San Francisco Dynamic Traffic Assignment Project
"DTA Anyway"

Final Calibration & Validation Report

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1. Introduction

This document presents the final calibration and validation results for the San Francisco Dynamic Traffic Assignment (DTA) project. It is an update to the *Working Draft Calibration and Validation Report*, which was prepared on July 13, 2012 and presented to the projects peer review panel. The report has been revised from the draft version to add information on calibration changes that were made since that time, update our description of some of the key findings from the original report based on further analysis, and more cleanly interface with the accompanying *Final Methodology Report*.

The *Final Methodology Report* covers the following topics:

- Background on the project and San Francisco DTA's role in the broader analysis toolkit.
- The entire model application process, including the development of model inputs and the process for converting relevant data from its static to dynamic representation.
- The final model parameters. Note that these parameters were included in the *Working Draft Calibration and Validation Report*, but have been moved to the *Final Methodology Report*, such that the final state of the model can be documented all in one place.
- Lessons learned from the project as a whole.

This Final Calibration and Validation Report focuses on the following topics:

- The process of calibrating the model, with a specific focus on themes that were identified during calibration and challenges that required revisions to the initial implementation.
- Final model results, compared to observed data, for the purpose of understanding the model's strengths and limitations for application.
- Sensitivity testing, for the purpose of evaluating whether the model results are reasonable and stable for application.

Three appendices are included as part of this report:

- Appendix A: Traffic Flow Parameters Data Collection.
- Appendix B: Summary of Calibration and Validation Parameter Settings
- Appendix C: Listing of DTA Test Runs

This report concludes with a summary of the findings of the calibration and validation process, specifically focused on the validity of the model for project applications, and next steps to be taken to improve both the calibration and validation.

2. Model Calibration

This section describes the process followed to calibrate San Francisco DTA. For the purpose of this document, calibration is considered to be the act of adjusting the model to better fit observed data. Validation, which is closely related, is considered to be the act of evaluating the model's performance against observed data.

This section also describes some of the pitfalls encountered and steps taken to avoid them. Please refer to the *Final Methodology Report* for a detailed listing of the final model parameters.

2.1 Approach to Model Calibration

In calibrating San Francisco DTA, we used the following basic approach:

- *Ensure quality inputs.* The bulk of the effort in calibrating has gone into the development of the inputs, and ensuring that those inputs are correct. This was especially true of the traffic control. We spent substantial effort cleaning up the network geometry to correspond to the actual intersection configurations, and handling special cases such as pedestrian-only signals and the unique intersection geometries that occur along Market Street. In the end, we have been able to import every relevant signal in the city based on actual timing plans, and we have done enough quality assurance to convince ourselves that they are 99% right.
- *Measure anything that can be measured.* If it was possible to measure or observe some aspect of reality, we sought to do so to provide a basis for our settings in the model. Those measurements were held in higher regard than settings where we were forced to make an assumption. The implication of this is that we avoided arbitrarily changing speeds and capacities to calibrate the model, but we took more liberty in making a judgment about how to define a perceived generalized cost equation because we had less basis for knowing the true value.
- *Evaluate the results qualitatively.* The first step after each model run was a visual inspection of the model results to determine whether there were any vehicles left waiting in the network as a result of excessive gridlock. We also evaluated the density, outflows and speeds using the visualization tools in Dynameq to identify whether any specific locations were causing gridlock, or whether the pattern of congestion looked logical based on our knowledge of the city.
- *Evaluate the results quantitatively.* Following the qualitative analysis, we compared the link and movement volumes to 15-minute and 60-minute counts. We also compared the travel times against observed travel times for segments defined in the congestion management plan.
- *Make defensible adjustments.* Based on our analysis of the results, we made hypotheses about what could be done to improve the assignment, and performed additional DTA runs to test our hypotheses. In doing this, we sought to avoid arbitrary changes, such as OD matrix estimation, and focused on adjustments we could justify.

The remaining portions of this section describe the steps taken during the calibration process in more detail.

2.2 Traffic Flow Parameters

Among the primary aspects of the model that can be calibrated are the traffic flow parameters. In Dynameq, the fundamental flow-density diagram is approximated in a simplified triangular (piece-wise linear) form (Figure 1). Representing flow as a function of density in each link, the positive slope in the first (increasing) segment is equal to Free Flow Speed (FFS), where the absolute value of the negative slope in the second (decreasing) segment is equal to the Backwards Wave Speed (BWS).

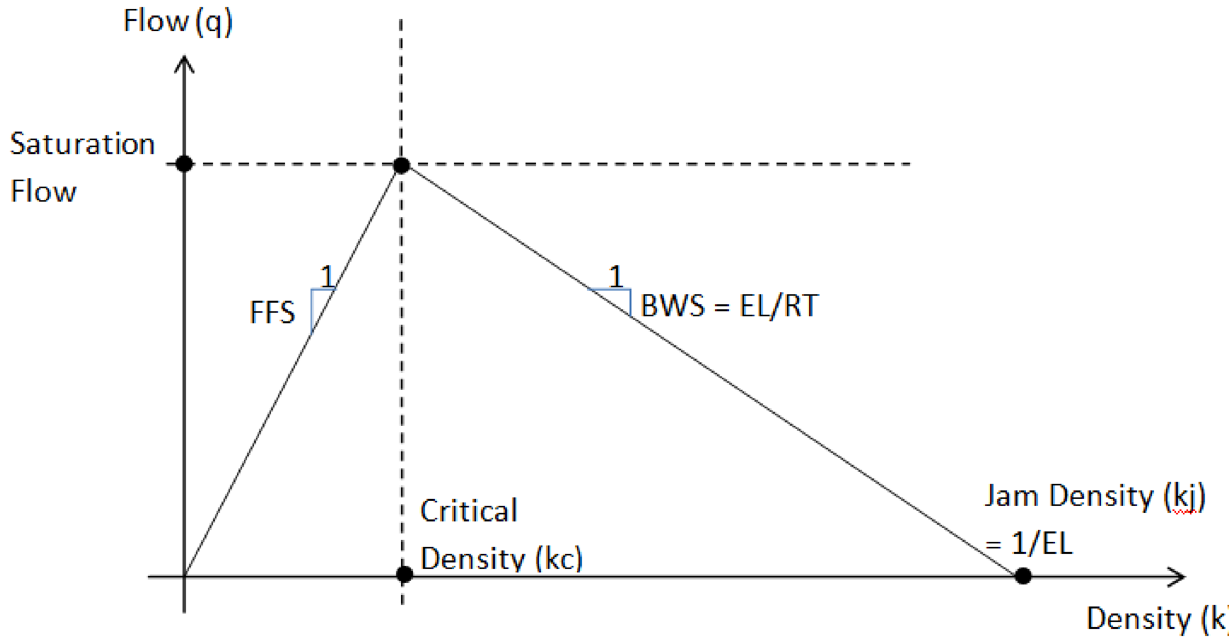

Figure 1. Flow-Density Relationship in Dynameq

The following parameters can be defined from this curve:

- *Free Flow Speed (FFS):* Free flow speed is the average speed that vehicles would travel in the absence of congestion or other adverse conditions (such as bad weather).
- *Saturation Flow:* The maximum flow that can traverse a segment of street.
- *Effective Length (EL):* Is the average space that the vehicles occupy on the street. It includes the vehicle length and spacing.
- *Jam Density (kj):* The maximum number of vehicles that can queue up per mile per lane. Jam density is regarding the stationary state of traffic with zero flow. (=1/EL)
- *Response time (RT):* The average time that takes for the vehicles to change speed after a change happening in the traffic flow state ahead.
- *Backwards Wave Speed (BWS):* The rate of propagating the change in the traffic flow state in the upstream, happening as a result of changes in the downstream traffic flow state. (=EL/RT)

The traffic flow parameters used in San Francisco DTA were calibrated using a two-phase process. First, field observations were taken of traffic flow conditions in San Francisco, as described in Appendix A. Second, a series of model sensitivity tests were conducted to evaluate the model's performance for a range of parameter values. This traffic flow parameter calibration process is documented in Appendix B, with the final coefficients shown in the *Final Methodology Report.*

2.3 Model Calibration Runs

The traffic flow parameter calibration just described was a part of a larger calibration effort. This effort focused largely on conducting a series of model calibration runs, with an evaluation of the model results against observed data for each run. Based on that evaluation, adjustments were made to the model in an effort to improve its expected performance. Examples of the types of changes made include: fixing network coding errors, handling special cases for traffic signal inputs, adjusting traffic flow parameters, and changing the generalized cost function.

The evaluation of the results of each test was done both quantitatively and qualitatively. In the quantitative process, we considered the final relative gaps (max, min, and mean) as a measure of how converged all time periods were, CPU time to indicate whether some modifications would result in much more computer time, the RMSE and GEH error measures between observed and modeled volumes, the ratio of modeled to observed flows, and the VMT and VHT. These measures were used to evaluate each test on its own and to compare tests to determine if a change resulted in an improvement in count-matching and other measures.

Although the quantitative measures provided numbers to compare between scenarios, many of the observations and alterations were made based on a qualitative analysis of the network results in the Dynameq interface. The measures that were considered when viewing the results in Dynameq were link occupancy, outflow and density to indicate congestion, link queuing to indicate congestion or unexpected lane-changing behavior, and the time required for all vehicles to clear the network after the end of the simulation period. Based on the level and location of congestion, we determined whether it was a system-wide issue (capacities set too low, generalized cost function) or something specific to that location (signal card or stop sign issues, number of lane, lane alignments).

One pattern observed in calibrating a congested DTA model is that a backup in one location can cause the entire network to break down. We relied upon visual inspection to find locations with gridlock in the network and to find locations that were not gridlocked but had high levels of congestion. One method of doing this is to display outflow as the color and density as the width of the links. Links with little to no outflow but high occupancy are gridlocked. The other method used to identify gridlock is to display link speed as the color and delay as the width. Links with very large amounts of delay and low speeds indicate heavy congestion. Figure 2 shows an example of a gridlocked intersection where width of the link represents the link density, and the red color indicates an outflow of less than five vehicles per hour. Plots of the lane queues were also used to identify unreasonable backups.

Figure 2. Gridlocked Area

By scrolling through the simulation times, we are able to identify the location where the gridlock originates as the first link or intersection where the outflow becomes very low and the density increases. This then allows us to isolate what problems are causing the gridlock at that particular location.

These congestion plots highlight an important difference between calibrating a static model and calibrating a DTA model. In the static model, the congested locations can be identified by links with high volume-capacity ratios, whereas severe congestion in DTA manifests as low flow, because the roadway is operating on the "back side" of the traffic flow curve. Under such conditions, real traffic flows can experience a sort of cliff effect, where they transition from stable flow to stop-and-go conditions. The DTA model is better able to mimic these conditions than the static model, but the result is that what may appear to be a minor change to model inputs can result in a large change to traffic conditions in the network.

Summaries of all of the validation and calibration tests performed are included in Appendix C. The summaries describe what was changed from the previous run, some basic statistics, and some observations on the results. It gives a sense for the dimensions of change attempted, and the areas investigated. The runs are titled according to the location they were run and the date they were created. For some runs, additional information is available on the project wiki[1], linking to spreadsheets with model versus count comparisons. Changes were made incrementally where possible to isolate the impact of each change individually and evaluate whether or not it should be incorporated in future tests.

[1] http://code.google.com/p/dta/wiki/ValidationTracker

One important change that is mentioned briefly in the validation tracker is that the last few test were run on an updated version of Dynameq. In the change from Dynameq 2.5.4.1 to Dynameq 2.6.0.1, many of the procedures were updated, and the results from the models are significantly different.

The final validation run is ResetSpeedFlow_v24_Dyn26. Interactive results and results summary spreadsheets from this run and others can be accessed at the project homepage by looking at the Validation Tracker wiki.

2.4 Important Issues Addressed in Calibration

Several important issues were found and addressed through the calibration process. These include: speed-flow parameters, generalized cost functions, pedestrian friction, transit-only lane permissions, signal phases, and demand loading.

Speed-Flow Parameters

While the data sources provided some guidance on setting the speed-flow parameters, there was some additional testing that was required to determine the correct vehicle length and response time values for the two modes (Cars and Trucks). The model was found to be very sensitive to truck congestion, and increasing the truck length by even 1ft was found to push the model into gridlocked conditions. Based on these findings, a series of tests were done to determine the appropriate truck length to use while maintaining the relationship that trucks are 1.5 times the length of cars.

During several runs, severe backups resulting in gridlock were observed at specific freeway divergence points on US-101. The DTA results showed a large number of vehicles switching lanes at the last minute, resulting in a backup that percolated through the network. After consultation with the DTA software developers, it was determined that driving behavior on urban freeways such as US-101 can be much more aggressive than the default settings we were using assumed. Therefore, traffic flow adjustments were made to compensate.

Additionally, parameters relating to critical gaps and follow-up times at intersections were adjusted from the defaults to determine which settings provided the most realistic results.

The two measures used to identify the best settings were the ratio of modeled to observed flows and the modeled average speed (calculated by dividing VMT by VHT). The combination of the two measures provided insight into how well each test matched the counts and also into the level of congestion in each test. The goal was to match both the volumes and levels of congestion found in reality, without the model becoming gridlocked.

Generalized Cost Functions

Several early calibration runs revealed traffic volumes much lower than the corresponding counts. This result was surprising, because the static assignment model produced reasonable results with the exact same demand. Further investigation revealed that traffic in the DTA model was being dispersed much more broadly throughout the grid network than traffic in the static model was. Because the available traffic counts are concentrated on arterials, the traffic was not disappearing, but instead was just moving to links without counts. Two changes were made to mitigate this issue.

First, it was recognized that for streets with stop controlled intersections, the DTA model was accounting for the intersection delay, but not for delay associated with acceleration and deceleration time. Therefore, the free flow speeds on locals and collectors, which have the majority of the stop signs, were adjusted downward to account for acceleration and deceleration time at the stop signs. A future enhancement may be to associate the acceleration and deceleration time directly with the stop-controlled intersection, rather than with the facility type as a whole.

Making this first change did not fully resolve the issue, though. Therefore, the generalized cost function used for path-building was modified to increase the perceived travel time on locals and collectors. This represents a preference for traveling on the arterial system, potentially due to the visibility of the route, or the displeasure associated with stopping at each block.

Pedestrian Friction

While some calibration runs devolved into gridlock, a number of others showed less congestion in the downtown area than anticipated. In addition, the software vendor recommended penalizing left and right turns to avoid unrealistic zig-zag paths through the network. Considering both of these together, it was noted that one important source of delay that was not being accounted for was conflicts between turning vehicles and pedestrians in the crosswalk. In much of the downtown area, turning vehicles must wait for a herd of pedestrians to cross before making their turn. Not only is there a delay to that vehicle, but to the vehicles behind it.

To serve as a proxy for these conditions, the traffic flow parameters were adjusted as a function of area type, with the denser area types given a larger penalty to account for heavier pedestrian traffic.

The San Francisco Municipal Transportation Agency's (SFMTA) June 2011 *City of San Francisco Pedestrian Count Report*[2] provides 2009 and 2010 pedestrian count data for 50 locations throughout San Francisco. For each count location, Highway Capacity Manual (HCM) methodology was used to determine an appropriate saturation flow reduction factor to approximate the impact of pedestrian activity on vehicular turning movement saturation flow rates. The distribution of calculated saturation flow reduction factors throughout San Francisco showed that outside of the central business district (CBD), few locations have enough pedestrian activity to significantly reduce vehicular turning movement capacity. In light of the minimal impacts outside of San Francisco's core districts, a pedestrian friction factor was applied only to intersections located in areas classified as Area Type zero or one. Due to the lack of pedestrian count information at more intersections, the project team decided to apply a uniform pedestrian friction factor throughout these CBD areas. Two pedestrian friction factor regimes were tested. In one case turning movement capacity was reduced by 25% in the CBD and 10% in adjacent downtown neighborhoods. In the other case turning movements capacities were reduced by 10% in the CBD and 5% in areas near the CBD. While the more restrictive settings more closely match friction factors computed using HCM methodology from observed volumes, the more restrictive settings produced excessive congestion in the network. The less restrictive pedestrian friction factors are included in the final model.

[2] http://www.sfmta.com/cms/rpedmast/Pedestrian-specificreports.htm

Transit-Only Lane Permissions

Another issue that arose in the course of the calibration tests was how to deal with the transit-only lane permissions. The transit-only lanes in San Francisco are restricted to allow transit vehicles as well as vehicles making right turns. Dynameq does not currently allow movement-specific vehicle class restrictions, so this was initially modeled by excluding all autos. This approach resulted in gridlock, starting from backups at several specific locations, such as coming out of the Stockton Street Tunnel.

To better simulate the true condition, a link-splitting method was introduced. In this method, all vehicles are allowed to use the "front" half of a link approaching an intersection, but only transit vehicles are allowed to use the bus lane on the "back" half of the link. Therefore, autos cannot make a through movement from the bus lane.

After implementing this approach, the impacts of this change had to be identified to ensure that it was accurately modeling the driver behavior. In the first set of tests with this new implementation, it was discovered that the method created congestion in regions that did not have issues in any previous testing. Some qualitative inspection of the congested locations and the new network revealed that short links with transit-only lanes were being split. Since Dynameq requires each link to be at least as long as the longest vehicle, the two new links were both being set to the minimum link length, effectively doubling the length of the corridor and the resulting travel time. After this issue was discovered, the code was modified to ensure that short links were no longer split. This was found to fix some of the issues that were seen after the first implementation of the transit-only lane splitting. The modified link lengths are an example of an issue that can only be found by a thorough investigation of the results and all network changes near newly-congested locations.

Signal Phases

Another issue that often required a more detailed inspection of congested locations was the signal phasing. Some signal cards have complicated signal plans that the code was not processing correctly in early tests. As congested intersections and corridors were identified, however, we were able to isolate and fix the issues with the signal processing script. Additionally, some signals plans are actuated or provide multiple options for allocating time in each phase depending on the level of congestion. For those plans, if the testing showed congestion at that location, the signal plans were adjusted within the limits specified in the signal card to correctly model the signal behavior given congestion levels on each approach.

Demand Loading

The final area of work was in the demand loading. In response to input from INRO and the peer review panel, the demand loading was extended from 3:30-6:30 to 2:30-7:30, providing a warm-up hour and a cool-down hour before and after the 3-hour PM peak period. This longer warm-up and cool-down time allows results to be captured for all three hours of the PM peak, with less concern for erroneous path loadings that can occur at the edges of the simulation period.

The primary complication of implementing this method was determining the portion of the midday and evening trip tables to assign in those hours. The SF-CHAMP midday simulation time is from 9:00 am to 3:30 pm, and the evening simulation covers the period from 6:30 pm to 3:00 am. While auto traffic for the 2:30-3:30 period may represent an average hour of auto traffic during the midday period, the truck traffic will likely be much lighter, given that truck drivers will anticipate higher traffic levels that come during the PM peak period. The same logic applies to determining the portion of the evening truck trip tables that would accurately represent the 6:30-7:30 truck traffic levels. Tests were performed for different portions of each of these truck trip tables being used until the congestion and count levels matched the expected truck volumes more accurately during those times.

In addition to the warm up and cool down periods, the temporal profile has been adjusted based on counts obtained from the PeMS[3] database for four network entry locations: U.S. 101 at the southeast entry point, I-80 on the Bay Bridge, US-101 near the Golden Gate Bridge, and I-280 at the southwest entry point. The counts at these collections were obtained for an average weekday (Tuesday through Thursday with no holidays) for two weeks. The counts for each 30-minute time period from 3:30 to 6:30 pm were then averaged to obtain a count for each location during that time segment. The count for each segment was then divided by the sum of the counts to obtain the portion of the flow experienced during that 30-minute period. Those portions were then averaged over those locations to obtain an approximate temporal profile. The final temporal profile is shown in section 2.7 of the *Final Methodology Report*.

3. Model Validation Results

This section presents the model validation results for the final model. The currently preferred results show improvement over the earlier calibration runs in terms of matching both volumes and congestion levels. The results are presented in more detail below.

3.1 Validation Standards

Two sources are considered for validation standards for this project.

The recently updated Travel Model Validation and Reasonableness Checking Manual[4] provides guidance on validating all aspects of travel models, but is clear to recommend a balanced approach between matching observed data and staying true to the theoretical foundations of the model. This manual provides a range of example validation guidelines (but no specific standards). The example guideline selected for this project is the Ohio RMSE Curve, which offers a target percent root mean squared error by volume group.

The second guideline is from the Caltrans Travel Forecasting Guidelines[5]. These guidelines include a standard that is based on the maximum desirable deviation for individual link counts. They recommend that at least 75% of count locations on freeways and principal arterials fall within the maximum desirable deviation.

In addition, given the importance of convergence to a DTA model, a self-imposed standard is adopted for the level of convergence. The target convergence is less than a mean of a 5% critical gap across all time periods, and more importantly a gap that appears stable upon visual inspection.

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[3] http://pems.dot.ca.gov

[4] Travel Model Validation and Reasonableness Checking Manual, Second Edition (Cambridge Systematics, 2010)

[5] State of California Department of Transportation Travel Forecasting Guidelines, November 1992, accessed at: http://ntl.bts.gov/DOCS/TF.html.

Travel times are evaluated and additional visual inspections are completed as part of the validation, but no specific standards are adopted for those evaluations.

3.2 Convergence

Figure 3 shows the critical gap convergence for the final calibration run. Across time periods, the minimum gap is 0.3%, the maximum gap is 6.2%, and the mean gap is 2.7%. The plots show that the gaps have been stable for almost 20 iterations.

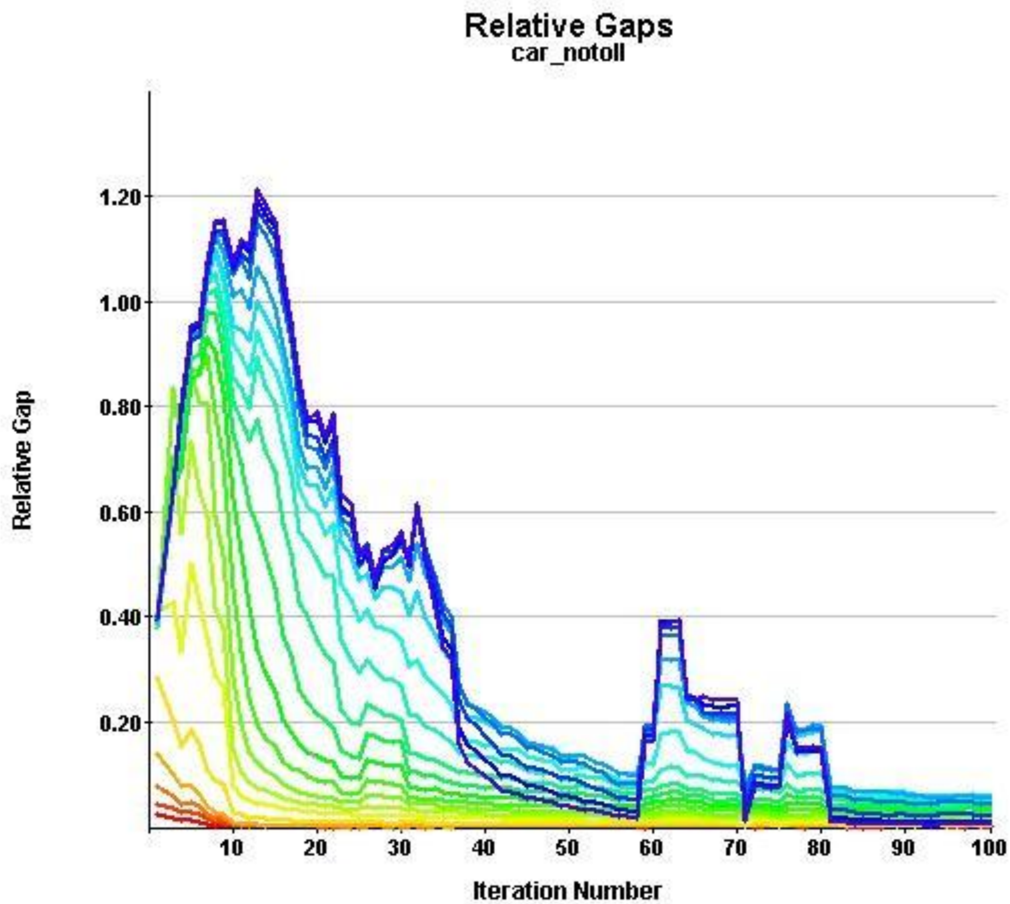

Figure 3. Convergence Graph for Base Scenario

3.3 Traffic Volumes

A set of traffic counts is available for validation on San Francisco streets during the 4:00 to 6:00 pm period in 15-minute increments. Only counts from 2009 or later are used, and only those collected on Tuesdays through Thursdays of non-holiday weeks when school is in session. If counts are available for multiple days, the volumes are averaged. This set of counts includes 391 turning movement counts and 190 link counts. To expand the data set, the turning movement counts are aggregated to generate a total link volume for the approaching link. Some links have both link counts and turning movement counts, so this provides traffic counts on 454 total links.

