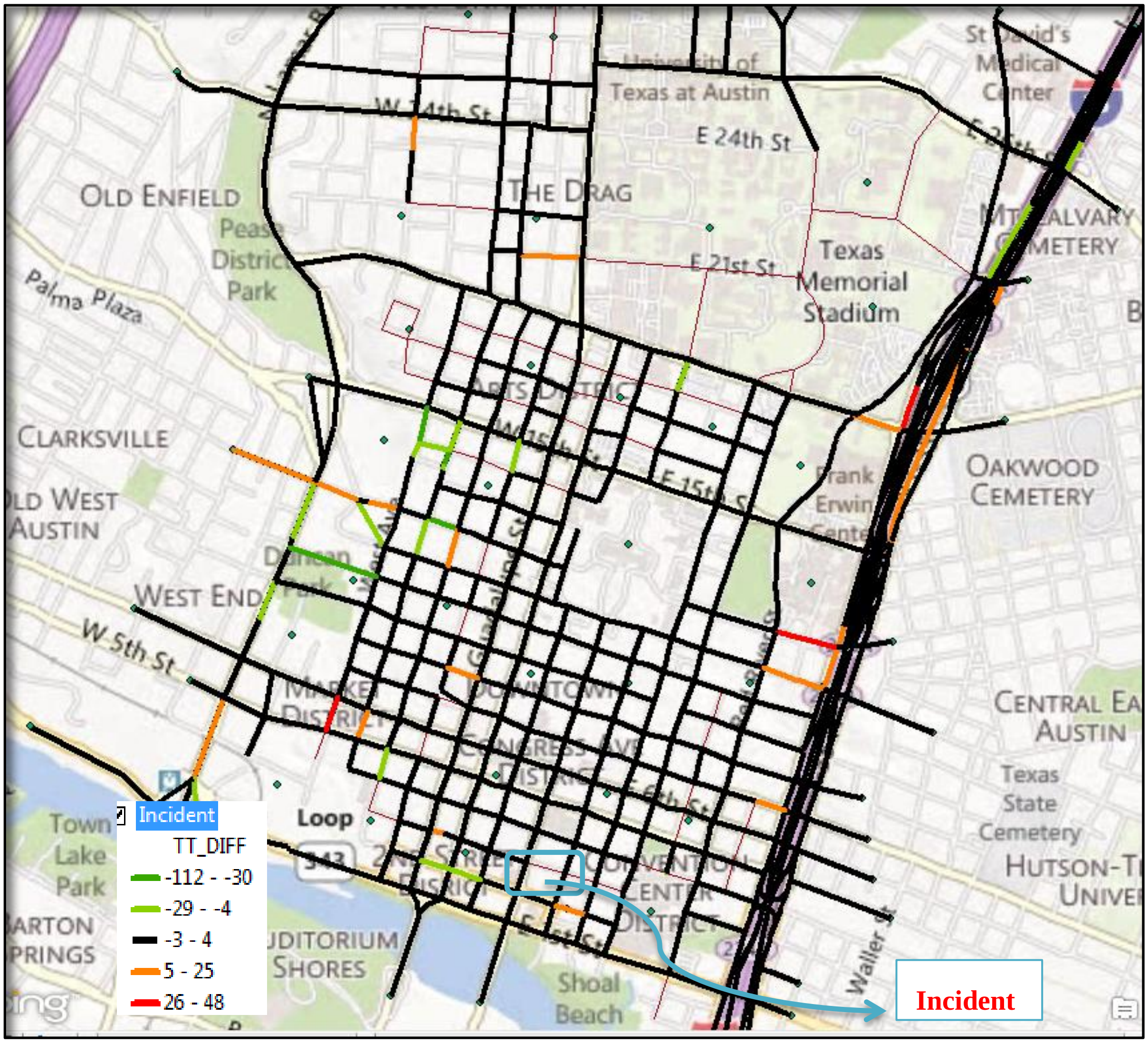

Figure 18: Travel Time Difference during incident with base network

As we are be able to see in these maps show that the northbound traffic is slightly heavier than southbound traffic. The volumes are generally larger during closure times than during typical conditions.