Table 1 and Figure 4 show the table and plot comparisons of observed vs. modeled volumes by time of day. The modeled and observed volumes both drop off at 6 pm because the set of count locations are different. There is a large set of counts that only extend from 4-6 pm, and those that extend to 6:30 pm happen to be in locations with lower volumes. We can see that the modeled volumes follow the same general pattern as the observed volumes, but for all time periods, the modeled volume is about 13% lower than observed. The model produces a 55% RMSE across all 15-minute count locations.

Table 1. Observed vs. Modeled Link Counts by Time of Day

Start Time	End Time	# Counts	Observed	Modeled	Difference	Percent Difference	RMSE	Percent RMSE	GEH
16:00	16:15	470	178	154	-24	-14%	97	54%	5.62
16:15	16:30	468	184	157	-26	-14%	97	53%	5.63
16:30	16:45	470	187	161	-27	-14%	101	54%	5.71
16:45	17:00	470	191	167	-23	-12%	105	55%	5.80
17:00	17:15	482	199	173	-26	-13%	106	53%	5.78
17:15	17:30	482	203	176	-27	-13%	112	55%	5.90
17:30	17:45	481	204	177	-27	-13%	108	53%	5.77
17:45	18:00	434	198	176	-22	-11%	106	53%	5.73
18:00	18:15	99	167	144	-23	-14%	111	67%	6.53
18:15	18:30	99	163	142	-21	-13%	107	66%	6.20
Total		**3,955**	**192**	**166**	**-25**	**-13%**	**104**	**55%**	**5.77**

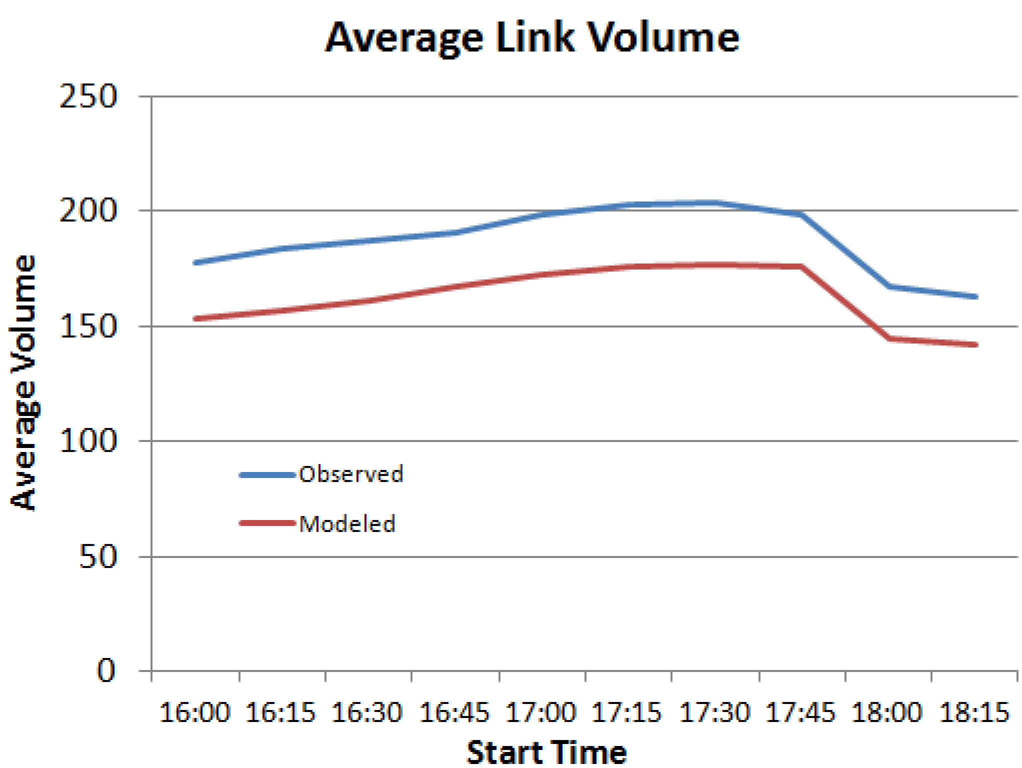

Figure 4. Observed vs. Modeled Link Counts by Time of Day

Error! Reference source not found. shows the percent root mean squared error by volume group, compared to the Ohio RMSE target. For this graph, the 15-minute volumes are aggregated to hourly volumes, with each location providing a 4-5 pm observation and a 5-6 pm observation. No peak-hour adjustment is made to the target curve. This plot shows higher RMSE for the lowest volume category, as expected, with volume groups above 500 showing an RMSE of around 40%, below the target curve.

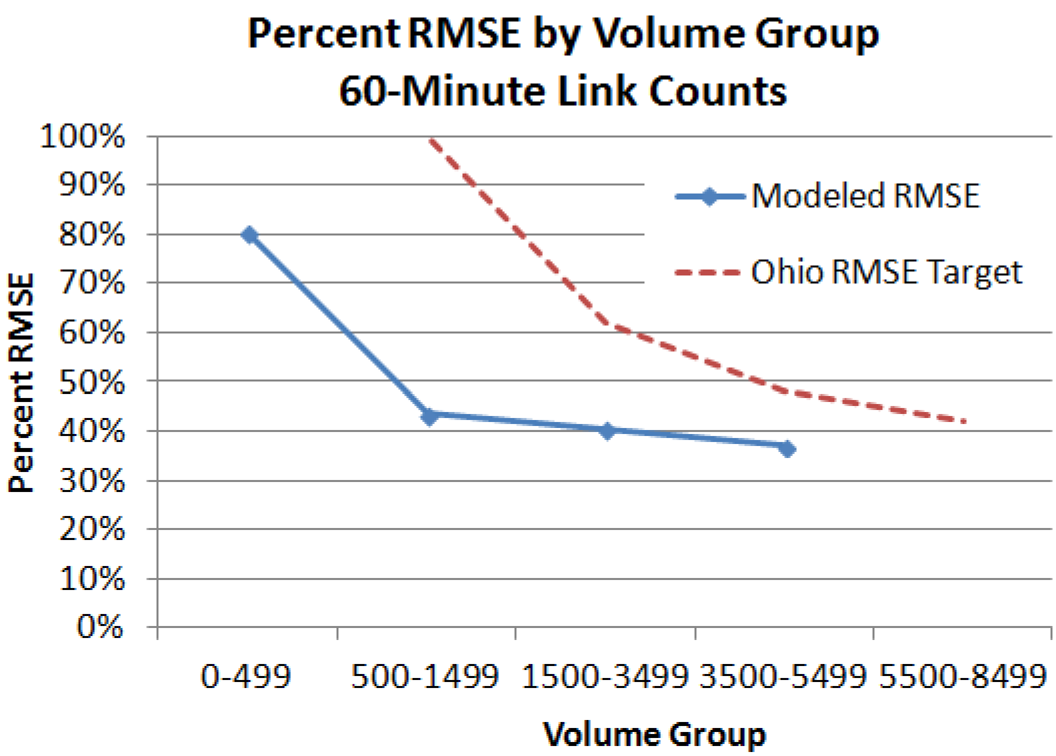

Figure 5 RMSE by Volume Group

Figure 6 and Figure 7 are two scatter plots produced which compare the modeled and observed volumes for both links and movements. These comparisons are made for 60-minute volumes. The yellow lines show the Caltrans targets for maximum desirable deviation, and the black lines show a linear curve fit through the data. Overall, 65% of links and 47% of movements fall within the maximum desirable deviation. The lower volume groups appear to show bigger deviations, though. Limiting the sample to arterials shows that 76% of major arterials and 77% of minor arterials fall within the maximum desirable deviation, exceeding the 75% target.

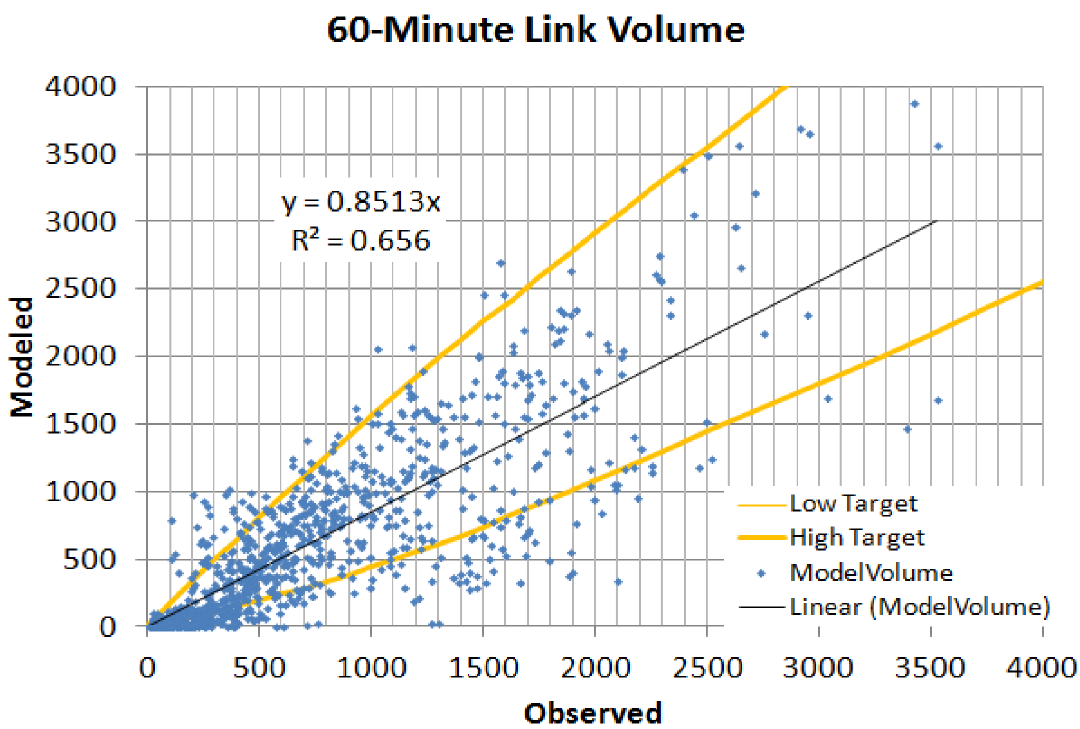

Figure 6. 60-Minute Observed vs. Modeled Link Volumes

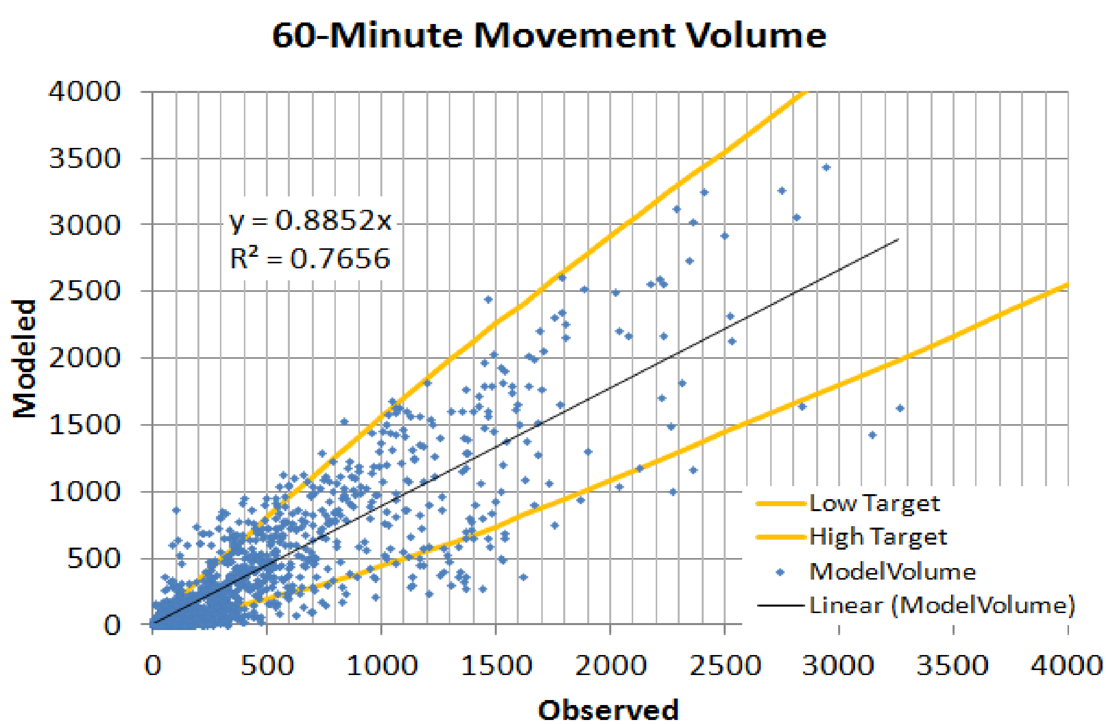

Figure 7. 60-Minute Observed vs. Modeled Movement Volumes

In addition to overall observed trends, we also examined differences across time of day, turn type, and facility type to determine if there are specific links or movements that are worse than others with regard to matching observed volumes. The other comparison tables and graphs (Turn Type, Facility Type, Free-Flow Speed, Number of Lanes, and Street Name) are produced in the same format as the time of day tables and provide various insights for us to use in the calibration process. These do not show any clear trends that could be readily corrected.

3.4 Speeds

In addition to link and movement volumes, we also have observed route travel times for some areas in the network. These can be processed and compared to the simulated travel times to provide another measure for validation. Figure 8 shows a scatterplot of observed vs. modeled route travel times for one of the calibration tests. There is a general trend toward modeled speeds being slightly lower (and travel times, therefore, slightly higher) than observed. It should be noted that the result is driven, by a handful of outliers.

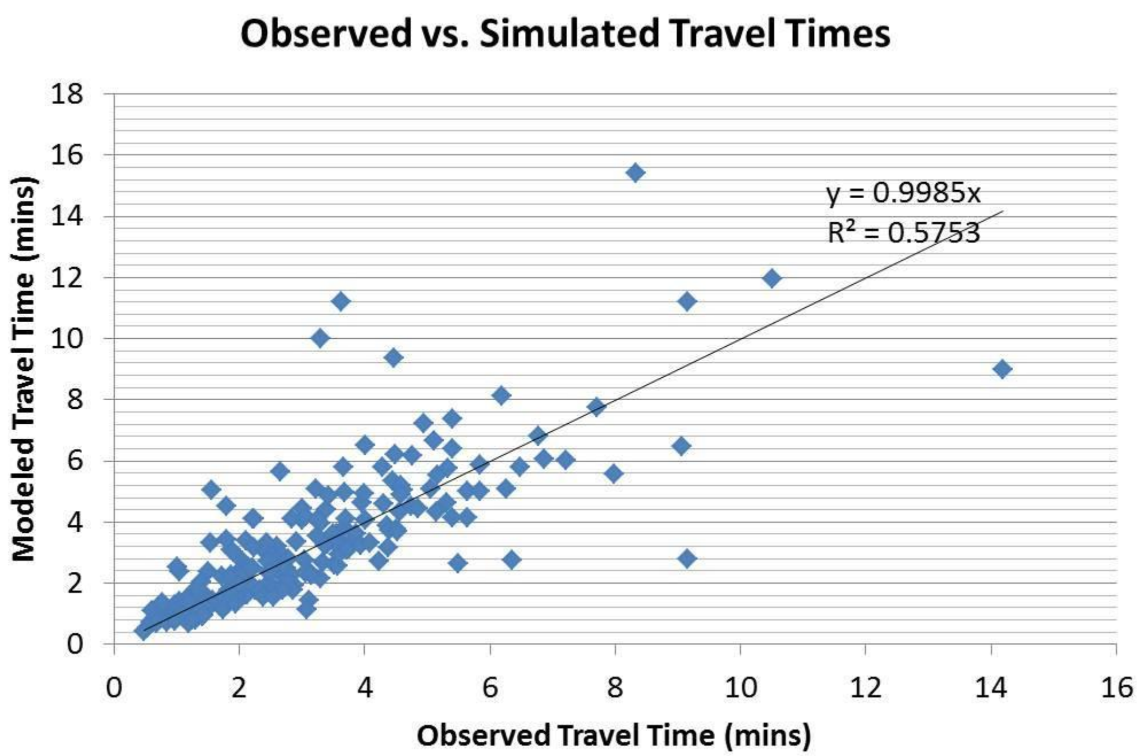

Figure 8. Observed vs. Modeled Travel Times

The outliers that are three or more minutes faster than observed travel times include:

- Montgomery from Broadway to Bush St
- Howard from The Embarcadero to South Van Ness Ave
- 3rd from Berry St to Market St

All three of these routes that are too fast are in the downtown area. The outliers that are three or more minutes slower than observed travel times include:

- 10th from Market St to Brannan St
- San Jose from 29th St to Randall St
- Portola from Burnett Ave to Vicente St
- 4th from Harrison to Channel
- Mission from Cesar Chavez St to Ocean Ave
- 19th from Sloat Blvd to Junipero Serra Blvd

Several of these routes include approaches to freeway on ramps. It is possible that the model is over-predicting the queuing at freeway ramp entrances. These travel time differences should be investigated in more detail prior to applications focused in these locations.

Table 2 demonstrates the differences in modeled and observed travel times by geographic area. This clearly shows that the greatest discrepancies in modeled and observed travel time are in the SE and SW regions, while the downtown area is closer to the observed travel times.

Table 2. Simulated to Observed Travel Times by Quadrant

Route Area	# Counts	Observed (mins)	Modeled (mins)	Difference	Percent Difference	RMSE	Percent RMSE
NE	119	3.1206	3.0292	-0.0914	-3%	1.3819	44%
NW	28	2.9738	3.0712	0.0974	3%	0.8661	29%
SE	31	3.1508	3.6194	0.4686	15%	1.6260	52%
SW	24	3.3550	4.3801	1.0251	31%	2.0964	62%
Total	**203**	**3.1501**	**3.5250**	**0.3749**	**12%**	**1.4694**	**47%**

3.5 Visual Inspection

As a basic check of the flows for the network as a whole, we compared bandwidth maps of the DTA results to equivalent output from SFCTA's static model. Figure 9 shows this comparison. The map on the left shows the results of a DTA assignment, while the results on the right show the static assignment.

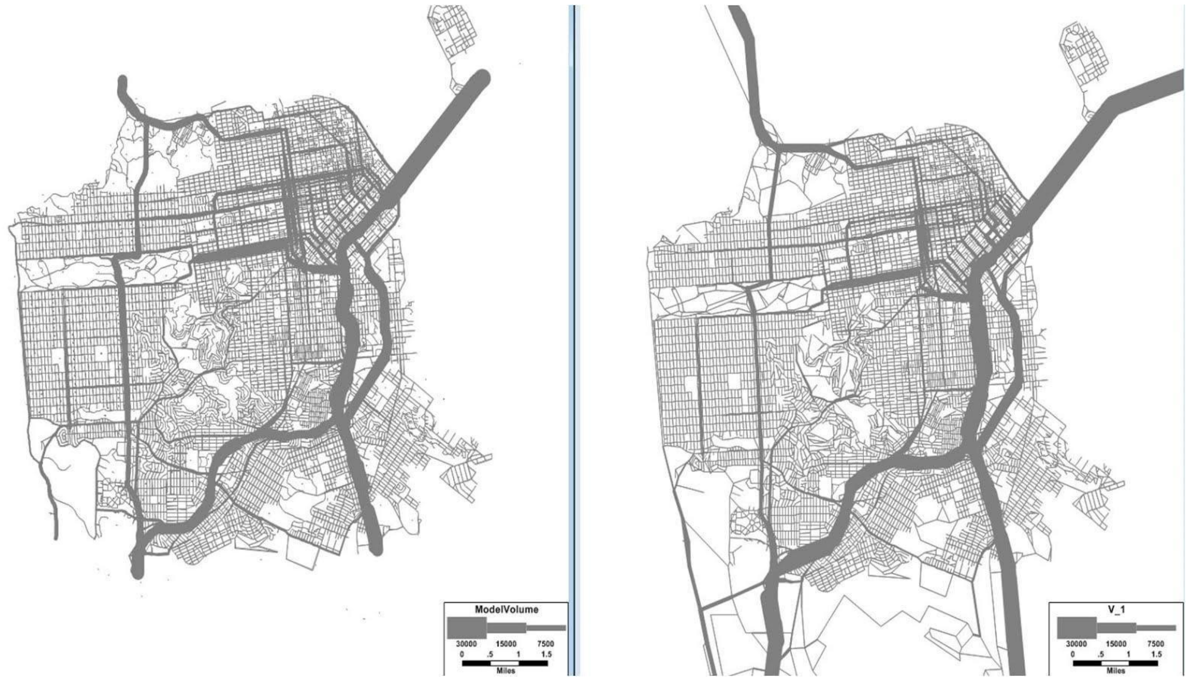

Figure 9. Flow Maps of DTA (left) and Static (right) models

We cannot assume that the static model is necessarily correct, but it does provide a more complete picture of travel than counts, and provides an additional tool for understanding the results. We were able to make some important observations from comparing these two maps. First, we can see that the DTA model has the same overall pattern of flows as the static model. We are also able to identify specific major arterials where the static model has more flow than the DTA model. A few of these that we identified this way in earlier tests are Sunset Blvd, Geary Blvd West of Park Presidio Blvd, and Market St. West of Octavia Blvd. This information provided us with direction for further investigation in those corridors, and was the basis for our introduction of a generalized cost penalty on locals and collectors. As shown in Figure 9, those corridors now have nearly as much as or more flow than the static test.

3.6 Recommendations for Project Applications

The validation results presented here show the DTA model produces reasonable results compared to observed counts and speeds. Therefore, we believe it to be valid for project applications. There remains room for improvement, however, and we recommend more detailed validation for major applications, such as large corridor studies. A project-level validation is expected to involve:

- Collecting detailed turning movement counts in the corridor of interest, and validating the model against those counts.
- Locating centroid connectors to feed the street network at the location of major driveways or parking lots.
- Identifying and accounting for special conditions in the corridor that may affect traffic operations, such as narrow lane widths, the presence of heavy pedestrian movements, or aggressive drive behavior in merge/weave sections.
- Evaluating modeled lane queues against observed queues.
- Making appropriate model adjustments to better match ground conditions.

The level of detail involved in a project-level validation is beyond what can be reasonably accomplished for the city as a whole, but several of these details can make a important difference to model results in a specific location.

To facilitate this project-level validation, DTA Anyway includes scripts to generate corridor plots showing the link volumes and speeds throughout a corridor, as well as the left and right turns onto and off of the corridor. Figure 10 shows an example of this set of outputs for 19th Ave from Fulton St. to Lake St. We can see that there are some fluctuations in both volume and speed along this corridor, but the volume decreases as the road approaches Geary Blvd. Figure 11 shows a similar plot for Harrison St from 4th St to 8th St. This corridor has significant fluctuations in speed and flow as it crosses many freeway approaches. Additionally, this corridor has some movement counts shown as dots which can be used to compare modeled movement volumes to expected movement volumes in this area.

These plots were produced for about 200 segments, corresponding to the corridors analyzed in the Authority's congestion management program. They can be used as a visual mechanism to identify volume or speed changes that violate our expectations and warrant further investigation.

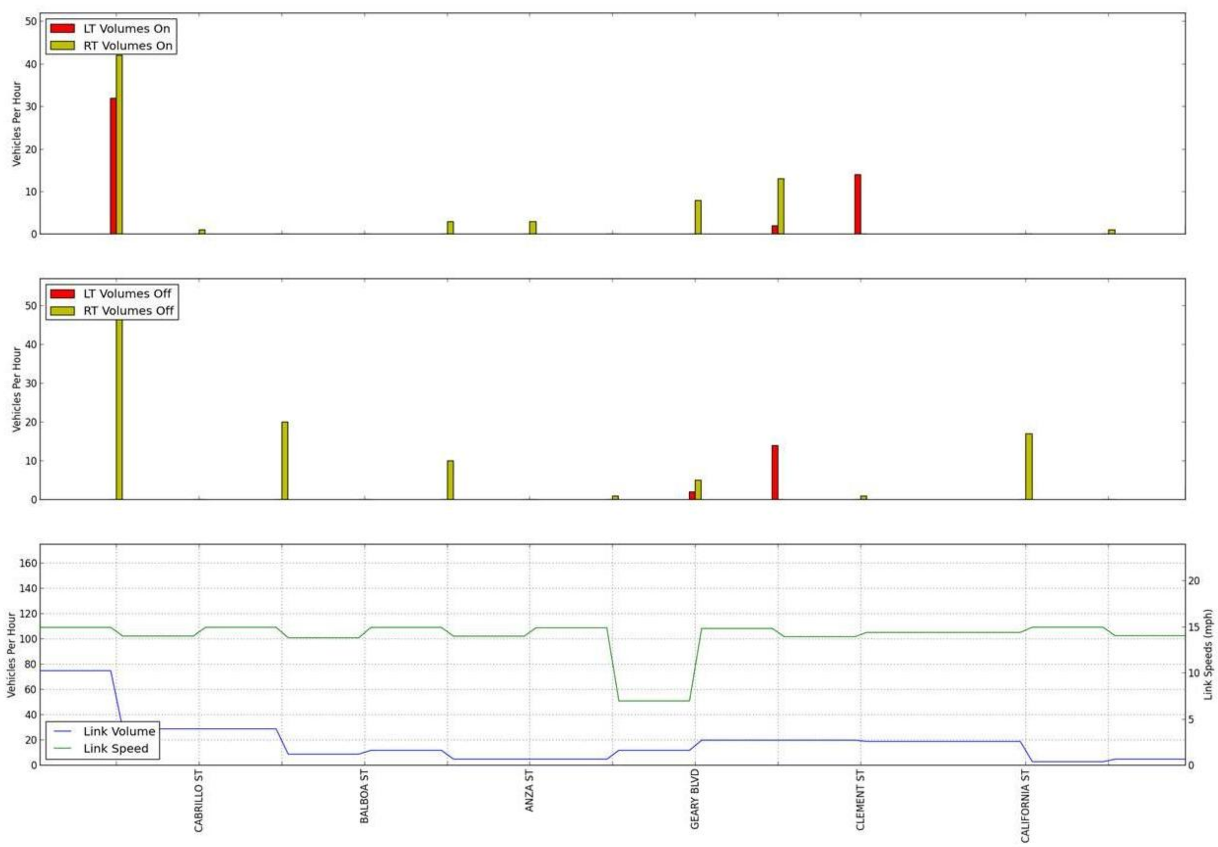

Figure 10. Corridor Plot of 19th Ave from Fulton St. to Lake St

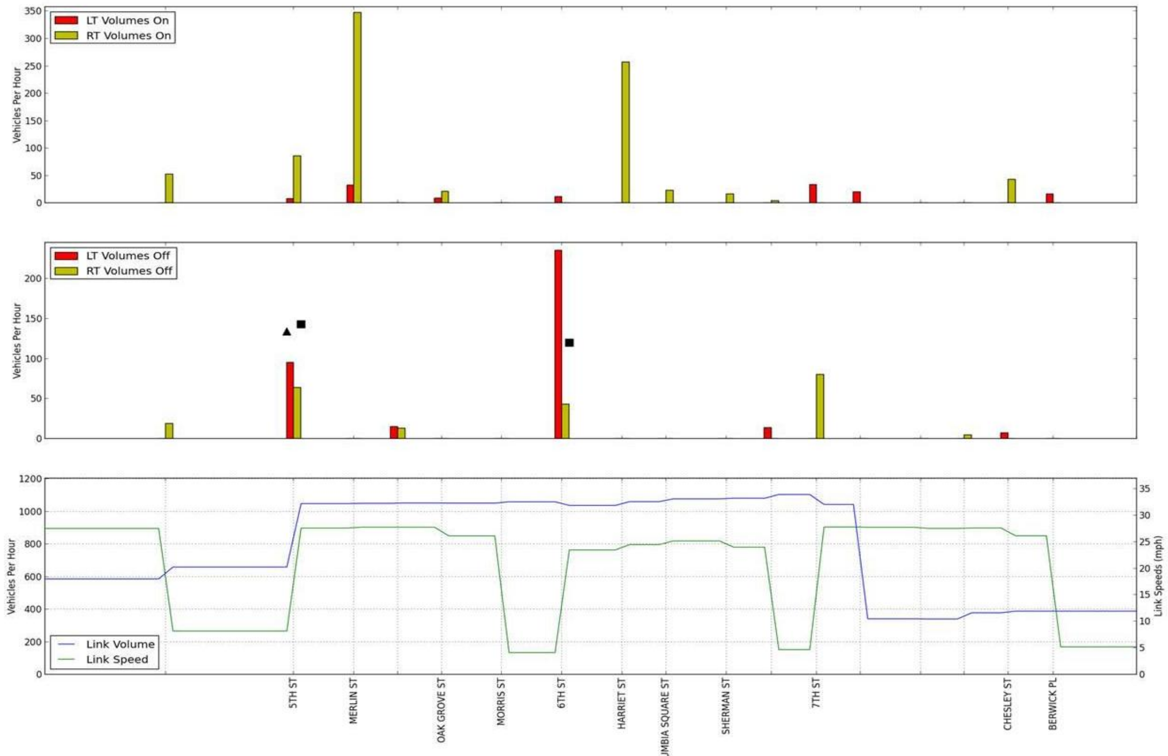

Figure 11. Corridor Plot of Harrison St from 4th St to 8th St

4. Sensitivity Testing and Model Application

In addition to ensuring that they provide reasonable results for a single scenario, we must test the final settings to ensure that they have an acceptable level of sensitivity to the types of changes that we may encounter in applications testing. These include altering the traffic flow parameters, different types of network changes, and different demand. Additionally, we need to be sure that the model results will not change drastically if we alter parameters such as the random seed value used in the DTA specifications. These tests allow us to ensure that the model results will not fluctuate greatly when they should not (i.e. a small network change) but that the model is sensitive enough to demonstrate expected results with larger changes (i.e. major network changes or future demand levels).

It is important to see this level of stability in both the model volumes and travel times. Many of the applications test that these models are used for will consider travel time savings as a measure of how much the network improves with that change. If travel times fluctuate dramatically with even small network changes, the results of the applications tests may not provide reliable measures of travel time changes. This type of testing can demonstrate problems with the network or DTA settings which may call into question the validity of applications tests. If, however, the sensitivity tests demonstrate reasonable results, it lends additional credibility to the results of the applications test done based on these settings.

4.1 Traffic Flow Parameters

Numerous DTA model runs were conducted to test the effects of altering traffic flow parameters in Dynameq. The parameters that were tested include vehicle characteristics, link free-flow speeds, response times, jam density (in passenger car equivalent units), gap acceptance, follow-up time for turning movements, and generalized cost expressions.

The effective passenger car vehicle length applied in the final calibration model is 21 feet. Sensitivity runs also tested the use of effective passenger vehicle lengths of 18.7 ft, 20 ft, 20.5 ft, 22 ft and 24 ft. These tests show that congestion is highly sensitive to effective vehicle length. A change of as little as 0.5 to 1 ft can make the difference between light and heavy congestion in San Francisco's CBD. Preventing a gridlocked assignment required reducing passenger car effective vehicle length from an observed value of 24 ft to the final calibration model value of 21 ft.

Sensitivity was also tested for passenger car response times. Response time values for level streets were tested at 1.0 sec, 1.2 sec, and 1.25 sec. Like effective vehicle lengths, higher response time values have a significant impact on traffic congestion in areas with moderate to high traffic volumes. The final calibration model setting of 1.0 sec is somewhat lower than observed values. Other sensitivity tests of traffic flow parameters included 20% and 50% reductions of gap acceptance terms and follow-up times at stop-controlled movements and permitted signalized movements. 20% reductions for either of these parameters are significant enough to clear gridlock from an assignment that would otherwise produce moderate gridlock.

Meanwhile, adding a distance term to the generalized cost expression greatly increased congestion; possibly by encouraging vehicles to choose direct paths through more congested areas rather than diverting around congestion.

The parameters applied in model runs designed to test traffic flow parameters are documented in detail in Appendix B.

4.2 Random Seed

The random seed is one of the DTA settings that can be adjusted to introduce more or less randomness into the model. As the random seed is changed, the results should change, but not by much. These tests were performed to confirm that adjusting the random seed, starting at 1.0 and testing 2.0, had a minor effect on the results.

The random seed changes the demand loading in two ways. First, the bucket rounding process is changed so that the assigned 15-minute matrices are slightly different between tests. Second, the model introduces randomness into when those trips are loaded onto the network. Even if the same 15-minute integer matrices are used, the random seed values would induce slight changes in which trips are loaded in each six-second departure time window within that 15 minutes. In smaller networks this may not have a large effect on results, but in a large network like the San Francisco network, the random seed values result in an observable change to the volumes and travel times. Figure 12 shows the convergence graph for this test. This test appears to have achieved a stable convergence.

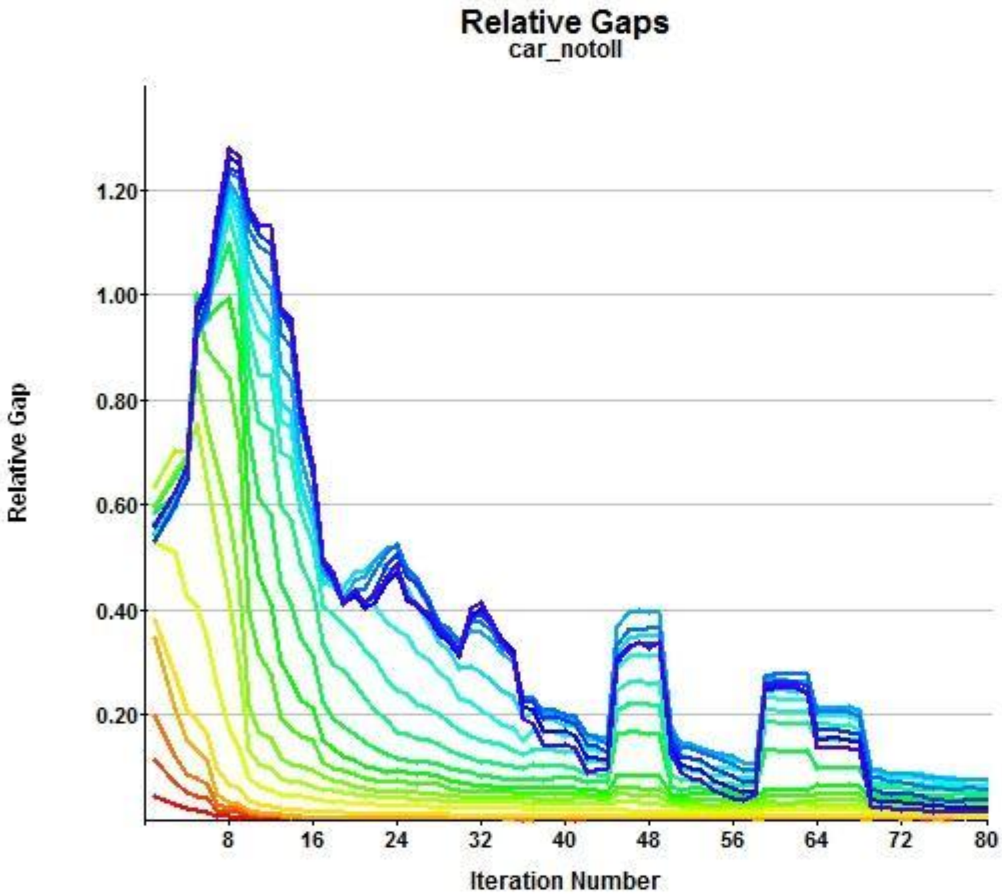

Figure 12. Convergence Graph for Random Seed Sensitivity Test

Figure 13 shows the network-wide changes in flow during the 5pm to 6pm hour that result from changing the random number seed, while Figure 14 is a closer look at the impacts in the CBD. The red links are those that experienced a decrease in flow of at least 100 vehicles, and the blue links are those where flow increased by at least 100 vehicles. These changes in general were small, with the largest change in flow of 610 vehicles on I-80 EB where there looks to be a tradeoff between I-80 and the surface streets. As expected, while there are small changes throughout the network, the largest flow changes are in the CBD and on freeways that feed the CBD. These are the most congested areas in the base test, so changing the trip tables with a new random seed value would be expected to have a greater impact in that region.

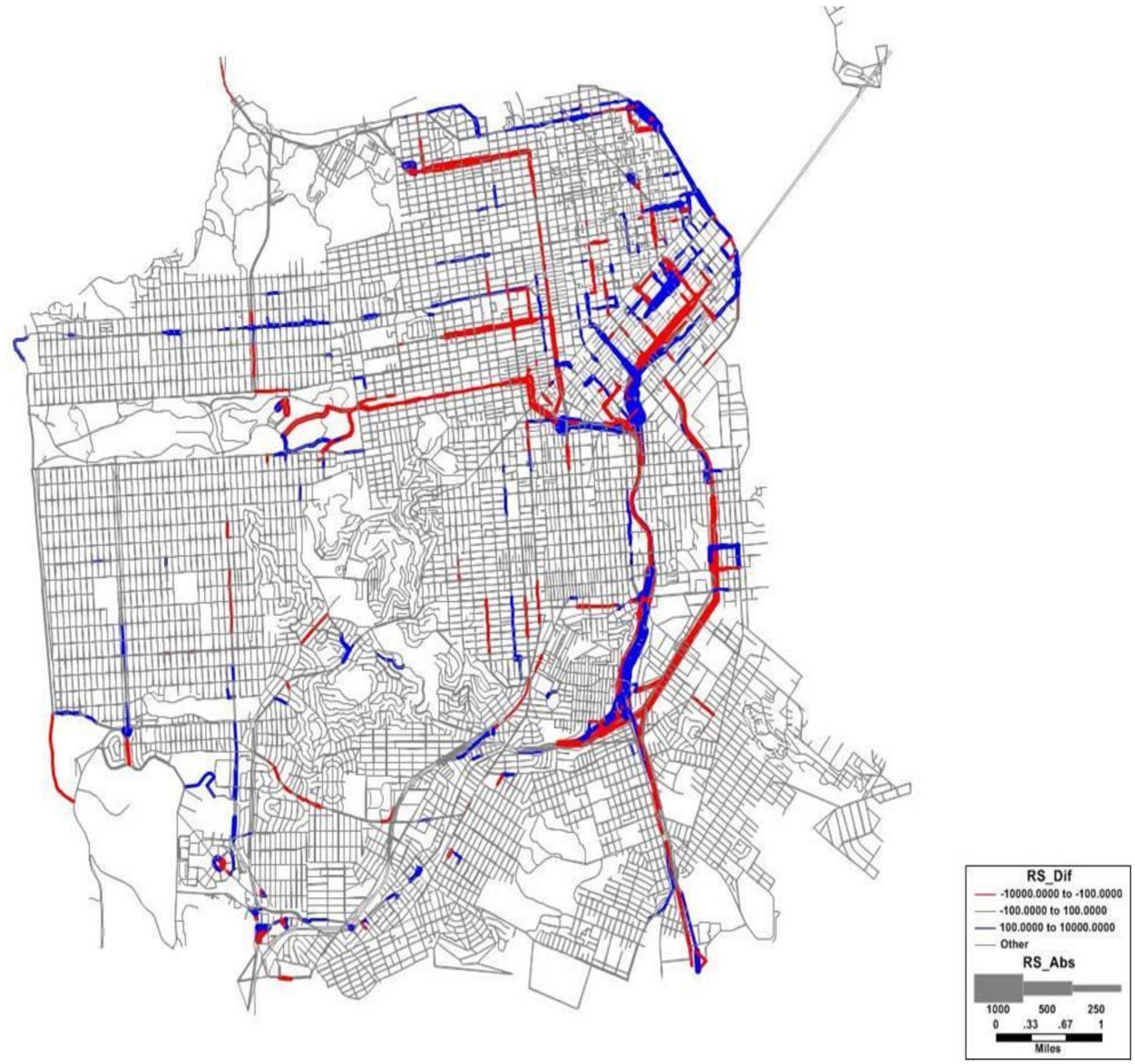

Figure 13. Flow Difference Map from 5:00 to 6:00 pm for Random Seed Test (Red links- decrease of at least 100 vehicles, Blue links - increase of at least 100 vehicles)

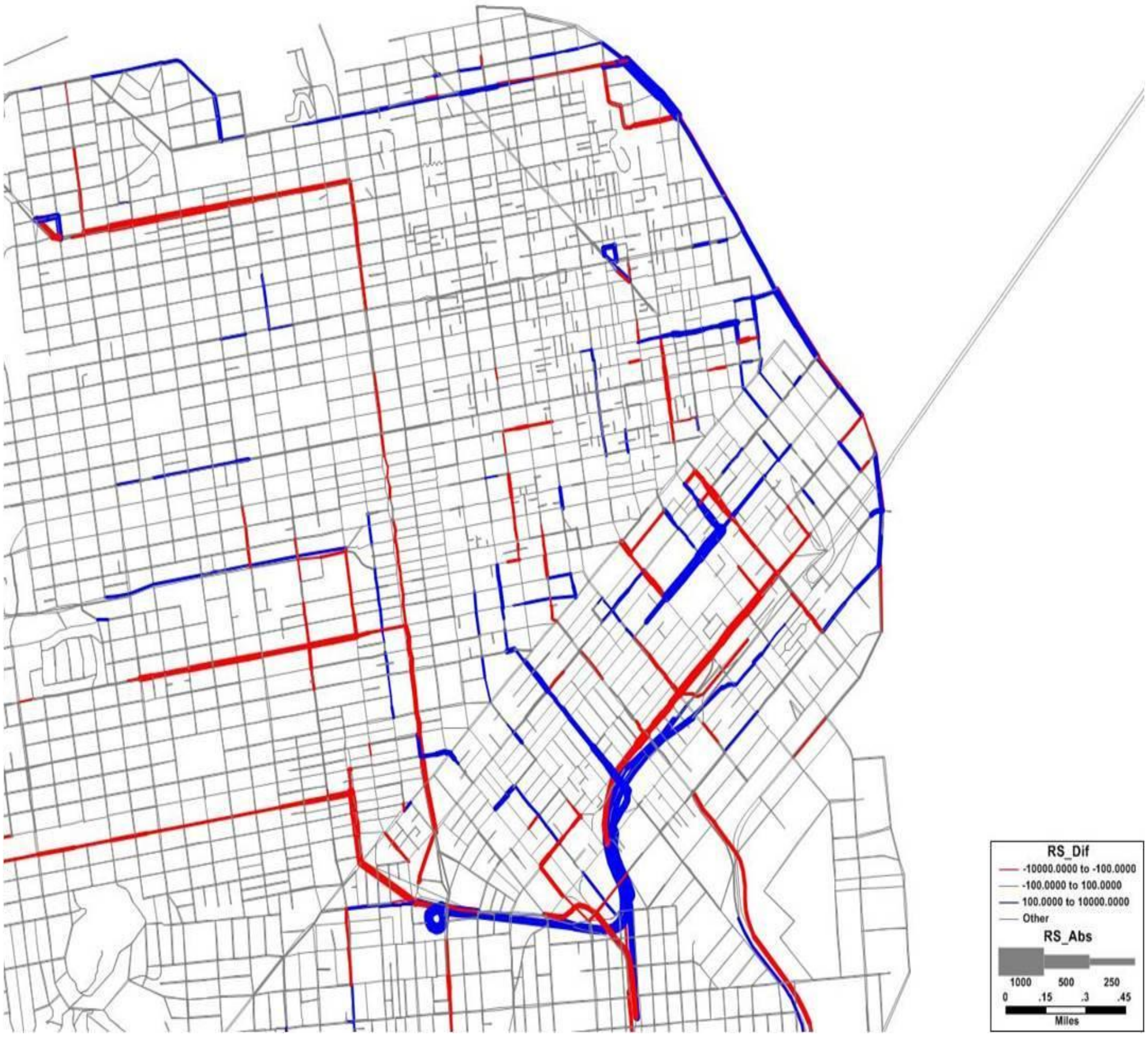

Figure 14. Flow Difference Map from 5:00 to 6:00 pm in CBD for Random Seed Test (Red links- decrease of at least 100 vehicles, Blue links - increase of at least 100 vehicles)

Figure 15 shows the change in speed resulting from the random seed test. Links in blue are those with an increase in speed of at least five mph and those in red had speed decreases of at least five mph. The regions with larger changes in speed generally correspond to the congested areas that also see large changes in volume, especially freeways in the Eastern portion of the network.

Figure 15. Speed Difference Map for Random Seed Test (Red links - decrease of at least 5 mph, Blue links - increase of at least 5 mph)

Both the volume and speed comparisons indicate that there is some measure of randomness in these results that we are unable to account for. It is possible that the size of the network and the high level of congestion in some areas of the CBD make this network more sensitive to changes in the random seed values. Additional testing is warranted to isolate where the impacts of the random seed are seen. The stochasticity is introduced both in the bucket rounding procedures that produce integerized 15-minute demand matrices and in the way that the demand is loaded within those 15 minutes. If additional random seed tests show similar results, calibration and applications test could both be run for multiple values of the random seed. The average of the results across all random seed tests would provide a more stable measure of the true impacts of the network changes and other applications.

4.3 Network Change

The network change sensitivity test performed was to remove one lane in each direction from Sunset Blvd from Ortega St to Taraval St. Based on previous results, it was clear that the current traffic levels on Sunset Blvd are low enough that removing a lane in each direction should not result in any additional congestion. The network change is expected to have much less impact than the applications tests since the change is a small alteration to an uncongested portion of the network.

Figure 16 shows the convergence graph for this test. The convergence is similar to that seen in the base scenario, with some additional instability around 72 iterations that settles by the end of the simulation at 80 iterations.

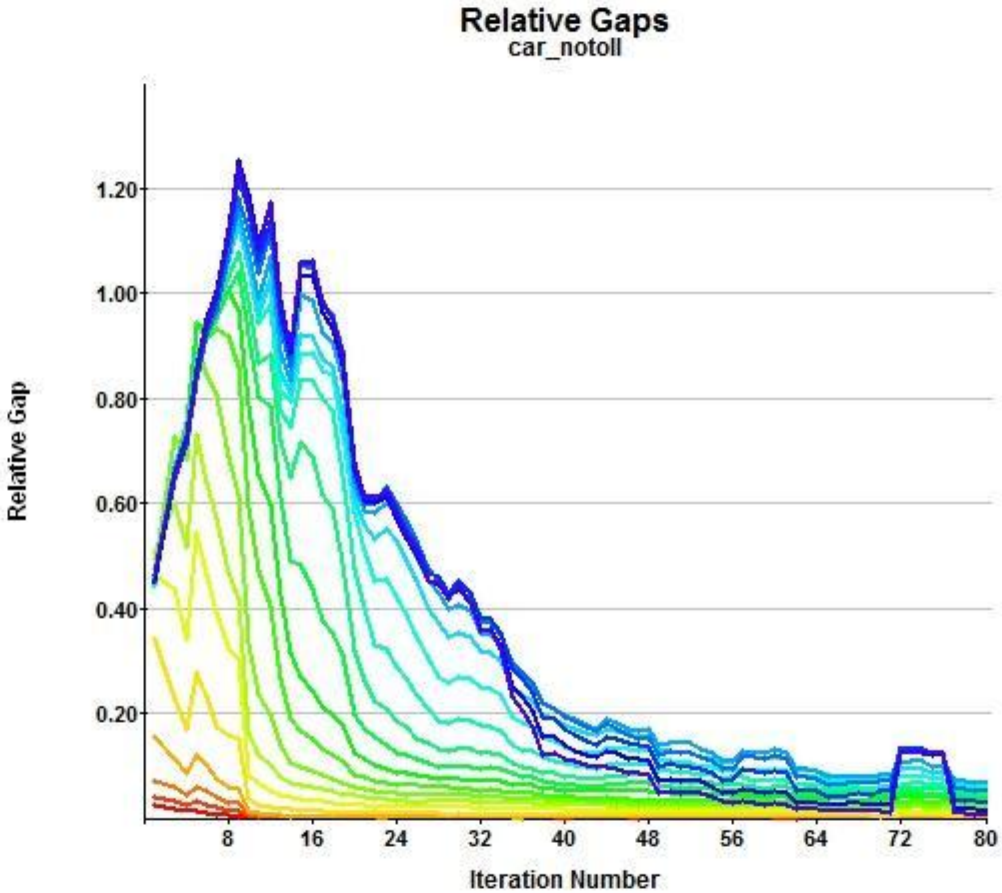

Figure 16. Convergence Graph for Small Network Change Sensitivity Test

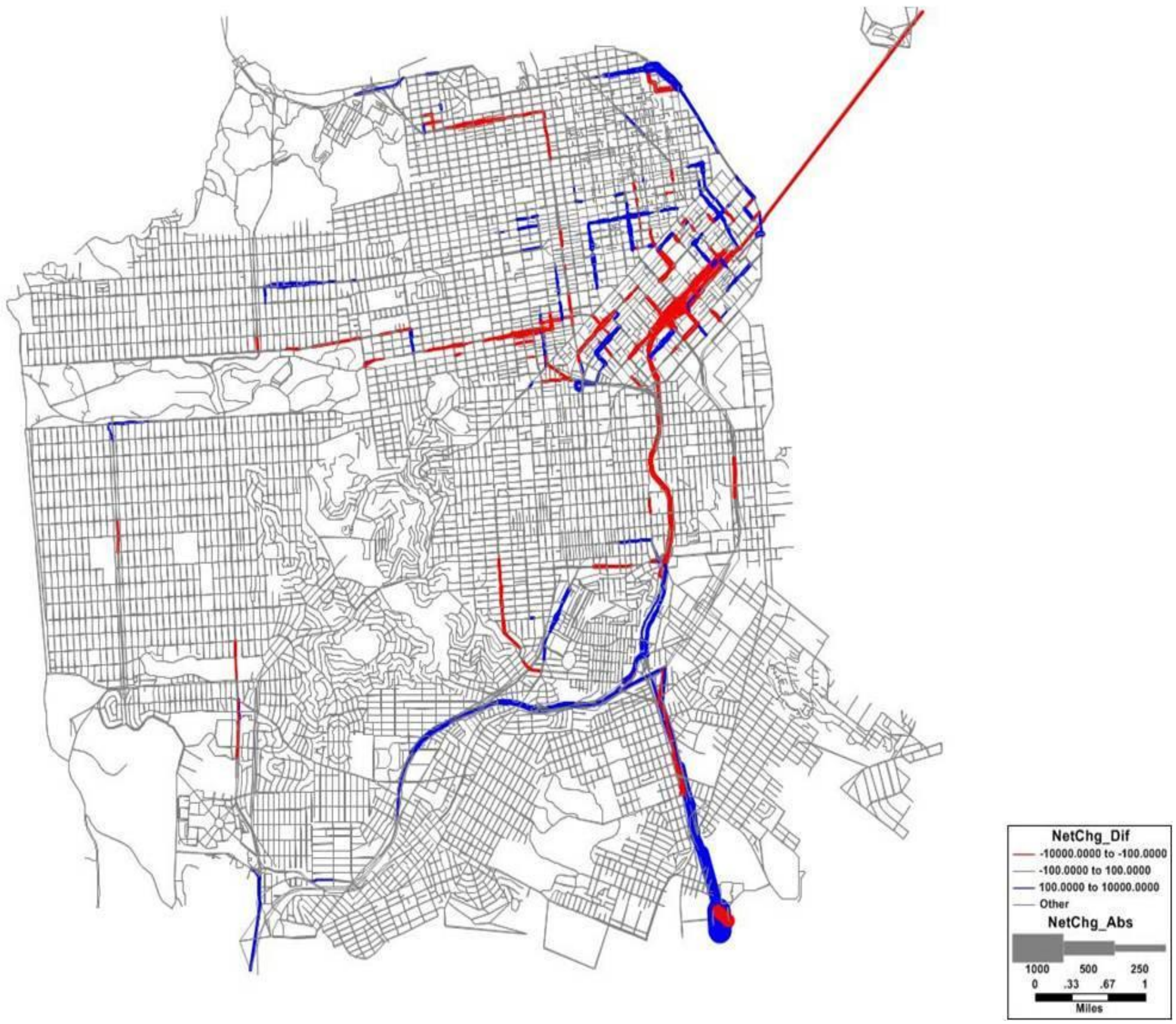

Figure 17. Flow Difference Map from 5:00 pm to 6:00 pm for Small Network Change (Red links- decrease of at least 100 vehicles, Blue links - increase of at least 100 vehicles)

Figure 17 shows a map of the flow changes throughout the network during the 5pm to 6pm hour. Red links indicate a decrease in flow of at least 100 vehicles while blue links are those where flow increased relative to the final calibration test by at least 100 vehicles. Although the only change to any of the inputs or settings was the removal of the lanes on Sunset Blvd, there are some impacts throughout the network. While the location of the flow changes was widespread, the magnitude of those changes was much relatively small, generally less than 300 vehicles, with the largest change of approximately 900 vehicles at a network entry point. The larger changes were primarily seen around centroid connectors and at network entry locations.