Using this information, we will be able to perform a test to determine the statistical significance of the differences between cases (not in scope of this project)

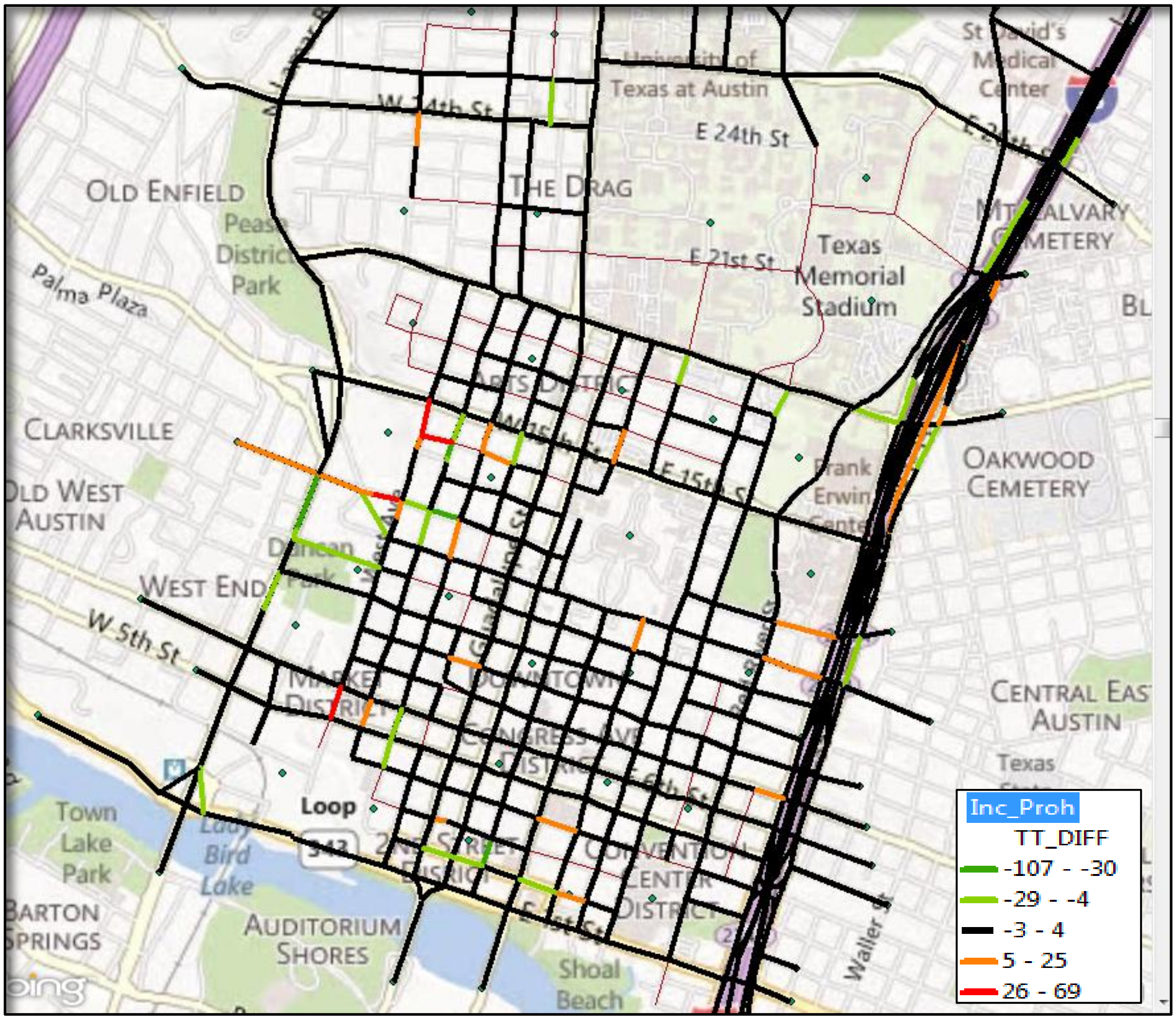

Figure 19: Travel time difference while assuming half of the drivers pay attention to notifications

7. Summry

These different scenarios show that a good traffic control plan has effect on traffic pattern and drivers trying to change their route if they are aware of possible closure.

Advance notice to the public via radio, television, newspapers, changeable message signs, and traveler information systems can encourage drivers to use alternate routes or travel at off-peak times.

The limitations of this study are listed and discussed next. First, the model inputs were not examined for quality and thus some uncertainties remain with the level of accuracy of this data. Second, the analysis was performed for year 2004 and thus conclusions of this study may not be up-to-date. Third, instanced of inappropriate use of centroid connectors were observed such as unrealistic connections or connection with nodes of intersecting roads. Fourth, a limited validation of traffic assignment results indicates the necessity of validation and calibration of the model. V/C ratios developed in this study are for planning purposes and should not be used as V/C ratios of traffic operations since traffic assignment results represent link demands versus volumes/flows.

References

1. Highway Capacity Manual. Transportation Research Board.Washington, D.C., 2010.
2. Manual on Uniform Traffic Control Devices. FHWA, U.S. Department of Transportation,Washington, DC, 2003.
3. Yosef Sheffi, *"Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods"*, Published by: Prentice-Hall, Inc.Englewood Cliffs, NJ 07632
4. Zhen (Sean) Qian, H. M. Zhang, "*On Centroid Connectors in Static Traffic Assignment: their effects on flow patterns and how to optimize their selections*" Transportation Research Record, TRB 91th Annual Meeting CDROM, 2012.