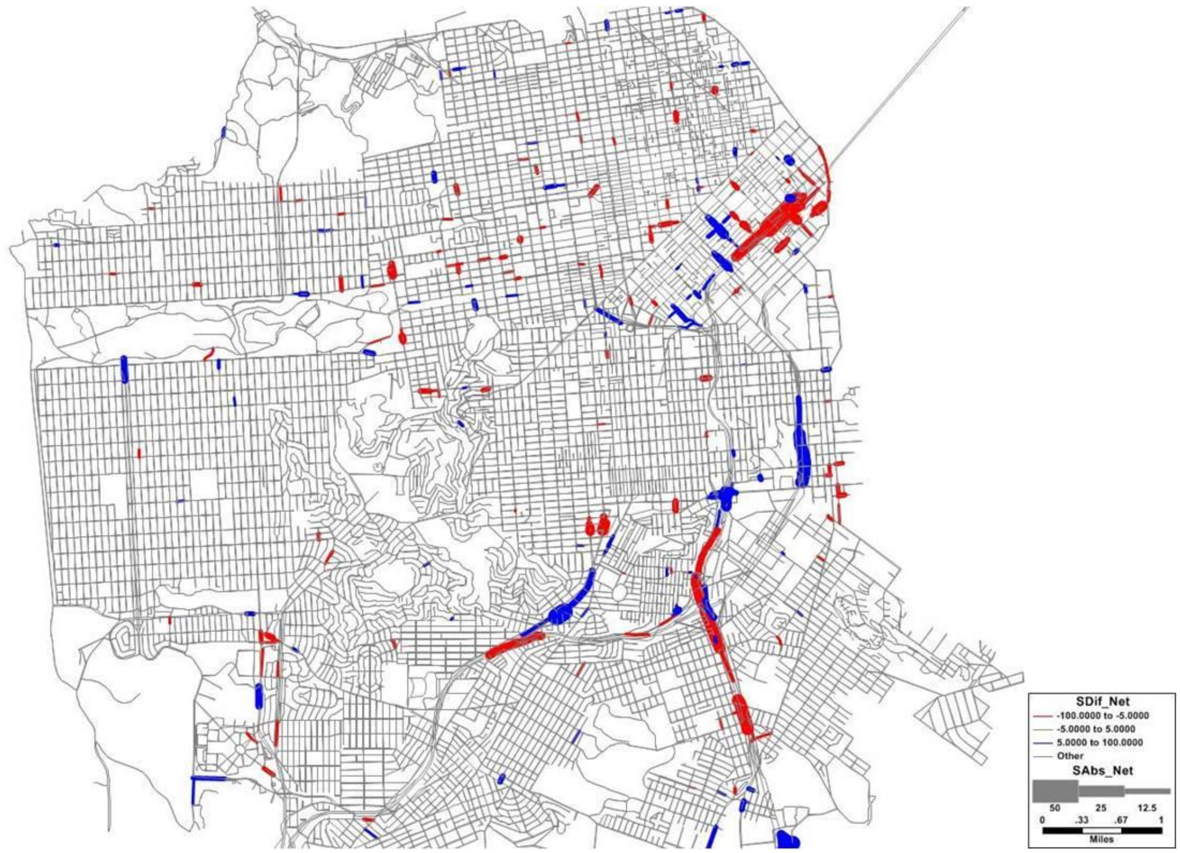

Figure 18. Speed Difference Map for Small Network Change (Red links - decrease of at least 5 mph, Blue links - increase of at least 5 mph)

Figure 18 shows a map of the difference in speeds with links that showed an increase of more than 5 mph shown in blue and those with a decrease of more than 5 mph in red. Comparing Figure 17 and Figure 18 would indicate that some regions that saw changes in flow did see large changes in speed. This is especially true on the freeways in the southern region. The volume changes in the CBD, however, did not generally correspond to a shift of more than five mph in the average speed, indicating that the existing congestion levels were either too low or too high to register a change in speed as a result of the volume changes.

There are, however, some links in the downtown region that has large changes in both volumes and travel times such as Brannan near The Embarcadero. This result may indicate a higher level of volatility in this region such that even a relatively small change in volume causes a large change in speed, causing re-routing for paths that use that link.

The network wide VMT and VHT are shown in Table 3. The VMT measure is very stable between these two runs, but there is some difference in VHT due to the travel time changes.

Table 3. VMT and VHT Differences

Route Area	Final Validation	Network Change	% Change
VMT (miles)	1,701,490	1,701,676	0.01%
VHT (hours)	83,919	85,021	1.31%
VMT/VHT (mph)	20.3	20.0	-1.29%

While the network differences observed in this test are modest, they warrant further investigation to better understand their drivers. Possible explanations include:

- These differences arise due to the simulation noise, as discussed above in the random number seed test. Options to mitigate this issue are to implement tighter control of the bucket rounding process or to run multiple simulations and average the results.
- These differences arise because of convergence noise. While both scenarios appear to be well converged, it is possible that running additional iterations to achieve a smaller relative gap will further stabilize the results.
- Some of these links could have multiple equilibria. This possibility can be investigated along with the previous topics.

A recommended future research topic is to further explore the primary drivers of this noise and recommend strategies to further stabilize the results across scenarios. It should be noted as well, that for testing a larger project, this level of noise is likely to be small in comparison to the project differences.

4.4 Future Demand

The future demand sensitivity test allows us to determine how the network would respond in its current condition to a 2040 demand level. While this test did eventually clear all traffic during the simulation period, it showed very high levels of congestion throughout the CBD and the major freeways. This result is expected since the existing demand results in high congestion levels. The 2040 demand increased the total number of car trips by 112,026 trips during the five-hour demand simulation period (2:30 - 7:30 pm).

Figure 19 shows the convergence graph for this test. After 130 iterations, this test was still not tightly converged. These results provide a basic comparison of flows and speeds, but it is clear that the 2040 demand levels overload this network, preventing it from cleanly converging.

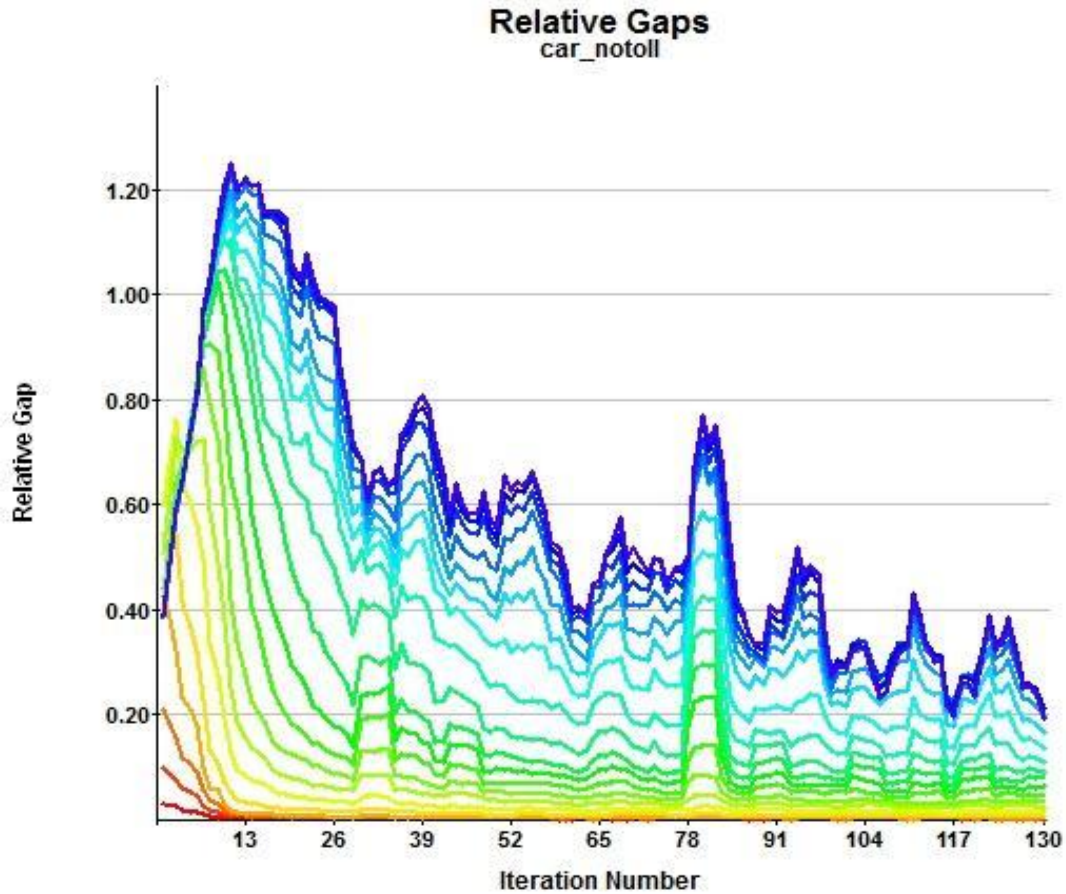

Figure 19. Convergence Graph for Future Demand Sensitivity Test

Figure 20 and Figure 21 show the flow differences during the 5:00 - 6:00 pm period resulting from using the 2040 demand tables. The blue links are those with a flow increase of at least 100 vehicles, and the red links are those with a flow decrease of at least 100 vehicles. While many links appear to have a decrease in flow, this does not indicate a light traffic on those links. Instead, as the congestion increases to the point of gridlock, the outflow and inflow on those links becomes very low. Since these maps show a comparison of flow levels, they show a decrease in flow on those highly congested links, a very different result than a static assignment model would show.

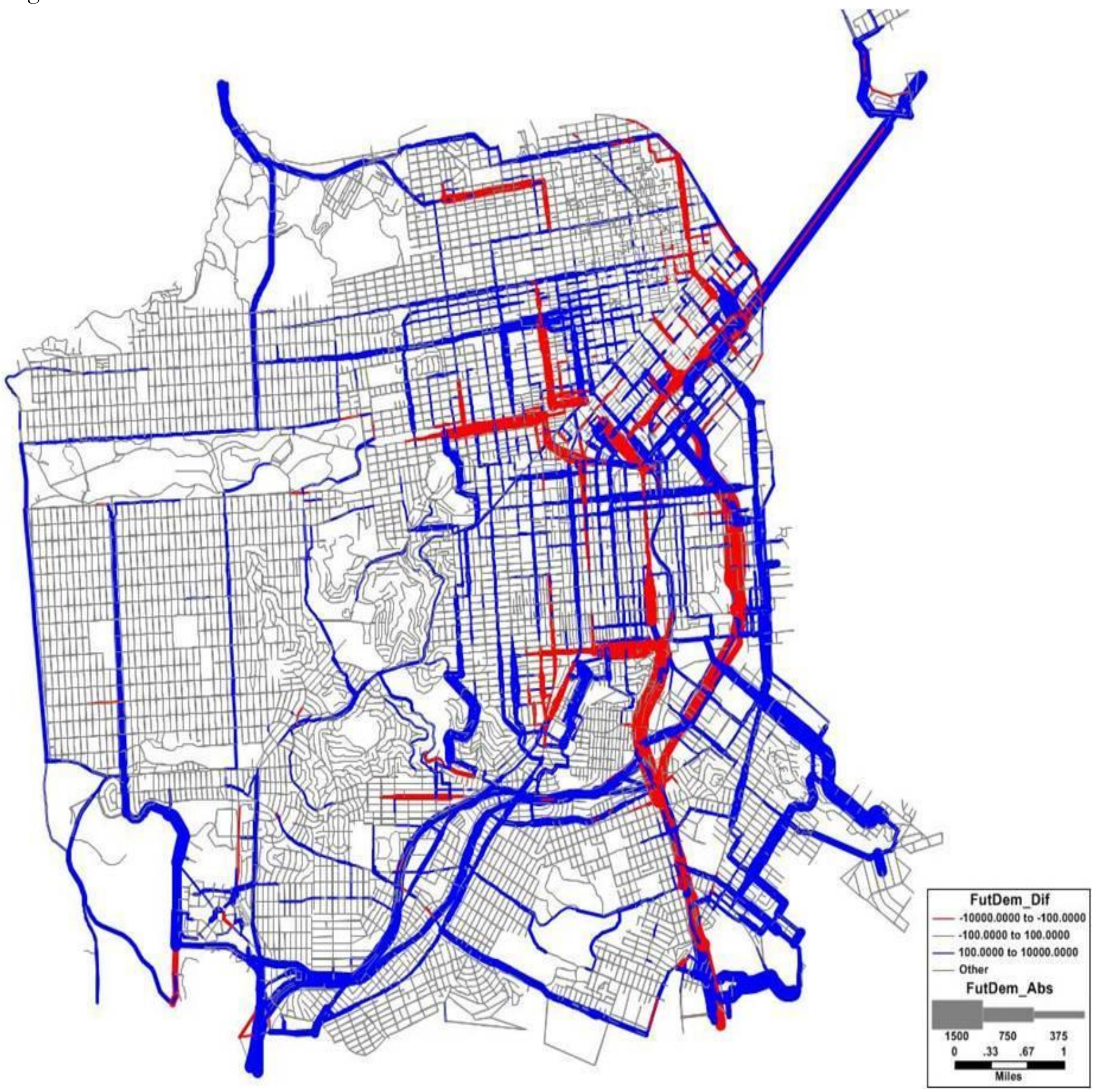

Figure 20. Flow Difference Map from 5:00 to 6:00 pm for 2040 Demand Test (Red links- decrease of at least 100 vehicles, Blue links - increase of at least 100 vehicles)

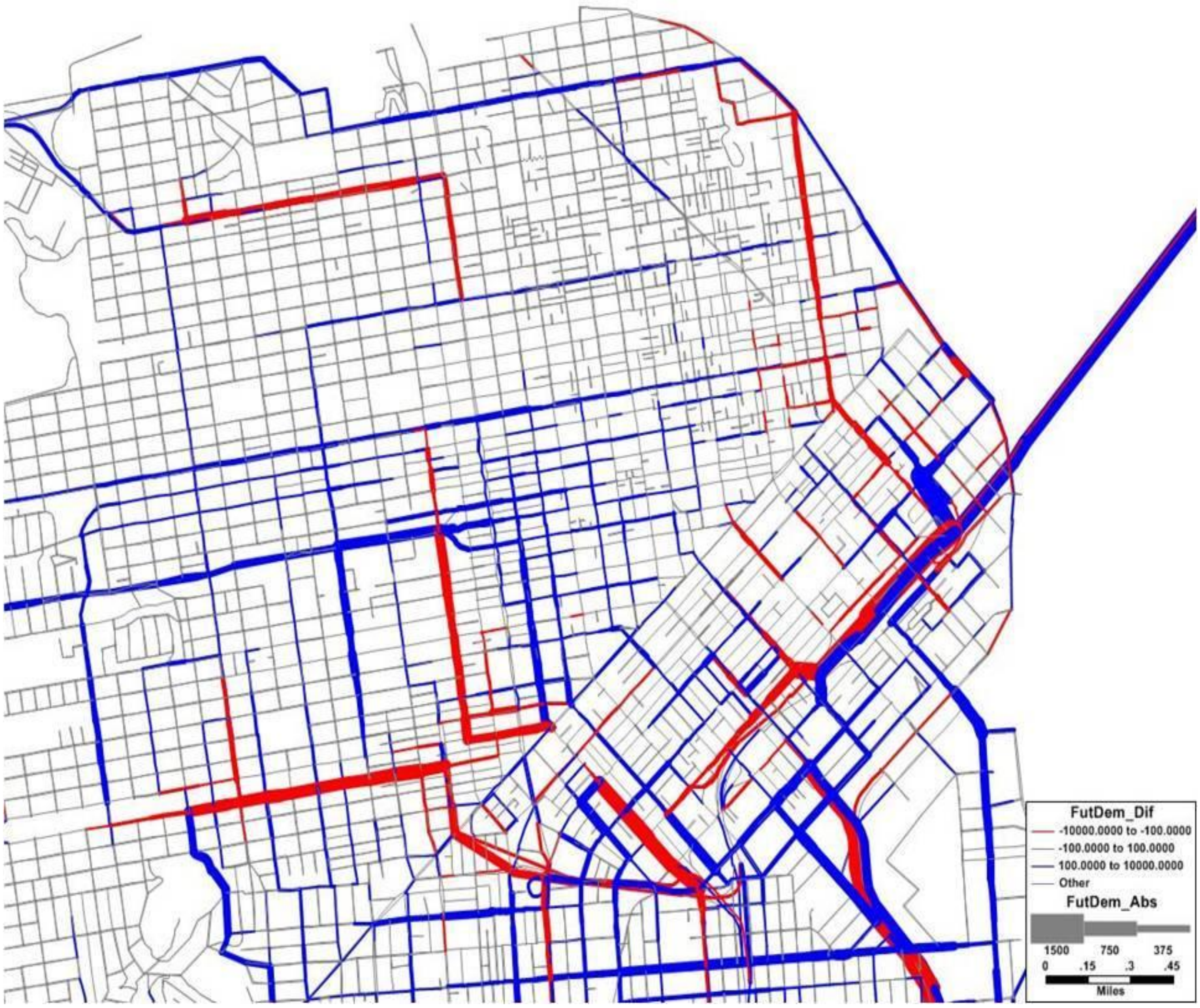

Figure 21. Flow Difference Map from 5:00 to 6:00 pm in CBD for 2040 Demand Test (Red links- decrease of at least 100 vehicles, Blue links - increase of at least 100 vehicles)

Figure 22 maps the change in speed in the 2040 demand scenario, with blue links representing a speed increase of at least 5 mph and red links a speed decrease of at least 5 mph. The speed comparison shows that many of the areas which seem to have a decrease in flow are in fact highly congested, with a large decrease in speed (and increase in travel time). This behavior is expected and illustrates one issue with using VMT and VHT values in comparing highly congested scenarios to a baseline scenario in a DTA model. The volumes, calculated based on the flows, may appear to decrease when the congestion and travel times are greatly increasing.

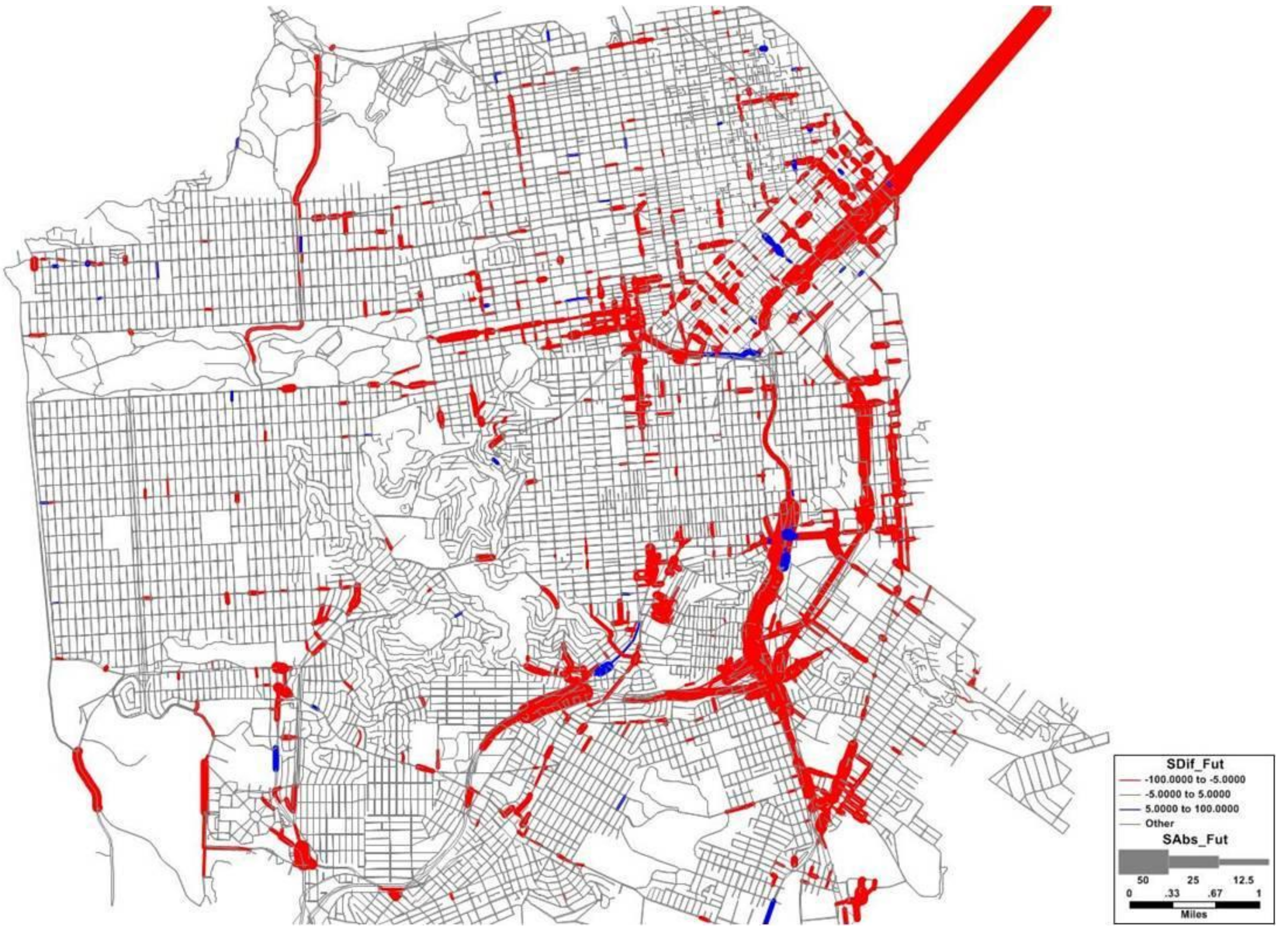

Figure 22. Speed Difference Map for 2040 Demand (Red links - decrease of at least 5 mph, Blue links - increase of at least 5 mph)

In addition to the finding that 2040 demand levels will cause high levels of congestion and gridlock in the CBD during the PM peak hour if no network changes are made, some additional observations may be made about these results. First, this test confirms that the SF-CHAMP procedure can generate a future-year demand level and that the DTA procedures can process and use those demands as inputs. More importantly, it is clear that the integration of the DTA network modeling and SF-CHAMP demand modeling procedures is important for accurate planning procedures. While the static modeling procedures allow for very high levels of congestion, the DTA models recognize that as traffic levels increase past the jam density, traffic behaves very differently. In planning and estimating demand, the additional travel times, queuing and gridlock created by these conditions should be accounted for and would likely change the mode and departure time choices being made.

4.5 Model Applications

We conducted two test model applications to see how the model performs under real-life sensitivity situations.

The first application tested the implementation of bus rapid transit along the Mission Street Corridor in the Mission District. The second application tested the implementation of a cordon-based congestion fee of three dollars that would be levied on all vehicles entering or leaving the northeast core part of San Francisco during peak hours. While these are not official policies under consideration by the Authority, these are examples of the types of scenarios that the Authority may want to test and whose sensitivities to diversion in static user equilibrium were found to be unrealistic. The detailed results of these tests are documented in the *Analysis of Applications Report*.

The key finding of the bus rapid transit application is that the DTA model predicts more traffic diversion than the static model. This occurs because the DTA model is more sensitive to congestion and does not allow volume to exceed capacity. Without the accounting for the impacts of the diversion to other nearby streets, the static model may not provide accurate feedback to the SF-CHAMP demand model on the true expected changes in travel times on some of the adjacent streets.

The second application tested the introduction of a congestion pricing measure, charging a $3 congestion fee to any vehicles entering or leaving the northeast quadrant of San Francisco. This region is delimited by Laguna St to the West, 18th St to the south, and the San Francisco Bay to the north and east.

They key finding of the congestion pricing model is that the DTA model provides more realistic results for both flow and speed changes. The static model predicted flow increases in some regions in the CBD where we would not expect to see them. The DTA model also clearly demonstrates flow increases in alternate paths near the cordon border, while the static model results don't show as large of a flow increase outside of the area region where the fee is charged. This is an important finding because if the static model is being used as feedback in the SF-CHAMP procedures, it may be underestimating the impacts of flow shifts on alternate routes and nearby streets in the area.

4.5 Recommendations for Project Applications

It is recommended that project applications carefully consider the potential for noise in the results due to either stochasticity in the exact departure time of trips or the level of convergence. The magnitude of these issues can be studied systematically, as recommended in the *Future Research Topics Report*. In the meantime, the tests presented in this report provide a baseline for the level of difference that can be expected, allowing the user to evaluate whether the difference due to the proposed project are greater than what is shown here.

5. Conclusions and Next Steps

The model calibration and validation process discussed in this report outline the basic "system-level" calibration of SF-DTA. It has been demonstrated that it is possible to conduct a reasonable system-level validation using trip tables fed directly from a travel demand model, without relying on matrix estimation.

The immediate next steps are to move on to model applications. It is expected that certain applications will warrant a "project-level" validation in which the model calibration is further refined to match volumes and travel times in a specific corridor of interest.

At a system-level, a logical next step to further refine the calibration is to identify origin-destination markets where SF-CHAMP is over- or under-estimating vehicle demand, and refine the SF-CHAMP calibration accordingly. In addition, a series of future model enhancements are identified in the accompanying Future Research Topics Report, several of which are expected to improve the model calibration. The steps that could improve the model calibration in the near term include:

- Update the handling of transit-only lanes. An upcoming version of Dynameq is expected to allow movement-specific permissions for each lane, allowing us to directly model the situation where autos are allowed into the transit lanes only if they are turning right.
- Improve the non-motorized representation to make the right turn and left turn capacity explicitly tied to the pedestrian and bicycle volumes.
- Incorporate a robust parking model, such that vehicles drive to the location they are parking at, rather than the location they are ultimately going to.
- Collect truck counts, and improve the truck and commercial vehicle models. Trucks have a disproportionate effect on congestion, but we have limited observations of their volumes and behavior.
- Improve the external geographic representation for trip ends outside San Francisco. This would allow a linkage to the trip records from SF-CHAMP, and allow the time-of-day profiles to be better captured.

A second area of study should focus on further understanding the stability of the model results across scenarios. Small differences were observed in both the random number seed test and the minor network change test. While the project differences observed in both the BRT and the congestion pricing scenarios appear to dominate the noise, it could become an issue for some applications. Therefore, it would be prudent to evaluate what steps can be taken to further stabilize the results, such as running with multiple random number seeds and averaging the results, more tightly controlling the bucket rounding process, or running to an even tighter level of convergence.

These steps should be pursued as resources and priorities allow.

Appendix A: Traffic Flow Parameters Data Collection

The objective of traffic flow parameter data collection is to maximize realism in the DTA model. In order to fulfill this objective, the project team made use of existing traffic data and supplemented these resources with specially designed traffic flow observations. This appendix describes the data sources relied on for traffic flow property estimation and the methodologies used to analyze the data.

Methodological Considerations

Sensor Data

The standard, well known, and widely accepted approach to capture the flow-density relationship on the roadway network is by statistically fitting a curve to observed flow-density data. The data required for this approach can be collected by coupled inductance loop detectors to record lane-by-lane counts and speeds. The time resolution for data aggregation in flow-density curve fitting process is preferred to be as fine as possible (5-10 minute intervals) to decrease the errors in the output. Larger time intervals (<30 minutes) for flow-density data aggregation usually result in noise data points that are generated by the interpolation of two or more different traffic flow states that have been aggregated over the time interval. The same inaccuracies may be generated when the traffic flow data from two or more lanes are aggregated. Adverse weather conditions may also increase the noise in flow-density data

It is also recommended that the collected data cover the whole spectrum of traffic flow states and is not limited to uncongested, free flow traffic states. Roadside construction, accidents, and adverse weather conditions are to be avoided in order to decrease the noise in flow-density data and to improve curve fitting accuracy. The impacts of weather conditions on freeway traffic operations have been studied by a number of researchers in traffic flow theory[6].

Surveys

In the absence of pre-existing flow-density data, another traffic flow engineering technique can be applied to estimate triangular fundamental diagram parameters. This technique can be applied for surface roadways where detailed sensor data is not available. In general, three independent parameters suffice, however, in order to assist in curve flattening (to triangular form), the applied data collection methodology captures as many traffic flow characteristics as possible. Therefore, the data collection strategy is designed to observe saturation flow rate (q_s), jam density (k_j), and backwards wave speed (BWS) in addition to existing speed survey data.

The Highway Capacity Manual and Institute of Transportation Engineering (ITE) Manual of Transportation Engineering Studies[7] provides traffic engineers with published guidelines for the observation of jam density, saturation flow rate, and free flow speed. However, one of the most challenging aspects in designing the data collection effort in this study is the estimation of BWS, since no published guideline exists for estimating this parameter in the absence of flow-density data. Consistent with the triangular simplification of the fundamental flow-density diagram, a simplifying assumption is assumed. The assumption is that the

[6] Saberi and Bertini, 2010[6]; Rakha et al., 2008[6]; Agarwal et al.[6], 2006

[7] Robertson, H.D., J.E. Hummer, and D.C. Nelson, Manual of transportation engineering studies. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1994.

backwards shockwave speed is constant throughout the congested state, and is equal to the slope of the flow-density trend line in the congested state (as it is in the triangular fundamental diagram).

When the assumption is made that backwards wave speed is constant across various congested states it becomes possible to observe all of the desired information from queue formation and dissipation at traffic lights. The queue formation at the red light reveals the jam density spacing of traffic, and queue dissipation during the green light phase represents the saturation flow state. The observable backwards propagation of the saturation flow state into the jam density state occurs at the backwards wave speed.

Figure 23 is a space-time schematic showing the trajectories of vehicles during red light queue formation and green light dissipation. This Figure shows how traffic flow parameters like Effective lengths of the vehicles (EF), driver Response Time (RT), and saturation flow Headways (H) can be collected by observing queue formation and dissipation.

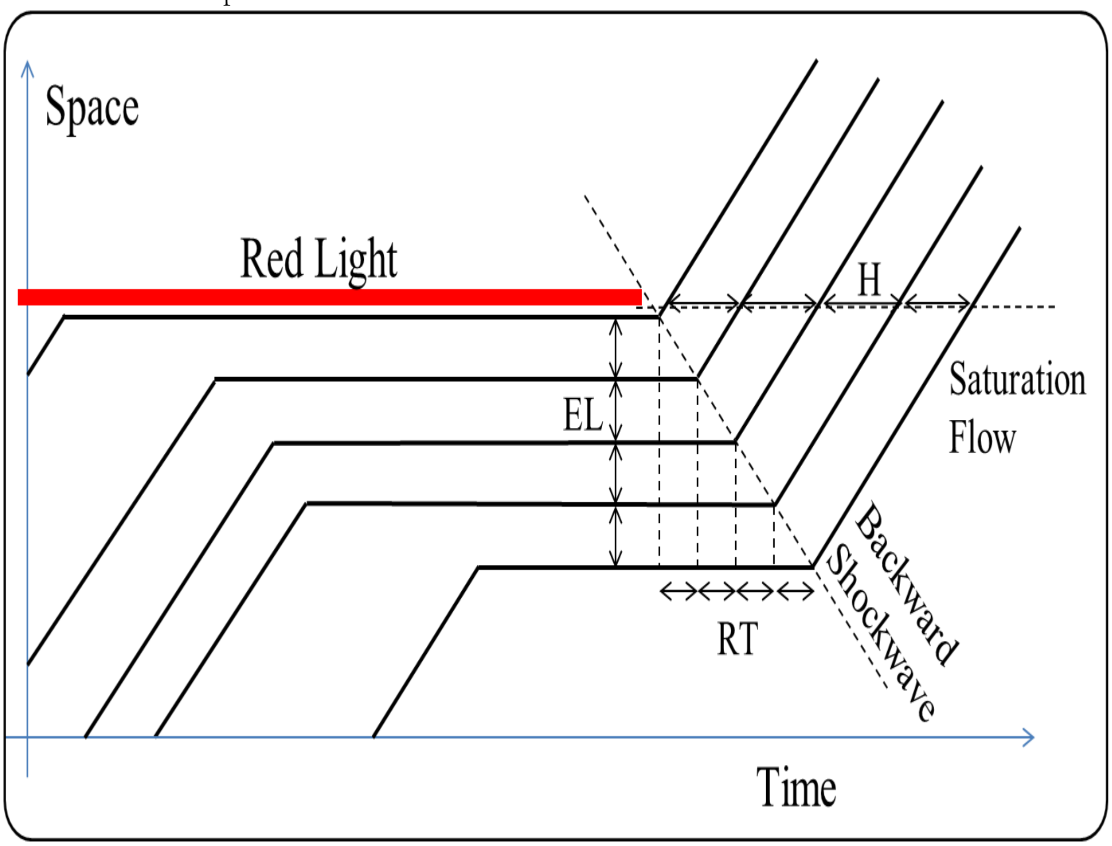

Figure 23. Space-Time Representation of Traffic Queue Formation and Dissipation at a Red Traffic Light

Sources of Data in San Francisco

The estimation of San Francisco traffic flow parameters for the San Francisco DTA model utilizes two pre-existing data sources in addition to queue behavior observations conducted specifically for this effort. The existing data sources are PeMS freeway sensor data and SFMTA speed survey data. These data resources and the dedicated data collection effort are explained in detail below.

Freeway Sensor Data

An incredibly valuable data resource for parameter estimation in this study is the inductance loop detector information for San Francisco freeways from the Caltrans Performance Measurement System[8] (PeMS). PeMS obtains 30-second resolution data in real time from the Caltrans District Transportation Management Center (TMC). Time-series and real-time traffic flow data is available to users on the PeMS website. The lane by lane traffic counts, average speeds, occupancy, etc. are available in time resolutions as focused as 5-minute aggregations. Inside San Francisco area sensor data from 15 freeway segments are available on PeMS, providing high resolution (5-minute) traffic flow data for 59 mainline lanes. For all 59 available San Francisco freeway lanes, 5-minute aggregated counts and average speeds from May 1st to May 31st, 2012 were downloaded and used for traffic flow parameters estimation parameters for freeways.

The first step in the curve fitting process is generating hourly (equivalent) flow-density scatter plots from the raw five-minute resolution speed vs. count data points. The next step is to find a piecewise linear (triangular) regression line to the flow-density scatter plots. In order to do this, two "fixed points" and two traffic density intervals – congested and uncongested – are defined. Each one of the two regression lines in congested and uncongested state are found by finding the slope of a line that passes the fixed point bookending the state that minimizes the sum squares of errors for all data points lying in the associated traffic state area.

The first fixed point is at the origin and is used to find the regression line in the uncongested segment. The second fixed point is the jam density given in terms of passenger car units per lane per hour (pcuplph) which is used to find the regression line of the congested segment. The jam density value is estimated based on data collection explained in a subsequent section. The uncongested area density interval is chosen from density zero to 30 of passenger car units per lane per mile (pcuplpm). The congested area is chosen subjectively by visual inspection of the flow-density trend, and ranges from a low between 40 and 70 pcuplpm and the jam density of 220 pcuplpm. The reason for the above-mentioned subjectivity in the congested area definition ensures that data points in the transition state from uncongested to congested are excluded. For a thorough survey of the existing rigorous approaches for segmentation methods between uncongested and congested flow states refer to Saberi (2010).

[8] http://pems.dot.ca.gov

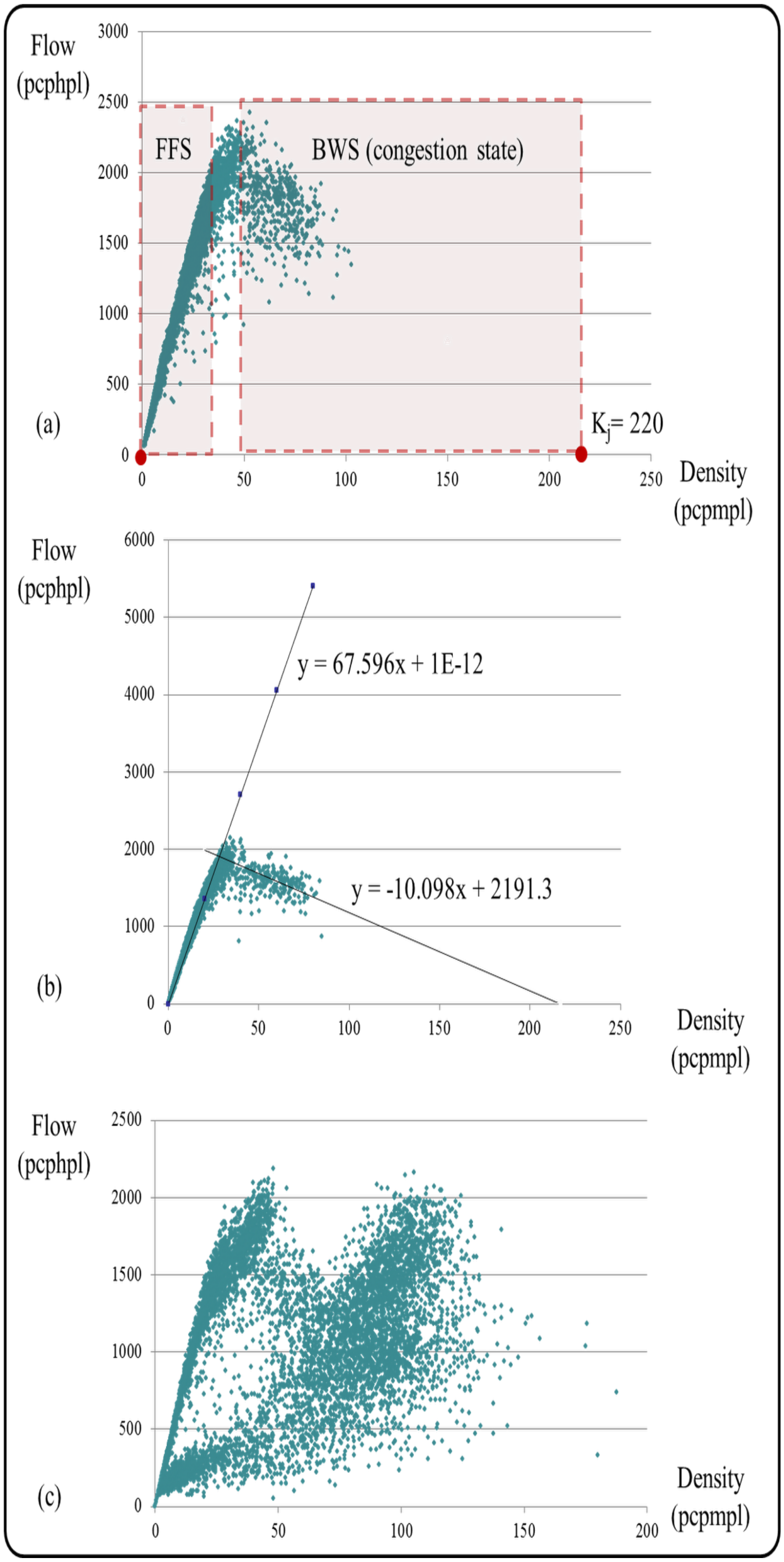

Figure 24. Flow-Density Scatter Plots

Figure 24(a) shows the defined two fixed point and two traffic states for the linear regression on one of the lanes in our study data set. Figure 24 (b) shows the estimated triangular flow-density relationship that is the result of linear regression in each flow state area. The slope of the regression line in the free flow state of traffic represents the free flow Speed, where the slope of the regression line in the congested state of traffic represents the backward wave speed.

In the PeMS data set used for this study there are cases were the flow-density scatter plots do not portray a triangular or trapezoidal shape. Some of these are just limited to free flow traffic conditions while others portray multiple trends in each traffic state (e.g. Figure 24 (c)). The lanes that do not have clear triangular plots are excluded from the data set used to estimate traffic flow parameters.

Speed Survey Data

Speed survey data is available for over 500 surface street locations in San Francisco. The data was collected in off-peak hours and in normal weather conditions between 2004 and 2012. The observation methodology requires a minimum of 4-second headways between one observed vehicle and the following observed vehicle. This requirement is intended to exclude the effect of leading vehicle speed on the observed vehicle although it is uncertain if four seconds is an adequate spacing to ensure true speed independence. 85th-percentile and 50th-percentile speeds are derived from the speed survey tallies to for free-flow speed parameter estimation for non-freeway facilities.

Of the 507 survey locations, 78% are located on arterial streets. The remaining survey locations are evenly distributed between local and collector functional classes. Speed surveys were conducted at geographically dispersed locations throughout San Francisco, including downtown areas as well as peripheral residential areas. Only 40 speed surveys (8%) were conducted on streets with grades in excess of positive or negative eight percent. Overall, the existing speed survey data provides a good picture of arterial free-flow speeds on relatively flat street segments, but it is underweighted for locations on smaller streets and steep hills.

Table 4. Average Speeds by Functional classification and Area Type (mph)

FT \ AT	Regional Core (0)	CBD (1)	Urban Business (2)	Urban (3)	All Area Types
Super Arterial	29.0**	27.9*	33.1*	36.3	**33.1**
Major Arterial	25.2*	25.9	29.7	30.7	**28.2**
Minor Arterial	26.7**	26.3*	28.4	29.5	**28.4**
Collector	No Data	28.5**	26.1*	28.2	**27.5**
Local	No Data	22.7**	27.3**	25.9	**25.9**
All	**25.9**	**26.2**	**29.0**	**29.8**	**28.6**

Notes:
** Indicates <10 observations
* Indicates 16-19 observations
Otherwise >20 observations

Local Traffic Flow Survey

In addition to existing data resource supplementary surveys of traffic flow behavior were conducted. The survey design is intended to record the effective length of vehicles when stopped at red lights (effective length at jam density), the flow rate of vehicles when released from a queue (saturation flow rate), and the response time of drivers to accelerate from a stopped position after the car in front begins to accelerate. Surveyors also measure the approximate slope of the street, the lane configuration of the intersection, and lane width. In total there are nine survey locations in San Francisco. The observation locations are limited to streets where desired traffic flow properties can be observed. Specifically, the survey methodology requires the observation of red light queue formation and smooth green light queue dissipation.

Locations where these conditions can be observed are primarily limited to multiple lane one-way streets where traffic volume is high enough to develop multiple vehicle queue lengths and where flow has minimal interference from conflicting turning movements. The surveys were distributed evenly between flat streets, steep uphill streets and steep downhill streets. All nine survey sites are located in or near San Francisco's CBD. All but one of the streets has a defined functional class that indicates an arterial street. A total of 320 queue dissipations were observed at the nine observation locations. Table 5 shows the functional classification (facility type and area type), lane count, grade, and count of observations for each location. Table 6 presents summarized observed data for effective vehicle length, vehicle headways (inverse of saturation flow rate), and driver response times.

Table 5. Profile of Survey Locations and Queue Dissipation Observations

Dir	Observed Street	Cross Street	# of Lanes	Facility Type	Area Type	Measured Grade	Network Grade	# of Queues
NB	Leavenworth	O'Farrell	3	12	0	11.2%	11.1%	28
NB	Leavenworth	Geary	3	12	0	7.9%	7.4%	20
EB	Golden Gate	Franklin	3	7	1	Flat	Flat	42
EB	O'Farrell	Van Ness	2	15	1	-10%	-10.3%	42
NB	Kearny	Bush	3	7	0	Flat	Flat	42
WB	Fell	Buchanan	4	15	1	5.2%	9.7%	42
SB	Hyde	Post	3	12	0	-7.9%	-11.2%	42
NB	Taylor	Post	3	4	0	8.5%	8.3%	20
NB	Van Ness	Golden Gate	3	7	0	Flat	Flat	42

Table 6. Observed Average Traffic Flow Parameters

Dir	Observed Street	Cross Street	# of Lanes	Facility Type	Area Type
Effective Length (Ft.)	Down	756	24.54	5.41	0.32
	Flat	1,134	24.05	5.14	0.25
	Up	990	24.32	5.63	0.29
Headway (Sec.)	Down	756	2.38	0.73	0.044
	Flat	1,125	2.57	0.91	0.044
	Up	558	2.72	0.78	0.054
Response Time (Sec.)	Down	747	1.09	0.39	0.023
	Flat	378	1.37	0.45	0.038
	Up	558	1.38	0.9	0.062

Appendix B: Summary of Calibration and Validation Parameter Settings

This section provides detailed parameter setting information for the 24 model runs leading to the final calibration model. Nine tables cover the range of inputs and settings that were adjusted across model runs. These tables cover some, but not all DTA Anyway code improvements that occurred during the period of these model runs. The 24 model runs for which parameters are shown were conducted in Dynameq 2.4.5.1. The final calibrated model features settings and parameters identical to those of v24, but the assignment was run using a test version of Dynameq 2.6.

Table 7. Vehicle Types

Model Run	Car Effective Length (ft)	Car Response Time (sec)	Truck Effective Length (ft)	Truck Response Time (sec)
v1	24	1.25	36	1.25
v2	24	1.0	36	1.0
v3	20	1.0	30	1.0
v4 to v7	22	1.0	33	1.25
v8 to v12	21	1.0	31.5	1.25
v13 & v14	22	1.0	33	1.25
v15 to v20	21	1.0	31.5	1.25
v21	20.5	1.0	30.75	1.25
v22	21	1.0	31.5	1.25
v23	20.5	1.0	30.75	1.25
v24	21	1.0	31.5	1.25

Table 8. Link Speed (mph) by Facility (FT) and Area Type (AT) Classification

Facility Type \ Area Type	AT0	AT1	AT2	AT3
Alley	10	10	10	10
Local	18	18	18	15
Collector	23	23	20	20
Minor Arterial	26	26	28	30
Major Arterial	28	28	30	32
Super Arterial	30	30	33	36
Ramp	30	30	35	35
Freeway - Freeway Connector	35	40	45	45
Expressway	60	65	65	65
Freeway	60	65	65	65

Table 9. Response Time

Model Run	Response Time Factor
v1 to v19	Flat: 1.0 Uphill: 1.1 Downhill: 0.9
v20 to v24	Flat: 1.0, Uphill: 1.1 Downhill: 0.9 0.8 for US-101 NB weave section at Potrero Hill

Table 10. Effective Length Factor

Model Run	Area Type 0	Area Type 1	AreaType 2+
v1 to v19	1.00	1.00	1.00
v20 to v24	0.95	0.95	1.00

Table 11. Project Settings by Model Run

Project Setting	v1 to v4	v5	v6 & v7	v8 & v9	v10 to v13	v14 to v24
Network Editing - Control Editing						
- crit gap crossing	4.00	2.00	4.00	3.20	4.00	3.20
- crit gap - merging	6.00	3.00	6.00	4.80	6.00	4.80
- critical wait	60.00	60.00	60.00	60.00	60.00	60.00
Capacity / Priority Templates						
AWSC						
- Follow-up time TH	3.20	3.20	2.56	3.20	3.20	3.20
- Follow-up time RT	3.20	3.20	2.56	3.20	3.20	3.20
- Follow-up time LT	3.20	3.20	2.56	3.20	3.20	3.20
TWSC						
- Crit gap LT from major	4.10	2.05	4.10	3.28	4.10	3.28
- Crit gap RT from minor	6.20	3.10	6.20	4.96	6.20	4.96
- Crit gap TH on minor	6.50	3.25	6.50	5.20	6.50	5.20
- Crit gap LT from minor	7.10	3.55	7.10	5.68	7.10	5.68
- Crit wait	60.00	60.00	60.00	60.00	60.00	60.00
- Follow-up LT from major	2.20	2.20	1.76	2.20	2.20	2.20
- Follow-up RT from minor	3.30	3.30	2.64	3.30	2.64	3.30
- Follow-up TH on minor	4.00	4.00	3.20	4.00	3.20	4.00
- Follow-up LT from minor	3.50	3.50	2.80	3.50	3.50	3.50
Roundabout	Default	Default	Default	Default	Default	Default
Merge						
- Crit gap	4.10	2.05	4.10	3.28	4.10	3.28
- Crit wait	60.00	60.00	60.00	60.00	60	60.00
- Follow-up	2.60	2.60	2.08	2.60	2.08	2.60
Signalized						
- Crit gap UT	6.50	3.25	6.50	5.20	6.50	5.20
- Crit gap LT conflict TH	4.50	2.25	4.50	3.60	4.50	3.60
- Crit gap LT conflict RT	4.50	2.25	4.50	3.60	4.5	3.60
- Crit gap turn on red	6.20	3.10	6.20	4.96	6.20	4.96
- Crit wait	60.00	60.00	60.00	60.00	60.00	60.00
- follow-up UT	4.00	4.00	3.20	4.00	4.00	4.00
- follow-up LT	2.50	2.50	2.00	2.50	2.50	2.50
- follow-up RT	2.50	2.50	2.00	2.50	2.50	2.50
- follow-up TH	1.80	1.80	1.44	1.80	1.80	1.80
- follow-up Turn on Red	4.00	4.00	3.20	4.00	4.00	4.00
- Allow turn on red	Yes	Yes	Yes	Yes	Yes	Yes

Table 12. Generalized Cost Expressions

Model Run	Generalized Cost Expression
v1 to v6	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn)
v7	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn) + 14.4*(length)
v8	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn)
v9	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn) + 28.8*(length)
v10	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn)
v11	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn) + 28.8*(length)
v12 to v15	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn) + 14.4*(length)
v16 to v18	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn) + 14.4*(length) + fac_type_pen*(1800*length/fspeed)
v19	Cars: ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn) + fac_type_pen*(1800*length/fspeed) Trucks: ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn) + 14.4*(length) + fac_type_pen*(1800*length/fspeed)
v20 to v24	ptime+(left_turn_pc*left_turn)+ (right_turn_pc*right_turn) + fac_type_pen*(1800*length/fspeed)

Table 13. Transit Lanes Implementation

Model Run	Transit Lane Implementation
v1 to v16	No transit only lanes
v17	Transit lanes allowing right turn from bus lanes at intersections (by splitting links)
v18	Transit lanes allowing right turns from bus lanes at intersections and centroid connectors (by splitting links)
v19 to v24	Transit lanes allowing right turns from bus lanes at intersections (by splitting links). Short links are not split.

Table 14. Turning Movements

Model Run	Description of Turning Movement Treatment	Follow-up Time for Turning Movements
v1 to v19	• Right turns that don't conflict with other turning movments are protected at signalized intersections • Left turns are permitted unless a dedicated turn phase is present in the traffic signal • Protected capacity determined by link capacity of link leading into movement • Permitted capacity determined by follow-up time in project settings	According to project settings
v20	• All signalized right turns and left turns have permitted status by default • If a signalized turning movement has a dedicated signal phase it has protected status • Protected capacity determined by link	AT0: 2.0s AT1: 2.22s AT2+: 2.67s

	capacity of link leading into movement • Permitted capacity determined by follow-up time and Area Type	
v21	• All signalized right turns and left turns have permitted status by default • If a signalized turning movement has a dedicated signal phase it has protected status • Protected capacity determined by link capacity of link leading into movement • Permitted capacity determined by follow-up time and Area Type	AT0: 2.0s AT1: 2.11s AT2+: 2.22s
v22	• All signalized right turns and left turns have permitted status • Protected capacity determined by link capacity of link leading into movement • Permitted capacity determined by followup time and Area Type	AT0: 2.0s AT1: 2.11s AT2+: 2.22s
v23	• All signalized right turns and left turns have permitted status • Protected capacity determined by link capacity of link leading into movement • Permitted capacity determined by followup time and Area Type	AT0: 2.0s AT1: 2.22s AT2+: 2.67s
v24	• All signalized right turns and left turns have permitted status by default • If a signalized turning movement has a dedicated signal phase it has protected status • Protected capacity determined by link capacity of link leading into movement • Permitted capacity determined by followup time and Area Type	AT0: 2.0s AT1: 2.11s AT2+: 2.22s

Table 15. Land Use

Model Run	Land Use Used in SF-CHAMP Model Run
v1 to v19	SCS Focused Growth 2010
v20 to v24	SCS Jobs Housing Connection 2010 (May 2012 draft)

Appendix C: Listing of DTA Test Runs

Below is a complete listing of the DTA test runs conducted during the calibration process, and some basic statistics and observations for each.

sf_jun7_530p

- Calibration run 1
- Convergence: Min = 0.01451, Max = 0.01809, Mean = 0.01687
- No waiting vehicles at the end of simulation

sf_jun8_420p

- Changes from last run: fixes to a handful of signals that were probably causing issues; upped the free-flow speed on freeways
- No waiting vehicles at the end of simulation

sf_jun18_630p

- Changes from last run: Transit Lanes (Issue 83), many stop signs added (See Comment 23 on Issue 35)
- Convergence: Min = 0.02675, Max = 0.01313, Mean = 0.02821
- Runtime: 20 hours for 50 iterations
- No waiting vehicles at the end of simulation

pb_jun27_530p

- Changes from last run:
    - Wrap in changes from codes and network
    - Decrease response time factors from 1.15 to 1.05
    - Run on PB machine
- Convergence: Min = 0.02915, Max = 0.1139, Mean = 0.0708
- Runtime: Approx. 15 hours to do 45 iterations
- RMSE:
- GEH:
- Overall Vol/Count Ratio:
- Observed Gridlock: A few NW of Market street and at SE entry point to the network, similar to previous run.
- Observations: Looks like gridlock is still being caused by capacities that are too low in these areas. Reducing the response time factor helped, but not enough. The next thing to test will be undoing some of the larger speed decreases.

pb_jul2_400p

- Changes from last run:
    - Wrap in changes from codes and network
    - Make sure the turn penalties are calculated correctly
    - Set trips to Cars and Trucks (not Generic)

- Convergence: Min = 0.0124001, Max = 0.0741798, Mean = 0.0377371
- Runtime: Approx. 12.28 hours to do 50 iterations
- RMSE: Links = 131 (57%), Movements = 64 (80%)
- GEH: Links = 7.12, Movements = 4.55
- Overall Vol/Count Ratio: Links = 0.6604, Movements = 0.7174
- Observed Gridlock: Entry point in SW corner of the region, Monterey Blvd near I-280, a couple of areas along Hwy 101 have a small amount of gridlock.
- Observations: We definitely need to update the code so that boundary connectors don't connect to ramps and so that the number of lanes on boundary connectors is the sum of the incoming or outgoing lanes. Still should maybe be seeing more traffic at entry points to I-80.

pb_july3_500p

- Changes from last run:
  - Centoid connectors at boundaries now can't connect to freeways or ramps, and the number of lanes is equal to the sum of the incoming or outgoing lanes.
- Convergence: Min = 0.0131095, Max = 0.0448661, Mean = 0.0303312
- Runtime: Approx. 12.46 hours to do 50 iterations
- RMSE: Links = 130 (56%), Movements = 63 (79%)
- GEH: Links = 7.05, Movements = 4.56
- Overall Vol/Count Ratio: Links = 0.6729, Movements = 0.7238
- Observed Gridlock: Some gridlock on streets intersecting with I-80.
- Observations: Left and right turns seem to be lower than other movements. We should see if lowering the turn penalties a little bit helps us match the movement counts better.

pb_july4_330p

- Changes from last run:
  - Turn penalties changed: lt_pc = 20, rt_pc=5.
- Convergence: Min = 0.0145885, Max = 0.0416506, Mean = 0.0291377
- Runtime: Approx. 16.33 hours to do 60 iterations
- RMSE: Links = 135 (59%), Movements = 67 (84%)
- GEH: Links = 7.45, Movements = 4.72
- Overall Vol/Count Ratio: Links = 0.6459, Movements = 0.6811
- Observed Gridlock: None. Some congestion along Hwy 101 NB and I-80 WB.
- Observations: This definitely made our matching of both link and movement counts worse. Next run we'll go back to 30 and 10 for the penalties. Matching is worst on FT 4, 5, and 6 for links and FT 7 for movements. Maybe check and see if those speeds should be lowered slightly or response time should be changed.

pb_july5_500p_I

- Changes from last run:
  - Added intrazonal trips back in (only about 1,000 total)
- Convergence: Min = 0.0107243, Max = 0.0459835, Mean = 0.0298107
- Runtime: Approx. 13.81 hours to do 55 iterations
- RMSE: Links = 130 (57%), Movements = 63 (79%)

- GEH: Links = 7.04, Movements = 4.56
- Overall Vol/Count Ratio: Links = 0.6686, Movements = 0.7230
- Observed Gridlock: None. There is congestion but no observed gridlock.
- Observations: This change only slightly improves the count matching. This is because there aren't a lot of intrazonal trips in the Cube trip tables, and the trips that are there are often fractional. These fractional trips are, in many cases, small enough that their effect doesn't show up when the trip tables are truncated as they're imported into Dynameq.

!! Important: This run included a problem with the code. It was replacing the existing trips between the zones with the intrazonal trips. I've fixed this problem, and I'll run a new assignment today. It still shouldn't make a big difference (only about 3,000 trips), but we'll see.

pb_july5_500p_S

- Changes from last run:
    a Made two-way stops with FT conflicts All-way
    b This does not include the intrazonal trips
- Convergence: Min = 0.012036, Max = 0.0496103, Mean = 0.0314793
- Runtime: Approx. 13.96 hours to do 55 iterations
- RMSE: Links = 130 (56%), Movements = 63 (79%)
- GEH: Links = 7.04, Movements = 4.58
- Overall Vol/Count Ratio: Links = 0.6729, Movements = 0.7238
- Observed Gridlock: None. There is congestion but no observed gridlock.
- Observations: This makes some difference, but we may see larger differences in the SF results based on how Lisa implemented the change. This run also does not include the updates to the connector codes that Lisa made or the changes to the counts. Those changes will all be wrapped in to the tests run over the weekend. Several detailed issues were observed:
    a Some of the worst offenders in the network are volumes that are much too low on Sunset, Great Highway, and Embarcadero. It looks like there is not enough congestion in the rest of e network to push people out of their way to use these facilities.
    b Counts that are intended for the Geary Tunnel are instead showing up on the adjacent surface street, where the volumes are in reality much lower. We should clean this up by moving the count, and our model will do better at this particular location.
    c At 4th & Harrison and 4th & Folsom, the all-red time is 24s. This can be traced back to the signal card where there are long pedestrian phases. Is that really right? Maybe it could be because of the convention center, but it seems excessive.
    d There is hourly count of 102 vehicles on Folsom St (links 16160). This looks like we're missing a zero.
    e The volumes on Turk are too high, whereas we tend to be low on Geary and Oak/Fell. Turk is coded as a major arterial. Seems like we may want to classify it as a minor arterial instead to get somewhat less flow.
    f The volume is too high on Claremont St. It looks like people may be too willing to drive over the hill.
    g The volume is too high on Taraval St. Not sure why this is.
    h At Octavia and Mission, there is a U-Turn permitted. There is also only one through lane on Octavia, whereas there should be two (perhaps because the U-turn is blocking it). Add to the U-Turn prohibitions list.

i. There are permitted movements (U-Turns and left turns) on Octavia that should not be permitted. Clean these up.
j. There are some signals that don't import cleanly on Octavia due to the complexity of the intersections with the side right turn/parking lanes. As a result, one is showing up as a TWSC and one is showing up as uncontrolled.

pb_july6_1200p

- Changes from last run:
    a. Fixed the issue with the intrazonal trips code.
- Convergence: Min = 0.0110936, Max = 0.0365741, Mean = 0.02541
- Runtime: Approx. 13.84 hours to do 55 iterations
- RMSE: Links = 133 (58%), Movements = 64 (80%)
- GEH: Links = 7.17, Movements = 4.59
- Overall Vol/Count Ratio: Links = 0.6527, Movements = 0.7145
- Observed Gridlock:
    a. The Embarcadero between Howard & Folsom
- Observations:
    a. It may look like our count-matching is worse, but this is because of the new counts added in, not because of the model.
    b. The intrazonal trips and all-way stops don't make a lot of difference. We will have to see if some of the capacity changes that Neema and Dan have been working on will give more improvement.
    c. There's something wrong with how Embarcadero & Folsom's signal card is being read in. The 38s phase should have both NB and SB Embarcadero, but it only has NB. I'll look into how we might be able to fix this.

pb_july6_430p

- Changes from last run:
    a. Neema's updates to the response time factors
- Convergence: Min = 0.0116106, Max = 0.0673996, Mean = 0.0331219
- Runtime: Approx. 17.61 hours to do 75 iterations (trying to get better convergence)
- RMSE: Links = 132 (57%), Movements = 64 (80%)
- GEH: Links = 7.04, Movements = 4.56
- Overall Vol/Count Ratio: Links = 0.6467, Movements = 0.7051
- Observed Gridlock:
    a. Stockton Tunnel/Stockton (same congestion as seen before in this area where the tunnel comes out and one lane becomes transit only.
    b. Market St. near Stockton
    c. I-280 NB @ Brannan
    d. Portola @ Sloat
    e. Harrison between 3rd & 4th St
    f. The Embarcadero between Howard & Folsom
- Observations:

a. Still ~ 1050 cars waiting at the end of the simulation. Centroids with waiting vehicles at the end are all in NE area. These capacities may be lowered too much by the most recent change.
b. Seeing a lot of new gridlock in the NE region. I assume this is because of the capacity changes. We may need to decrease the response time factor a bit (possibly down to 1.20).

pb_july9_400p_BL

- Changes from last run:
    a. Removed bus lanes and updated signal timings with code fix
- Convergence: Min = 0.0100908, Max = 0.0361953, Mean = 0.0252914
- Runtime: Approx. 15.66 hours to do 60 iterations
- RMSE: Links = 135 (59%), Movements = 64 (80%)
- GEH: Links = 7.32, Movements = 4.59
- Overall Vol/Count Ratio: Links = 0.6459, Movements = 0.7085
- Observed Gridlock: None
- Observations:
    a. Congestion on 6th St between Bryant & Harrison - both signals are correct, so there must be some other issue here.
    b. Without the bus lanes, the max. delay in Stockton Tunnel is about 1.5 minutes, much less than before.
    c. There is still some congestion on the arterials around Market St., and I-80 in the NE region, but not nearly as much as before.
    d. Flow in the western region is still concentrated mostly on 19th Ave. We need to figure out why we're not getting much flow on Great Hwy or Sunset Blvd.

pb_july9_500p_CBD

- Changes from last run:
    a. Bus lanes in, but speeds in CBD increased to match AT1 and response time factor decreased from 1.25 to 1.2 for non-freeway links
- Convergence: Min = 0.00985006, Max = 0.0374433, Mean = 0.0231557
- Runtime: Approx. 13.06 hours to do 60 iterations
- RMSE: Links = 137 (59%), Movements = 65 (81%)
- GEH: Links = 7.40, Movements = 4.62
- Overall Vol/Count Ratio: Links = 0.6345, Movements = 0.713
- Observed Gridlock:
    a. Market St starting around 4th St.
    b. Stockton Tunnel
    c. California around Kearny
    d. Battery St. & Clay St. around where they intersect (checked signal, and timing is correct)
    e. Mason & Columbus around where they intersect (checked signal, and timing is correct)
    f. Laguna & Market where they intersect (signal timing is correct)
- Observations:

a. We still get huge amounts of congestion in the CBD. Since changing the speeds and response time factor didn't help much, it looks like fixing the transit-only lane issues is more important.
b. At the end of the simulation (at 21:30) there were still 1850 vehicles waiting. This much gridlock is definitely causing our flows to be too low.
c. At least half of these gridlocked areas are around bus-only lanes that could be causing congestion. Others are areas that are fed by congestion from other bus-only problems (like Market & 4th having residual problems from the Stockton St. congestion after the tunnel).
d. Next step will be to figure out how to deal with the bus-only lane issues, decide if we want to keep these speed and response time factor changes, and increase the demand by 25% - 30% to see if that helps us match the counts.

pb_july10_500p_30D

- Changes from last run:
    a. No Bus lanes, includes the changes in the CBD speeds and response time factors
    b. Main change is that internal demand was increased by 30%
- Convergence: Min = 0.0112683, Max = 0.0645339, Mean = 0.0325649
- Runtime: Approx. 13.51 hours to do 60 iterations
- RMSE: Links = 155 (68%), Movements = 72 (90%)
- GEH: Links = 8.18, Movements = 4.86
- Overall Vol/Count Ratio: Links = 0.6316, Movements = 0.7526
- Observed Gridlock: Pretty much everywhere. There are way too many places to list
- Observations:
    a. We seem to be doing a better job of matching counts here until about 5:30, at which point the gridlock starts and our modeled flows have a huge drop.
    b. This definitely overloads the network, but even with gridlock, we are doing a better job of matching the movement counts than before. The next step might be to try an increase of just 10%.
    c. We've never seen gridlock on the freeways before, but here we get significant amounts of gridlock on most of them, driving the modeled flow way down.

pb_july11_1000a_10D

- Changes from last run:
    a. Internal demand was increased by 10%
- Convergence: Min = 0.0105004, Max = 0.0479881, Mean = 0.0276245
- Runtime: Approx. 14.85 hours to do 60 iterations
- RMSE: Links = 131 (57%), Movements = 64 (80%)
- GEH: Links = 7.00, Movements = 4.52
- Overall Vol/Count Ratio: Links = 0.6948, Movements = 0.7668
- Observed Gridlock: None. There is congestion in some areas but no gridlock.
- Observations:
    a. Increasing demand by 10% instead of 30% allows us to get closer to the counts without overloading the network. It does lead to more congestion in the CBD, but not gridlock.

b We'll see how penalizing the locals and collectors affects the results in the next test. It's possible that a combination of the two would get us closer to the flows that we're looking for.

c We're still seeing a lot of congestion on 6th St. around I-80. Is this congestion there in real life, or is there something going on in the network that we need to look at?

pb_july11_300p_FT

- Changes from last run:
    a Locals and collectors were penalized by 1*FFTime
- Convergence: Min = 0.00730297, Max = 0.0535901, Mean = 0.0324052
- Runtime: Approx. 14.19 hours to do 60 iterations
- RMSE: Links = 122 (53%), Movements = 61 (76%)
- GEH: Links = 6.85, Movements = 4.47
- Overall Vol/Count Ratio: Links = 0.8074, Movements = 0.855
- Observed Gridlock: None. There is congestion in some areas but no gridlock.
- Observations:
    a These results look much better than what we've seen before. We're matching counts even better than we did by increasing demand by 10%.
    b Arterial Plus is still the one facility type where we are really low. We might want to consider changing the properties of those ones somehow to increase flow. I'm not sure if we need to decrease speed to slow them down or add capacity to attract more vehicles. We can look into that next week.
    c This test still has no bus-only lanes. Things may change a lot when we add them back in with the right-turns. I think that will be the next test that we need to do.

pb_july19_830p

- Changes from last run:
    a Network changes (mostly Octavia)
    b Signal changes (yellow time)
    c Bigger transit vehicles
- Convergence: Min = 0.00776709, Max = 0.05473, Mean = 0.0345985
- Runtime: Approx. 14.16 hours to do 60 iterations
- RMSE: Links = 52% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 6.63, Movements = 4.34
- VMT = 1,523,412 miles, VHT (4-6pm) = 66,768 hours
- Overall Vol/Count Ratio: Links = 0.8019, Movements = 0.8569
- Observed Gridlock: None. There is congestion in some areas but no gridlock.
- Observations:
    a These results, on most measures, are better than what we had in the last test with the local and collector penalties.
    b There is more congestion than we've seen before on the Market St. crossings, especially those that feed into and off of I-80.
    c Octavia definitely has more traffic than before, probably because the all-way stops were preventing vehicles from using Octavia in previous tests.

d Speed matching is better in terms of slope and percent difference, but the RMSE is slightly higher.

pb_july31_900a

- Changes from last run:
  a Input trip tables were in 30-min slices, not the whole 3 hours.
- Convergence: Min = 0.00754429, Max = 0.0869174, Mean = 0.0507424
- Runtime: Approx. 14.53 hours to do 60 iterations
- RMSE: Links = 54% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.75, Movements = 4.34
- VMT = 1,524,309 miles, VHT (4-6pm) = 71,785 hours
- Overall Vol/Count Ratio: Links = 0.7777, Movements = 0.8441
- Observed Gridlock: None. There is congestion in some areas but no gridlock.
- Observations:
  a Unfortunately, the slices do seem to have a significant effect on the flows. This is because having the trip tables input in 30-minute slices seems to cause a shift (about 600 trips total) from 5-6pm to 4-5pm.
  b We should be able to control the effects of these changes somewhat by applying our own demand profile in the future, but we do want to see less variation between time periods from the bucket rounding if possible.
  c One of the biggest changes we see is in travel times. When you look at just 4-5 vs. 5-6, the VHT changes a lot from the previous test. The demand profile obviously has significant effects on the flows, but we need to make sure that we can set it to what we want instead of allowing the changes that happen as a result of the Dynameq bucket rounding.

pb_aug1_230p

- Changes from last run:
  a 25% of PM demand added to start and end of demand period (14:30-15:30 and 18:30-19:30)
  b Signals updated so that overlapping yellow/green has yellow time
- Convergence: Min = 0.00619515, Max = 0.0936764, Mean = 0.0483475
- Runtime: Approx. 21.51 hours to do 65 iterations (needed more iterations to reach stable convergence)
- RMSE: Links = 56% (1,748 counts), Movements = 78% (7,643 counts)
- GEH: Links = 7.34, Movements = 4.57
- VMT = 1,332,327 miles, VHT (3:30-6:30pm) = 53,093 hours
- Overall Vol/Count Ratio: Links = 0.7112, Movements = 0.773
- Observed Gridlock: Gridlock in many places in the CBD. Most of the gridlock develops after the simulation period during the 6:30-7:30 hour, but it doesn't clear as the simulation ends.
- Observations:
  a This actually seems to make things worse. One of the issues is that we're not sure how much demand to add to the start and end hours. We also need to look at how much the bucket rounding is re-distributing these trips.

b We're not clearing out the demand from the network, but one of the reasons that this may be happening is the addition of starting all-red time to signal phases where it exists. Before the signals timing just started wherever the green time started.

c Next two runs will be testing the new speeds that Neema uploaded both with and without the additional hours of demand.

d The pems data that I'm using to estimate the demand profile can also give a better idea of how much demand we should be adding to the start and end hours (in terms of the % of the PM demand).

e This test did take more iterations to converge to a stable point than other tests have. That may be another consideration in terms of running time. To reach stable convergence, this simulation took 21 hours, but we also may be able to shorten that when we go back to the simpler generalized cost expression.

pb_aug3_330p_NS

- Changes from last run:
    a Neema's speed updates
    b Demand back to 15:30-18:30 (extended demand used in next test)
- Convergence: Min = 0.00850662, Max = 0.0477658, Mean = 0.0302559
- Runtime: Approx. 14.62 hours to do 60 iterations
- RMSE: Links = 52% (1,748 counts), Movements = 73% (7,643 counts)
- GEH: Links = 6.31, Movements = 4.22
- VMT = 1,436,086 miles, VHT (3:30-6:30pm) = 64,728 hours
- Overall Vol/Count Ratio: Links = 0.7312, Movements = 0.7915
- Observed Gridlock: None. Congestion in the CBD, but no gridlock.
- Observations:
    a We don't get the same boost in count-matching that we did from penalizing the collectors, and locals. However, we do get closer than we were before the speed changes.
    b We see congestion where it is expected: the major roadways crossing Market to get to the freeway and clustered around freeway on and off-ramps.
    c We may want to introduce the local-local facility type or the distance measure in the generalized cost to further penalize the use of very small local streets - especially those South of the park in the Western region pulling traffic from Sunset and 19th.

pb_aug3_430p_DE

- Changes from last run:
    a Demand extended to 14:30-19:30 with 15% of PM demand added as start and end hours
- Convergence: Min = 0.00648877, Max = 0.0696583, Mean = 0.0339798 (Converged to gridlock)
- Runtime: Approx. 19.14 hours to do 60 iterations
- RMSE: Links = 53% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.39, Movements = 4.27
- VMT = 1,431,466 miles, VHT (3:30-6:30pm) = 66,695 hours
- Overall Vol/Count Ratio: Links = 0.7203, Movements = 0.7241

- Observed Gridlock: All over the CBD after about 6:00. Starts mostly E of Stockton and N of market then branches West along Broadway and California. After 6:30 it seems to reach a critical point and everything becomes gridlocked.
- Observations:
  a Even adding only 15% of the PM demand seems to really overload the network. This isn't something that will be fixed with the demand profile. The bucket rounding here results in a pretty even distribution of demand within the 15:30-16:30 period.
  b We need to figure out why this gridlocks the network to such a huge extent. Without the extra time there was congestion in this area of hte CBD but no gridlock, so it's not a network/signal timing issue.
  c I may try changing the demand profile of the start and end hours to make it more like incremental loading instead of having an even distribution. We would have more demand in the second half of the 14:30-15:30 hour and in the first half of the 18:30-19:30 hour.
  d If we can get rid of the gridlock we may start matching counts better since these results are pretty close to what we see in the test without the extended demand even though we have gridlock toward the end here.

pb_aug7_1000a_1S10E

- Changes from last run:
  a Demand extended to 14:30-19:30 with 1% of PM demand added as start hour and 10% added as end hour
- Convergence: Stopped after 40 iterations as it was clearly converging to gridlock.
- Runtime:
- Overall Vol/Count Ratio:
- Observed Gridlock: All over the CBD. This test converged to gridlock pretty early on and never recovered.
- Observations:
  a Clearly the end hour demand is causing a lot of problems. This adds extra demand to a very congested network, and it seems to be the tipping point in terms of our traffic exceeding the capacity in the CBD.

pb_aug7_1000a_10S1E

- Changes from last run:
  a Demand extended to 14:30-19:30 with 10% of PM demand added as start hour and 1% added as end hour
- Convergence: Min = 0.00740795, Max = 0.08556, Mean = 0.0346489
- Runtime: Approx. 34.27 hours to do 60 iterations (other programs were running at the same time and slowing this down)
- Overall Vol/Count Ratio:
- Observed Gridlock: Not nearly as bad as when demand is added to both start and end hours. Only about 400 vehicles waiting at the end of the simulation. Primarily gridlocked in CBD.
- Observations:
  a Adding the demand only to the start doesn't seem to be nearly as bad as adding it at the end. The end hour gets gridlocked since we already have a very congested network at that time

even without the additional demand. The gridlock then propagates backward to the 5:30-6:30 time period.

b While this is useful to know (that the gridlock is more because of the end hour than the start hour), we still shouldn't have this many problems.

c Next test will be to see if using only 5% of the demand in the additional hours and only 90% of the demand in the PM peak still has gridlock. This shouldn't because it will be the same total amount of demand just loaded over a longer time period.

pb_aug13_1000a_MDPMEV

- Changes from last run:
    a Actual MD and EV trip tables used. % of each demand set used was based on taking a 1-hour portion of the total demand period.
- Convergence: Project this was in has become corrupted, so I can't access the test anymore to get the convergence info.
- Runtime:
- RMSE: Links = 68% (1,748 counts), Movements = 90% (7,643 counts)
- GEH: Links = 8.40, Movements = 4.89
- VMT = 1,225,908, VHT (3:30-6:30pm) = 64,484 hours
- Overall Vol/Count Ratio: Links = 0.5869, Movements = 0.6967
- Observed Gridlock: All over the CBD starting around 5:30/6:00
- Observations:
    a Clearly switching to MD/EV trip tables hasn't helped us. We still have huge amounts of gridlock that make the counts look really low. We are measuring outflow and comparing to counts in the output processing, so when there is gridlock, the gridlocked vehicles don't get counted at all.
    b Is there a different measure that we should be using? Are the counts really outflow or some combination of outflow and occupancy?

pb_aug13_400p_90PM

- Changes from last run:
    a Demand extended to 14:30-19:30 with 15% of MD demand added as start hour and 12% of EV demand added as end hour and only 90% of PM demand used in PM peak hours; Demand profile also used for PM hours based on counts at boundary locations
- Convergence: Min = 0.00973505, Max = 0.0929695, Mean = 0.0361602 (Stopped at 50 iterations because of obvious gridlock issues)
- Runtime: Approx. 21.86 hours for 50 iterations
- Overall Vol/Count Ratio:
- Observed Gridlock: All over the CBD
- Observations:
    a This still doesn't seem to make sense. By decreasing the PM demand we should be freeing up enough capacity to get the vehicles through the network.
    b One observation from this test is that there are a lot of truck trips in the MD and EV trip tables, and the trucks may be overloading the network in the added demand.

pb_aug15_400p_RT

- Changes from last run:
  - a Response Times changed to 1.1 where 1.2 and 1.2 where 1.32 in AT 0 and 1 to increase capacity. (MD and EV extended demand still used.)
- Convergence: Min = 0.0123642, Max = 0.0991522, Mean = 0.0373117(Stopped at 51 iterations because of obvious gridlock issues)
- Runtime: Approx. 22.30 hours for 51 iterations
- Overall Vol/Count Ratio:
- Observed Gridlock: All over the CBD
- Observations:
  - a Even this significant increase in capacity wasn't enough to clear the gridlock. We may need to look at other problems.

pb_aug16_1030a_Cap

- Changes from last run:
  - a Response Times changed to 1.1 where 1.2 and 1.2 where 1.32 in AT 0 and 1 to increase capacity. (MD and EV extended demand still used.)
  - b Speeds in the CBD increased by 10 mph (except freeways)
- Convergence: Min = 0.00904175, Max = 0.0627537, Mean = 0.0310921
- Runtime: Approx. 29.31 hours for 60 iterations
- Overall Vol/Count Ratio:
- Observed Gridlock: All over the CBD
- Observations:
  - a We still had about 21,000 vehicles waiting at the end of the simulation. There's clearly something overloading the network here.
  - b The next step will be to see how much the additional truck trips are affecting this gridlock.

pb_aug20_530p_NoT

- Changes from last run:
  - a RT and speeds back to normal.
  - b Truck demand for start and end hours set to zero.
- Convergence: Min = 0.00634479, Max = 0.128235, Mean = 0.0569804 (This wasn't a stable convergence since the relative gap was still shifting some, but after 60 iterations we had enough information to decide what to do for the next test.)
- Runtime: Approx. 20.18 hours for 60 iterations
- RMSE: Links = 50% (1,748 counts), Movements = 71% (7,643 counts)
- GEH: Links = 6.10, Movements = 4.19
- VMT = 1,418,136, VHT (3:30-6:30pm) = 70,735 hours
- Overall Vol/Count Ratio: Links = 0.7433, Movements = 0.8034
- Observed Gridlock: Ocean & Alemany, parts of Silver Ave,Columbus, Broadway, Laguna, Tayor (CBD in general)
- Observations:
  - a We only have about 750 vehicles waiting at the end of the simulation here. Clearly the trucks are a major factor in the gridlock developing after we add the start and end hours.

b. Also, it's a good sign that we're getting back up closer to counts again. If we can load the network with the start and end demand and get it to clear (or mostly clear), we may get much closer to counts.

pb_aug21_530p

- Changes from last run:
  a. Only 1% of truck demand used for start and end hours
  b. Stop signs added at centroid connectors (preliminary implementation without custom priorities file)
  c. Response time for trucks changed from 1.6 to 1.25
- Convergence: Min = 0.00697173, Max = 0.0682133, Mean = 0.0297328
- Runtime: Approx. 22.59 hours to do 60 iterations
- RMSE: Links = 50% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 6.01, Movements = 4.19
- VMT = 1,464,957, VHT (3:30-6:30pm) = 66,708 hours
- Overall Vol/Count Ratio: Links = 0.7505, Movements = 0.8082
- Observed Gridlock: None. We have heavy congestion in some parts of the CBD, but one of the changes we made here really cleared things out.
- Observations:
  a. Amazingly, we have no gridlock at the end of the simulation and are able to completely clear the network. There is congestion in the CBD, as there should be, but it's not as much as we've seen in past simulations.
  b. I can't be sure yet if it is the trucks or the stop signs on centroid connectors, but something has had a big effect on letting traffic get through the network here.
  c. It might be worthwhile to test just the stop signs and/or just the changes to truck response times to isolate which change is having the biggest effect on getting rid of the gridlock that we've seen in previous tests.
  d. We can start adding back in more of the MD and EV trucks to get a more accurate warm up/cool down time now.

pb_aug22_530p_50T

- Changes from last run:
  a. Only half of an hour's worth of truck demand used for start and end hours
- Convergence: Min = 0.00759221, Max = 0.0858625, Mean = 0.0354923
- Runtime: Approx. 22.22 hours to do 60 iterations
- RMSE: Links = 50% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 6.09, Movements = 4.21
- VMT = 1,445,020, VHT (3:30-6:30pm) = 66,455 hours
- Overall Vol/Count Ratio: Links = 0.7453, Movements = 0.8036
- Observed Gridlock: Stockton, Columbus, Broadway, Bay, Union, Mason and then spreading to the rest of the CBD starting about 6:15.
- Observations:
  a. This many trucks at the start and end overwhelm the network even with the updated truck response time.

b Next test will be to run the same test with 1/4 of an hour's worth of MD and EV trucks.
c Stop signs on centroid connectors are only working at external centroids. We'll need to test these changes again when the stop sign priorities are corrected on the connectors.

pb_aug23_500p_25T

- Changes from last run:
  a Only 1/4 of an hour's worth of truck demand used for start and end hours
- Convergence: Min = 0.00698851, Max = 0.0618205, Mean = 0.0277422
- Runtime: Approx. 24.44 hours to do 65 iterations (needed the extra 5 iterations to reach convergence)
- RMSE: Links = 49% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 5.97, Movements = 4.19
- VMT = 1,462,665, VHT (3:30-6:30pm) = 65,152 hours
- Overall Vol/Count Ratio: Links = 0.7504, Movements = 0.8084
- Observed Gridlock: None. There is heavy congestion in the CBD but no gridlock.
- Observations:
  a Adding back the MD and EV trucks doesn't seem to make a lot of difference in the results. As long as it doesn't cause gridlock.
  b We need to test Lisa's changes to allow for stop signs at connectors.
  c We may want to play with the truck response times a bit to find out what gets us to the right level of congestion to match our counts without causing total gridlock.

pb_aug27_1130a_SCent

- Changes from last run:
  a Only 1% of the MD and EV truck trip tables were used.
  b Lisa's fix for the stop sign priorities on centroids was incorporated
- Convergence: Min = 0.0069094, Max = 0.0606801, Mean = 0.026982
- Runtime: Approx. 24.49 hours to do 65 iterations (needed the extra 5 iterations to reach convergence)
- RMSE: Links = 49% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 6.00, Movements = 4.18
- VMT = 1,465,257, VHT (3:30-6:30pm) = 66,293 hours
- Overall Vol/Count Ratio: Links = 0.7524, Movements = 0.8077
- Observed Gridlock: None.
- Observations:
  a The correct implementation of the stop signs on centroid connectors not only improved count matching, but it also creates much less congestion in the CBD.
  b The next step will be to add more of the trucks back into the start and end hours.
  c It will be good to test this when Dan has added the pedestrian friction for turning movements. The combination of the two effects should allow us to increase congestion somewhat with the turning friction without causing gridlock.

pb_aug28_530p

- Changes from last run:

   a. Only 1/3 of an hour of the MD and EV truck trip tables were used.
- Convergence: Min = 0.00750854, Max = 0.0754229, Mean = 0.0323439
- Runtime: Approx. 22.90 hours to do 60 iterations
- RMSE: Links = 50% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 6.04, Movements = 4.20
- VMT = 1,459,743, VHT (3:30-6:30pm) = 66,543 hours
- Overall Vol/Count Ratio: Links = 0.7408, Movements = 0.8027
- Observed Gridlock: None.
- Observations:
   a. We still don't have heavy congestion in the CBD, even with 1/3 of an hour's worth of trucks added to the start and end hours.
   b. I think this is a good place to stop with adding trucks and go on with other testing. 1/3 of an average hour's worth of MD and EV trucks seems like a realistic level of trucks for the start and end hours.

pb_sept4_430p_RS_T1

- Changes from last run:
   a. Set the Random Seed value to 5 (changed from 1).
- Convergence: Min = 0.00681721, Max = 0.0667021, Mean = 0.0326394
- Runtime: Approx. 27.05 hours to do 60 iterations (It's slower because I moved the project to a newer, slightly slower computer. This computer has a slower processor but tons of hard drive space, which is more important right now given how big the files for each scenario run are.)
- RMSE: Links = 50% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 6.04, Movements = 4.17
- VMT = 1,468,712, VHT (3:30-6:30pm) = 66,837 hours
- Overall Vol/Count Ratio: Links = 0.7543, Movements = 0.8064
- Observed Gridlock: None.
- Observations:
   a. The pattern of convergence is different that we see with a random seed of 1. The peak in the relative gap is much higher and sharper, and it happens much sooner.
   b. The largest changes weren't very large. The largest difference in total link flow (over all 3 hours of the PM peak) was 2,551 vehicles. For the most part, the changes were on a few major arterials. The flow generally increased in one direction and dropped off in the other direction, increasing the flow on multiple nearby arterials.
   c. We do a slightly better job of matching counts with this setting because it re-balances flows a bit between the major arterials and the smaller arterials around them.
   d. Given the change in convergence and a noticeable change in some of the volumes, I'm going to run another test with the random seed set to 2 instead to see how sensitive these values are to a smaller change.

pb_sept5_500p_RS_T2

- Changes from last run:
   a. Set the Random Seed value to 2 (changed from base of 1).
- Convergence: Min = 0.00683357, Max = 0.0768023, Mean = 0.0354672

- Runtime: Approx. 31.84 hours to do 60 iterations
- RMSE: Links = 50% (1,748 counts), Movements = 73% (7,643 counts)
- GEH: Links = 6.08, Movements = 4.18
- VMT = 1,468,480, VHT (3:30-6:30pm) = 66,193 hours
- Overall Vol/Count Ratio: Links = 0.7518, Movements = 0.8075
- Observed Gridlock: None.
- Observations:
  a. After looking at the batch file again, I realized that some of the signal plans might be slightly different than the Aug. 28 test. That one had 4:30 as the signal plan time to look for, and both of these have 3:30. I'll run a new test that has everything the same except the Random Seed so we have a definite base.
  b. Between the two different random seed tests there were some differences, but those were smaller than the difference between each test and the Aug 28 test, which leads me to believe that the signal timing may be to blame for some of that difference.
  c. The convergence looked different than it did for a random seed of 1 or 5. Changing this value does seem to have a significant impact on the speed and pattern of convergence, but the impact on flows is somewhat smaller.

pb_sept10_830a_Base

- Changes from last run:
  a. Random Seed = 1. The signals this time are the same as with the Sept 4 and 5 tests.
- Convergence: Min = 0.00750274, Max = 0.0882354, Mean = 0.0346544
- Runtime: Approx. 23.76 hours to do 60 iterations (this was run as an additional DTA in the Sept. 4 scenario, so some of the bucket rounding, etc. may not have been required, which would shorten the run time)
- RMSE: Links = 50% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 6.03, Movements = 4.16
- VMT = 1,458,712 miles; VHT (3:30-6:30pm) = 66,837 hours
- Overall Vol/Count Ratio: Links = 0.7533, Movements = 0.8057
- Observed Gridlock: None.
- Observations:
  a. Interestingly, the flow comparison seems to show a larger difference in the test where the Random Seed =2.
  b. Neither test showed large shifts of more than 1,600 vehicles over the 3-hour PM peak.

sf_sept7_1200p_ResetSpeedFlow?_v1

- Changes from last run:
  a. Discovered that speed, flow, and density parameters had been misunderstood. Reset vehicle effective length and response time to match intended parameters.
- Convergence: Min = 0.00773108, Max = 0.15868, Mean = 0.0483952
- Runtime: Approx. 23.87 hours to do 50 iterations
- Observed Gridlock: Gridlock occurs around 5:30 PM. Approximately 50k waiting vehicles accumulate and do not dissipate.
- Observations:

a This run resulted in severe congestion leading to gridlock. This was anticipated due to the significant increase in PCU effective length relative to previous runs. Subsequent runs will relax response time and jam density to observe the sensitivity of gridlock to these parameters.

sf_sept10_430p_ResetSpeedFlow?_v2

- Changes from last run:
  - a Reduced car and truck response time from 1.25 sec to 1.0 sec to test sensitivity of gridlock in previous run to response time.
- Convergence: Min = 0.00682784, Max = 0.131843, Mean = 0.050911
- Runtime: Approx. 44.78 hours to do 60 iterations
- RMSE: Links = 53% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.48, Movements = 4.28
- VMT = 1,357,472, VHT (3:30-6:30pm) = 67,550 hours
- Overall Vol/Count Ratio: Links = 0.7296, Movements = 0.8009
- Observed Gridlock: Starts around 18:00 at 25th St & Harrison (in the South); 3rd/Geary/Market; Freemont/Pine/Market; On-Ramp to I-80 at Freemont & Harrison; Stockton & Columbus, Mason & Columbus, Gough near California; after 18:10 the gridlock quickly spreads over the whole CBD and most of the rest of the Northern region.
- Observations:
  - a The gridlock is really bad here. In some areas it develops where we saw it when we had issues with trucks, but the locations along Market are clearly because of the changes to the car properties.
  - b The count-matching is clearly worse, but that may be more because there are so many vehicles that never even get to enter the network because of the gridlock.

sf_sept10_500p_ResetSpeedFlow?_v3

- Changes from last run:
  - a Car and truck response time still 1.0 sec. PCU effective length reduced to 20ft from 24ft and Truck effective length reduced from 36ft to 30ft.
- Convergence: Min = 0.00675461, Max = 0.0593676, Mean = 0.0264851
- Runtime: Approx. 50.29 hours to do 60 iterations
- RMSE: Links = 52% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.29, Movements = 4.32
- VMT = 1,469,785, VHT (3:30-6:30pm) = 62,884 hours
- Overall Vol/Count Ratio: Links = 0.7604, Movements = 0.8191
- Observed Gridlock: None.
- Observations:
  - a This test has no gridlock and very little congestion in the CBD. We really need to find a halfway point between the extreme gridlock caused by the V2 settings and the lack of congestion we see with these settings.
  - b This set of speed-flow parameters is going to be used in the first PB test for prohibiting left turns from connectors.

pb_sept11_LTCent

- Changes from last run:
  a Settings from V3 with left turns from centroids prohibited
- Convergence: Min = 0.00693941, Max = 0.0689223, Mean = 0.0304047
- Runtime: Approx. 34.94 hours to do 60 iterations (Running another instance of Dynameq and two other programs at the same time)
- RMSE: Links = 52% (1,748 counts), Movements = 75% (7,643 counts)
- GEH: Links = 6.39, Movements = 4.32
- VMT = 1,471,900, VHT (3:30-6:30pm) = 64,420 hours
- Overall Vol/Count Ratio: Links = 0.7518, Movements = 0.8151
- Observed Gridlock: Fleeting in some areas of the CBD. Rarely lasts more than 5-15 minutes.
- Observations:
  a This test creates gridlock where there wasn't even congestion with the V3 settings. Clearly, prohibiting the left turns over-crowds the other movements. It might be a better idea to just add a high penalty to those left turns instead of prohibiting them.

pb_sept12_LT2

- Changes from last run:
  a Still prohibiting left turns with car length set to 24ft and truck response time to 1.25sec
- Convergence: Min = 0.00685579, Max = 0.1337749, Mean = 0.0507178
- Runtime: Approx. 32.23 hours to do 60 iterations (Running another instance of Dynameq and two other programs at the same time)
- RMSE: Links = 52% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.31, Movements = 4.27
- VMT = 1,399,539, VHT (3:30-6:30pm) = 67,483 hours
- Overall Vol/Count Ratio: Links = 0.7417, Movements = 0.8065
- Observed Gridlock: 3rd & Market, Freemont & Market, Columbus; Spreads out to the rest of the CBD around 18:00.
- Observations:
  a This test has lots of gridlock.
  b I think we need to try an in-between test that is halfway between V2 and V3 settings.
  c I think we need to try penalizing the left turns from centroids instead of prohibiting them.

sf_sept13_ResetSpeedFlow_v4

- Changes from last run:
  a Test of effective length midpoint between v2 and v3 because v2 is gridlocked and v3 is not congested. Effective length for PCUs set to 22ft. Effective length of trucks set to 33ft.
- Convergence: Min = 0.00734649, Max = 0.127082, Mean = 0.0544831
- Runtime: Approx. 29.82 hours to do 60 iterations
- RMSE: Links = 51% (1,748 counts), Movements = 73% (7,643 counts)
- GEH: Links = 6.27, Movements = 4.24
- VMT = 1,439,454, VHT (3:30-6:30pm) = 65,007 hours
- Overall Vol/Count Ratio: Links = 0.761, Movements = 0.8169
- Observed Gridlock: Fleeting in some locations in the CBD, but never lasts more than 5-10 mins.

- Observations:
    a This one clearly didn't reach a very steady convergence, but it looked like it was good enough at 60 iterations to process the results and decide what to do next.
    b Some combination of these settings and a penalty on left turns out of centroids might be the best option to test next.
    c There was some occasional gridlock here, but not much. There was some serious congestion in parts of the CBD, so we want to avoid increasing the parameters beyond this until we test some of the settings in Dynameq (like gap acceptance) that could help with the congestion.

sf_sept18_ResetSpeedFlow_v4_extendedRuns

- Changes from last run:
    a Previous model run did not seem to be fully converged at 60 iterations. The DTA was continued to 85, 100, 125, and 130 iterations. At both 85 and 100 iterations results did not seem fully converged, so more iterations were added. Gridlock was present in 125th iteration, but absent in 130th iteration.
- Convergence: Min = 0.00678499, Max = 0.0405788, Mean = 0.02269
- Runtime: Approx. 80.41 hours to do 130 iterations (0.619 hr / iter.)
- RMSE: Links = 52% (1,748 counts), Movements = 74% (7,659 counts)
- GEH: Links = 6.35, Movements = 4.30
- VMT = 1,657,896, VHT (3:30-6:30pm) = 78,756 hours
- Average Speed (VMT/VHT) = 21.2 mph
- Overall Vol/Count Ratio: Links = 0.7522, Movements = 0.8143
- Max waiting vhcls: 351, Max traveling vhcls: 33,609
- Observed Gridlock: After some iterations gridlock was present, but not in the final iteration
- Observations:
    a Heavy congestion on EB Market approaching central freeway, and on WB Harrison at 4th.
    b Severe congestion upstream from WB Harrison occurs after 6:30 PM.
    c Clayton and Market needs to be corrected. Signalization is missing and cars are allowed to perform movements that only MUNI is allowed to make.

sf_sept18_ResetSpeedFlow_v5

- Changes from last run:
    a Uses same speed/flow/density parameters as V4, but adjusts critical gap settings. Critical gap values reduced by 50% from the default settings for all movement and control categories. Critical wait times were not adjusted.
- Convergence: Min = 0.00611203, Max = 0.18799, Mean = 0.0503522
- Runtime: Approx. 70.79 hours to do 130 iterations (0.545 hr / iter.)
- RMSE: Links = 51% (1,748 counts), Movements = 73% (7,659 counts)
- GEH: Links = 6.26, Movements = 6.34
- VMT = 1,643,236, VHT (3:30-6:30pm) = 78,510 hours
- Average Speed (VMT/VHT) = 20.9 mph
- Overall Vol/Count Ratio: Links = 0.7545, Movements = 0.8179
- Max waiting vhcls: 1,352, Max traveling vhcls: 36,589
- Observed Gridlock: None, all vehicles clear

- Observations: None

sf_sept25_ResetSpeedFlow_v6

- Changes from last run:
  - a PCU effective length remains at 22' (33' for trucks)
  - b Critical gap returned to default settings
  - c All follow-up times reduced by 20% (AWSC, TWSC, merge and signalized permitted mvmts)
- Convergence: Min = 0.00654758, Max = 0.0503777, Mean = 0.028217
- Runtime: Approx. 71.44 hours to do 90 iterations (0.79 hr / iter.)
- RMSE: Links = 51% (1,748 counts), Movements = 74% (7,659 counts)
- GEH: Links = 6.34, Movements = 4.33
- VMT = 1,658,414, VHT (3:30-6:30pm) = 77,295 hours
- Average Speed (VMT/VHT) = 21.5 mph
- Overall Vol/Count Ratio: Links = 0.7503, Movements = 0.8094
- Max waiting vhcls: 577, Max traveling vhcls: 33,270
- Observed Gridlock: None, all vehicles clear
- Observations: None.

sf_sept25_ResetSpeedFlow_v7

- Run v7 was not completed. The model crashed midway through and was not restarted. By the time the crash occurred other model runs rendered v7 unnecessary.

sf_sept25_ResetSpeedFlow_v8

- Changes from last run:
  - a PCU eff. length reduced to 21' (31.5' for trucks)
  - b Critical gaps reduced by 20% for crossing, merging, TWSC, Merge, and Signalized movements
- Convergence: Min = 0.00677008, Max = 0.0833202, Mean = 0.0370174
- Runtime: Approx. 46.31 hours to do 60 iterations (0.77 hr / iter.)
- RMSE: Links = 51% (1,748 counts), Movements = 74% (7,659 counts)
- GEH: Links = 6.24, Movements = 4.25
- VMT = 1,673,241, VHT (3:30-6:30pm) = 77,680 hours
- Average Speed (VMT/VHT) = 21.5 mph
- Overall Vol/Count Ratio: Links = 0.7619, Movements = 0.8176
- Max waiting vhcls: 222, Max traveling vhcls: 30,709
- Observed Gridlock: None, all vehicles clear
- Observations: None.

pb_sept26_530p_V9

- Changes from last run:
  - a Vehicle lengths changed to 21ft and 31.5 ft for cars and trucks

b. Critical gaps reduced by 20% for crossing, merging, TWSC, Merge, and Signalized movements
c. Distance term added to generalized cost expression

- Convergence: Min = 0.00512647, Max = 0.0506207, Mean = 0.0214311
- Runtime: Approx. 38.13 hours to do 70 iterations (two other models running at the same time)
- RMSE: Links = 52% (1,748 counts), Movements = 75% (7,643 counts)
- GEH: Links = 6.30, Movements = 4.29
- VMT = 1,627,728, VHT (3:30-6:30pm) = 77,972 hours
- Average Speed (VMT/VHT) = 20.9 mph
- Overall Vol/Count Ratio: Links = 0.7496, Movements = 0.8083
- Observed Gridlock: Columbus Ave., Bay St. around Columbus, Stockton, Geary/Market/3rd St; quickly spreads from these areas to whole CBD after 18:20
- Observations:
  a. This one is very clearly converged, but there is still significant gridlock.
  b. Once we have the results of V8, we can see how much of the gridlock is caused by the distance term in the Generalized Cost and how much by the changes to the critical gap.

pb_sept27_900a_V10

- Changes from last run:
  a. Vehicle lengths set to 21ft and 31.5 ft for cars and trucks
  b. Critical gaps and follow-up time all set to defaults except TWSC RT and Thru follow-up and Merge follow-up all decreased by 20%.
- Convergence: Min = 0.00658655, Max = 0.0646256, Mean = 0.0278028
- Runtime: Approx. 67.35 hours to do 80 iterations (two other models running at the same time)
- RMSE: Links = 51% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.30, Movements = 4.29
- VMT = 1,654,206, VHT (3:30-6:30pm) = 78,366 hours
- Average Speed (VMT/VHT) = 21.1 mph
- Overall Vol/Count Ratio: Links = 0.7485, Movements = 0.8105
- Observed Gridlock: For the most part, there seems to be not a lot of congestion. The only problem area is at Market & Freemont where it actually backs up the I-80W off-ramp and creates congestion back onto I-80W, but only after 19:15 (which is really odd).
- Observations:
  a. With these settings we get very little congestion. This makes some sense since we decreased the vehicle lengths.

pb_sept27_930a_V11

- Changes from last run:
  a. Vehicle lengths set to 21ft and 31.5 ft for cars and trucks
  b. Critical gaps and follow-up time all set to defaults except TWSC RT and Thru follow-up and Merge follow-up all decreased by 20%.
  c. Distance term added to generalized cost expression
- Convergence: Min = 0.00526515, Max = 0.0388225, Mean = 0.0205391
- Runtime: Approx. 64.46 hours to do 80 iterations (two other models running at the same time)

- RMSE: Links = 51% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.19, Movements = 4.28
- VMT = 1,634,490, VHT (3:30-6:30pm) = 77,110 hours
- Average Speed (VMT/VHT) = 21.2 mph
- Overall Vol/Count Ratio: Links = 0.7544, Movements = 0.8094
- Observed Gridlock: Starts and Columbus Ave. and intersecting streets such as Bay St., Taylor, Stockton, Mason, etc.; Spreads out to the rest of the CBD after 18:20
- Observations:
    a Like V9, the convergence is clearly stable after 80 iterations, but there is significant gridlock.
    b Comparing this to the results of V10, we can see that the generalized cost term creates a lot of congestion that is not there otherwise.
    c Our next test should be to try the same settings with a smaller coefficient on the generalized cost (half of the current coefficient).

pb_oct1_500p_V12

- Changes from last run:
    a Vehicle lengths set to 21ft and 31.5 ft for cars and trucks
    b Critical gaps and follow-up time all set to defaults except TWSC RT and Thru follow-up and Merge follow-up all decreased by 20%.
    c Coefficient of distance term halved (now 14.4)
- Convergence: Min = 0.00573276, Max = 0.0441135, Mean = 0.021717
- Runtime: Approx. 25.85 hours to do 70 iterations
- RMSE: Links = 51% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.30, Movements = 4.27
- VMT = 1,656,335, VHT (3:30-6:30pm) = 76,288 hours
- Average Speed (VMT/VHT) = 21.7 mph
- Overall Vol/Count Ratio: Links = 0.7475, Movements = 0.8079
- Observed Gridlock: None.
- Observations:
    a Convergence looked steady after 70 iterations with no gridlock.
    b By halving the coefficient on the generalized cost term, we can still get results without gridlock.
    c Test V13 will keep these same settings with the vehicle lengths increased back up to 22 and 33 ft respectively.
    d For other test going forward we should process the V6 and V8 results and compare them to V10 to see which critical gap/follow-up time settings give the best results. We can then apply the different vehicle lengths and generalized cost terms to the best one.

pb_oct3_900a_V13

- Changes from last run:
    a Vehicle lengths set to 22ft and 33 ft for cars and trucks
    b Critical gaps and follow-up time all set to defaults except TWSC RT and Thru follow-up and Merge follow-up all decreased by 20%.
    c Coefficient of distance term halved (now 14.4)

- Convergence: Min = 0.00557595, Max = 0.0783259, Mean = 0.0360715
- Runtime: Approx. 34.32 hours to do 100 iterations (messy convergence)
- RMSE: Links = 51% (1,748 counts), Movements = 73% (7,643 counts)
- GEH: Links = 6.19, Movements = 4.24
- VMT = 1,631,560, VHT (3:30-6:30pm) = 78,726 hours
- Average Speed (VMT/VHT) = 20.7 mph
- Overall Vol/Count Ratio: Links = 0.7547, Movements = 0.8144
- Observed Gridlock: None.
- Observations:
    - a Convergence was really unsteady, but there was no gridlock at the end of the simulation.
    - b The count-matching seems to be better here with more congestion due to the increase in car length (vs. V12).
    - c There is some very heavy congestion in the CBD here, but it clears out by the end of the simulation time.
    - d Given the amount of congestion, with these settings we would definitely get gridlock in a test with future demand.

pb_oct8_1230p_V14

- Changes from last run:
    - a Same settings as V8 test for critical gap and follow-up time
    - b Vehicle lengths set to 22ft and 33ft
    - c Distance term of 14.4*length added to generalized cost function
- Convergence: Min = 0.00559359, Max = 0.0419954, Mean = 0.0232241
- Runtime: Approx. 40.40 hours to do 100 iterations (could have probably stopped around 80, but I was in meetings all day yesterday so let it run to 100)
- RMSE: Links = 51% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.29, Movements = 4.27
- VMT = 1,636,903, VHT (3:30-6:30pm) = 77,819 hours
- Average Speed (VMT/VHT) = 21.0 mph
- Overall Vol/Count Ratio: Links = 0.7475, Movements = 0.8083
- Observed Gridlock: None.
- Observations:
    - a Very converged by the time it stopped.
    - b There is some heavy congestion in the CBD and on 25th St, Gough, and Laguna between 19:00 and 19:30, but it's not as bad as in V13.
    - c This test actually does a worse job of matching counts than the V8 test without the distance term in the generalized cost.
    - d We may need to have some compromise here. The next test that would be good to do might be V8 critical gaps and follow-up time with the generalized cost term but with the vehicle lengths decreased to 21 and 31.5.

pb_oct10_400p_V15

- Changes from last run:
    - a Same settings as V8 test for critical gap, follow-up time and vehicle length

    b. Distance term of 14.4*length added to generalized cost function
- Convergence: Min = 0.0056292, Max = 0.0400427, Mean = 0.0203637
- Runtime: Approx. 60.33 hours to do 80 iterations (takes more time when running at the same time as a test with facility type penalty)
- RMSE: Links = 51% (1,748 counts), Movements = 74% (7,643 counts)
- GEH: Links = 6.25, Movements = 4.27
- VMT = 1,661,988, VHT (3:30-6:30pm) = 77,527 hours
- Average Speed (VMT/VHT) = 21.4 mph
- Overall Vol/Count Ratio: Links = 0.7478, Movements = 0.8092
- Observed Gridlock: None.
- Observations:
    a. There is some congestion but no gridlock.
    b. These results are not too different (in terms of count-matching). Hopefully the test with the facility type penalty will show better results.

pb_oct10_500p_V16

- Changes from last run:
    a. Same settings as V8 test for critical gap, follow-up time and vehicle length
    b. Distance term of 14.4*length added to generalized cost function
    c. Facility type penalty of 1/2 FF Time added to generalized cost function
- Convergence: Min = 0.00414533, Max = 0.0526134, Mean = 0.0247232
- Runtime: Approx. 60.66 hours to do 80 iterations (takes more time when running at the same time as a test with facility type penalty)
- RMSE: Links = 48% (1,748 counts), Movements = 72% (7,643 counts)
- GEH: Links = 6.05, Movements = 4.17
- VMT = 1,677,175, VHT (3:30-6:30pm) = 80,639 hours
- Average Speed (VMT/VHT) = 20.8 mph
- Overall Vol/Count Ratio: Links = 0.8321, Movements = 0.8679
- Observed Gridlock: None.
- Observations:
    a. There is not much congestion.
    b. These results are really good compared to what we've been seeing in other tests.

pb_oct15_430p_V17

- Changes from last run:
    a. Same settings as V16 with the transit lanes allowing right-turns added
- Convergence: Min = 0.00398136, Max = 0.0725547, Mean = 0.0371406
- Runtime: Approx. 31.93 hours to do 100 iterations (needed 100 and still didn't have a very steady/stable convergence)
- RMSE: Links = 50% (1,748 counts), Movements = 72% (7,659 counts)
- GEH: Links = 6.24, Movements = 4.22
- VMT = 1,630,582, VHT (3:30-6:30pm) = 82,980 hours
- Average Speed (VMT/VHT) = 19.7 mph
- Overall Vol/Count Ratio: Links = 0.7968, Movements = 0.8496

- Observed Gridlock: Many areas of the CBD, but not severe enough that it didn't clear by the end of the simulation.
- Observations:
    a There is way too much congestion to use these settings for testing anything like future demand.
    b It's possible that also splitting the approaches to centroid connectors would help some of this congestion, but it may be that in some areas of the CBD we just don't have enough capacity on some of these links to accommodate all of the traffic.
    c We might want to consider slightly increasing capacities in the CBD to account for the fact that in real life, drivers to use those bus-only lanes at times to get around congestion even if they're not turning right.

sf_octxx_V18

- Changes from last run:
    a Same as V17 run, but different implementation of transit lanes. In the previous run transit lane links are split in half to allow right turning vehicle to use transit lanes at intersections. In this run links are also split to allow right turning vehicles to use the transit lanes for access to centroid connectors.
- Observed Gridlock: The model run is heavily congested. Gridlock appears and does not dissipate. Waiting vehicles never enter the network and traveling vehicles never clear.
- Observations:
    a Heavy congestion on SB US-101 from downtown to San Mateo border. Approaches at Octavia, 10th, S. Van Ness, and Cesar Chavez all experience lengthy approach queues.
    b US-101 congestion highlighted a couple of network coding errors on the Central Freeway that either reduce approach throughput or alter intersection configuration.

sf_oct22_V19

- Changes from last run:
    a Same as V17, but with minor updates to transit lane link splitting logic. Very short links are no longer split. Also removes the distance term from the generalized cost expression for cars (but maintains it for trucks). JHC 2012 land use is not used, but it will be implemented for the next run.
- Observed Gridlock: Yes.
- Observations: Gridlock.

sf_oct29_V20 (finalCalibration1)

- Changes from last run:
    a JHC 2012 land use
    b Effective length factor of 0.95 in AT0 and AT1 (1.0 elsewhere)
    c All turning movements are permitted, unless they have a dedicated signal phase (in which case turn is protected movement)
    d 21' effective PCU length (trucks x1.5)
    e Turning movement follow-up times are 2.0 sec (AT2+), 2.22 sec (AT1) and 2.67 (AT0)

f Response time factor of 0.8 for weaving link of NB US-101
g Same bus lane implementation as previous run
h 21' effective PCU length (trucks x1.5)

- Convergence: Min = 0.453391%, Max = 10.4815%, Mean = 4.45782%
- Runtime: Approx. 44.6 hours to do 65 iterations
- RMSE: Links = 52% (1,740 counts), Movements = 75% (7,643 counts)
- GEH: Links = 6.33, Movements = 4.29
- VMT = 1,702,774, VHT (3:30-6:30pm) = 80,226 hours
- Average Speed (VMT/VHT) = 21.2 mph
- Overall Vol/Count Ratio: Links = 0.8483, Movements = 0.8818
- Observed Gridlock: Gridlock present at 50 iterations. No gridlock at 65 iterations.
- Observations:
  a Heavy congestion and long multi-block queues throughout the CBD.
  b Vehicles can clear, but it takes a long time.

sf_oct29_V21 (finalCalibration2)

- Changes from last run:
  a All turning movements are permitted, unless they have a dedicated signal phase (in which case turn is protected movement)
  b 20.5' effective PCU length (trucks x1.5)
  c Turning movement follow-up times are 2.0 sec (AT2+), 2.11 sec (AT1) and 2.22 (AT0)
- Convergence: Min = 0.461168%, Max = 7.03288%, Mean = 3.19193%
- Runtime: Approx. 65 hours to do 47.95 iterations
- RMSE: Links = 52% (1,740 counts), Movements = 77% (7,643 counts)
- GEH: Links = 6.37, Movements = 4.30
- VMT = 1,720,317, VHT (3:30-6:30pm) = 78,768 hours
- Average Speed (VMT/VHT) = 21.8 mph
- Overall Vol/Count Ratio: Links = 0.8464, Movements = 0.8716
- Observed Gridlock: None
- Observations:
  a Very little congestion on freeways or local roads.
  b No congestion on EB I-80 over Bay Bridge

pb_oct29_V22 (finalCalibration3)

- Changes from last run:
  a All turning movements are permitted, even when there is a dedicated turning movement phase
  b 21' effective PCU length (trucks x1.5)
  c Turning movement follow-up times are 2.0 sec (AT2+), 2.11 sec (AT1) and 2.22 (AT0)
- Convergence: Min = 0.467392%, Max = 10.602%, Mean = 5.00126%
- Runtime: Approx. 62.80 hours to do 77 iterations
- RMSE: Links = 51% (1,740 counts), Movements = 73% (7,643 counts)
- GEH: Links = 6.17, Movements = 4.20
- VMT = 1,709,866, VHT (3:30-6:30pm) = 79,365 hours

- Average Speed (VMT/VHT) = 21.5 mph
- Overall Vol/Count Ratio: Links = 0.8462, Movements = 0.8714
- Observed Gridlock: No gridlock at 77 iterations
- Observations:
    - a Fairly heavy congestion.
    - b V24 tests the same parameters, but with protected turn phases for protected turning movements

pb_oct29_V23 (finalCalibration4)

- Changes from last run:
    - a All turning movements are permitted, even when there is a dedicated turning movement phase
    - b 20.5' effective PCU length (trucks x1.5)
    - c Turning movement follow-up times are 2.0 sec (AT2+), 2.22 sec (AT1) and 2.67 (AT0)
- Observations:
    - a Model run completed on PB computers

sf_oct31_V24 (finalCalibration5)

- Changes from last run:
    - a All turning movements are permitted, unless they have a dedicated signal phase (in which case turn is protected movement)
    - b 21' effective PCU length (trucks x1.5)
    - c Turning movement follow-up times are 2.0 sec (AT2+), 2.11 sec (AT1) and 2.22 (AT0)
- Convergence: Min = 0.464949%, Max = 10.5833%, Mean = 4.44329%
- Runtime: Approx. 32.33 hours to do 70 iterations
- RMSE: Links = 51% (1740 counts), Movements = 76% (7643 counts)
- GEH: Links = 6.32, Movements = 4.28
- VMT = 1,720,317, VHT (3:30-6:30pm) = 78,768 hours
- Average Speed (VMT/VHT) = 21.8 mph
- Overall Vol/Count Ratio: Links = 0.8512, Movements = 0.8741
- Observed Gridlock: No gridlock at 70 iterations, but heavy congestion accumulates and clears in later periods.
- Observations:
    - a Long queues develop for many blocks along key arteries.
    - b Lots of congestion around Battery and Market. For future runs will need to shift 8 seconds from Market St green time to Battery/1st.
    - c Lane configurations for Bay Bridge entrances at 1st and Essex need to be adjusted. Need to adjust response time factor to account for merging as well.

pb_nov1_NetChg (Network Change Sensitivity Test)

- Changes from last run:
    - a Some slight changes to signals and bus dwell times vs. V24
    - b 5-block section of Sunset Blvd has one lane removed in each direction
    - c Dynamic Path Search was used in the DTA

- Convergence: Min = 0.471757%, Max = 9.73225%, Mean = 4.74552%
- Runtime: Approx. 51.13 hours to do 80 iterations (moved to a faster computer at iteration 64)
- RMSE: Links = 51% (1740 counts), Movements = 73% (7643 counts)
- GEH: Links = 6.23, Movements = 4.22
- VMT = 1,712,952, VHT (3:30-6:30pm) = 82,294 hours
- Average Speed (VMT/VHT) = 20.8 mph
- Overall Vol/Count Ratio: Links = 0.8283, Movements = 0.8614
- Observed Gridlock: None. Heavy congestion in some areas, but no total gridlock.
- Observations:
    a Convergence looks very different than without dynamic path search. There is a second peak in the relative gaps around 60 iterations where the later time periods begin to break up the congestion and choose better paths.
    b Some heavy congestion at Broadway and Battery. Maybe worth checking to see if a signal is causing this since there's not as much congestion anywhere else in the CBD.
    c Still seem to have issues at I80W off-ramp to Freemont. This area gets very heavily congested toward the end of the simulation time.

pb_nov8_V25

- Changes from last run:
    a Same as SF's V25 run but with 0.8 RTF on freeways in AT0 and AT1
- Convergence: Min = 0.473007%, Max = 6.56926%, Mean = 3.19799%
- Runtime: Approx. 53.16 hours to do 85 iterations
- RMSE: Links = 51% (1740 counts), Movements = 74% (7643 counts)
- GEH: Links = 6.17, Movements = 4.22
- VMT = 1,721,058, VHT (3:30-6:30pm) = 79,246 hours
- Average Speed (VMT/VHT) = 21.7 mph
- Overall Vol/Count Ratio: Links = 0.8376, Movements = 0.8643
- Observed Gridlock: None.
- Observations:
    a Not as much congestion in this test. Lowering the response time on freeways in/near the CBD really clears up some areas where we were seeing congestion in previous tests.
    b The convergence was still a bit messy with this one. There were three separate peaks in the relative gap: one at around 20 iterations, another at about 42 iterations, and one at about 63 iterations. Hopefully the newer version of Dynameq will help get rid of some of this odd behavior so that we reach convergence sooner. Having to run this out past 80 iterations means a long time to do each test.

resetspeedflow_v24_Dyn26

- Changes from last run:
    a Same as V25 w/Dwell but running in Dynameq 2.6.0
- Convergence: Min = 0.274272%, Max = 6.19217%, Mean = 2.66666%
- Runtime: Approx. 108.8 hours (4.53 days) to do 100 iterations
- RMSE: Links = 53% (1740 counts), Movements = 76% (7643 counts)
- GEH: Links = 6.30, Movements = 4.23

- VMT = 1,701,490, VHT (3:30-6:30pm) = 83,919 hours
- Average Speed (VMT/VHT) = 20.27 mph
- Overall Vol/Count Ratio: Links = 0.8332, Movements = 0.8901
- Observed Gridlock: None.
- Observations:
  a Some congestion in the CBD around Columbus, but anything bad enough to cause gridlock.
  b There were some odd jumps in the relative gaps in later iterations, but it looks converged at 100 iterations.

pb_nov15_300p_netchg3

- Changes from last run:
  a Same as SF Reset Speed Flow V24 w/ Dwell but Sunset has 1 fewer lane in each direction from Ortega to Taraval
- Convergence: Min = 0.272598%, Max = 6.98232%, Mean = 2.9929%
- Runtime: Approx. 56.95 hours (2.37 days) to do 80 iterations
- RMSE: Links = 54% (1740 counts), Movements = 78% (7643 counts)
- GEH: Links = 6.38, Movements = 4.29
- VMT = 1,701,676, VHT (3:30-6:30pm) = 85,021 hours
- Average Speed (VMT/VHT) = 20.01 mph
- Overall Vol/Count Ratio: Links = 0.8265, Movements = 0.8815
- Observed Gridlock: None.
- Observations:
  a Some congestion in the CBD around Columbus, but anything bad enough to cause gridlock.
  b There were some odd jumps in the relative gaps in later iterations, but it looks converged at 80 iterations.
  c More detailed analysis of changes in flow and travel times on each link will be used for the sensitivity analysis.

sf_brt_scenario

- Changes from last run:
  a BRT center lane on Mission from 14th St to Cesar Chavez, lanes on Mission and South Van Ness adjusted
- RMSE: Links = 52% (1740 counts), Movements = 76% (7643 counts)
- GEH: Links = 6.23, Movements = 4.26
- VMT = 1,703,312, VHT (3:30-6:30pm) = 84,000 hours
- Average Speed (VMT/VHT) = 20.28 mph
- Overall Vol/Count Ratio: Links = 0.8496, Movements = 0.8932
- Observed Gridlock: None.
- Observations: See Analysis of Applications Report.

pb_nov15_futdem

- Changes from last run:
  a 2012 network with 2040 demand
- Convergence: Min = 0.357%, Max = 21.7%, Mean = 8.87%

- Runtime: Approx. 101.8 hours (4.24 days) to do 130 iterations
- RMSE: Links = 52% (1740 counts), Movements = 79% (7643 counts)
- GEH: Links = 6.13, Movements = 4.14
- VMT = 1,909,226, VHT (3:30-6:30pm) = 113,254 hours
- Average Speed (VMT/VHT) = 16.86 mph
- Overall Vol/Count Ratio: Links = 0.8871, Movements = 0.9584
- Observed Gridlock: Some around Columbus, Turk, and links feeding onto I-80, but it clears by the end of the simulation time
- Observations:
    a Heavy congestion, but it does clear by the end of the simulation.
    b Even after 130 iterations, it wasn't very converged because of the high levels of congestion.

pb_nov19_RS

- Changes from last run:
    a Random Seed Test (Random Seed =2)
- Convergence: Min = 0.307%, Max = 7.90%, Mean = 3.37%
- Runtime: Approx. 46.70 hours (1.94 days) to do 80 iterations
- RMSE: Links = 53% (1740 counts), Movements = 77% (7643 counts)
- GEH: Links = 6.30, Movements = 4.27
- VMT = 1,710,198, VHT (3:30-6:30pm) = 85,906 hours
- Average Speed (VMT/VHT) = 19.9 mph
- Overall Vol/Count Ratio: Links = 0.8467, Movements = 0.8988
- Observed Gridlock: None.
- Link to Validation Spreadsheets: PB Random Seed Test Reports
- Observations:
    a Flow values vary more than we would expect in some areas.

sf_nov21_pricing

- Changes from last run:
    a Congestion Pricing Application Test
- Convergence: Min = 0.0501%, Max = 5.51%, Mean = 2.03%
- Runtime: Approx. 50.6 hours (2.11 days) to do 70 iterations
- RMSE: Links = 68% (1740 counts), Movements = 98% (7643 counts)
- GEH: Links = 8.45, Movements = 5.22
- VMT = 1,443,680, VHT (3:30-6:30pm) = 67,866 hours
- Average Speed (VMT/VHT) = 21.3 mph
- Overall Vol/Count Ratio: Links = 0.5565, Movements = 0.6454
- Observed Gridlock: None.
- Link to Validation Spreadsheets: SF Congestion Pricing Application Test Reports
- Observations:
    a Demand is much lower, so there is little to no congestion.
    b Even the CBD is pretty clear with heavy congestion in only a few places and dissipating quickly.
    c Flow moves away from the CBD to take paths that avoid going through that area.