# San Francisco County Transportation Authority (SFCTA) Travel Model Peer Review Report

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U.S. Department of Transportation
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## Disclaimer

The views expressed in this document do not represent the opinions of FHWA and do not constitute an endorsement, recommendation or specification by FHWA. The document is based solely on the discussions that took place during the peer review sessions and supporting technical documentation provided by San Francisco County Transportation Authority (SFCTA).

## Acknowledgements

The FHWA wishes to acknowledge and thank the peer review panel members for volunteering their time to participate in the peer review of the SFCTA travel demand model (TDFM) and for sharing their valuable experience.

The Peer Review Panel Members were:

- Joe Castiglione (Resource Systems Group)
- Xuesong Zhou (University of Utah)
- David Stanek (Fehr & Peers)
- Bruce Griesenbeck (Sacramento Area Council of Governments)
- Vassilis Papayannoulis (IBI Group)

Brief biographies for each of the peer review panel members are presented in Appendix C.

## Report Organization

This report is organized into the following sections:

- Overview of SFCTA – this section gives an introduction to the demographics, land use and transportation characteristics of the region, and SFCTA's planning responsibilities.
- Development of the SFCTA DTA Model – this section provides a historical context of travel modeling at SFCTA, development of DTA model framework, SFCTA's current model improvement program, and their goals for the peer review.
- Model Improvement Plan of SFCTA – intended use of the DTA model and its contribution to improving the travel model.
- Topics of Interest to SFCTA – a list of topics prepared by SFCTA in the context of the DTA model to guide the peer review discussion.
- Peer Review Panel Response to SFCTA Questions– review panel responses to the specific technical questions posed by SFCTA.
- Panel Discussion and Recommendations – this section provides the peer review panel's recommendations to SFCTA including prioritized next steps.

In addition, the report includes the following appendices:

- Appendix A – list of peer review participants
- Appendix B – peer review meeting agenda
- Appendix C – biographies for each of the peer review panel members
- Appendix D – SFCTA DTA project calibration and validation report
- Appendix E – SFCTA DTA project model integration options report

## Report Purpose

This report summarizes the results of a peer review of the SFCTA Dynamic Traffic Assignment (DTA) model. The peer review was supported by the Travel Model Improvement Program (TMIP), which is sponsored by FHWA. The peer review of a travel model can serve multiple purposes, including identification of model deficiencies, recommendations for model enhancements, and guidance on model applications. This peer review focused specifically on the DTA model being developed by the SFCTA, and not on the SFCTA's overall SF-CHAMP activity-based travel demand model system. Given the increasing complexities of travel demand forecasting practice and the growing demands by decision-makers for information about policy alternatives, it is essential that travel forecasting practitioners have the opportunity to share experiences and insights. The TMIP-supported peer review provides a forum for this knowledge exchange.

SFCTA's overall goal for model improvement and motivation for seeking a TMIP peer review is to obtain feedback on its ongoing efforts towards developing a DTA model and using it for analyzing proposed transit improvements, analyzing traffic diversions caused by those transit improvements, and comparing the effectiveness of roadway pricing alternatives. In order to make the project successful, the authority sought an assessment of the DTA model developed so far along with strategic guidance on calibration and validation of the model. The peer review panel was also requested to provide suggestions on how the agency's activity-based travel demand model, called SF-CHAMP (San Francisco's Chained Activity Modeling Process), may optimally be integrated with the DTA model currently in development. To that end, the peer reviewers spent one day discussing the needs and goals of the Authority and then responding to specific questions from SFCTA and its planning partners. The results of that discussion and recommendations from the panel are presented here. SFCTA and its partner agencies should carefully assess the feedback from the peers when prioritizing its final model development plan. While the advice of the peers is invaluable, there are many factors to work through when considering a model improvement strategy: the peer recommendations should be regarded as suggestions for SFCTA and its partners to consider rather than prescriptions to be followed.

# 1.0 San Francisco County Transportation Authority Overview

## *1.1 San Francisco County Transportation Authority Responsibilities*

The San Francisco County Transportation Authority (the Authority) is the transportation planning agency for city and county of San Francisco (Figure 1). The Authority was originally created in 1989 to administer funds from Prop B, a local sales tax for transportation. It currently administers and oversees the delivery of Prop K sales tax program which has superseded the original sales tax measure. The Authority has been called upon to take on a number of additional roles and responsibilities since its establishment. It is the designated Congestion Management Agency (CMA) of San Francisco County and is responsible for developing and maintaining San Francisco's official travel demand model: SF-CHAMP (San Francisco's Chained Activity Modeling Process). Since 1990, the Authority has also served as the San Francisco Program Manager for grants from the Transportation Fund for Clean Air (TFCA).

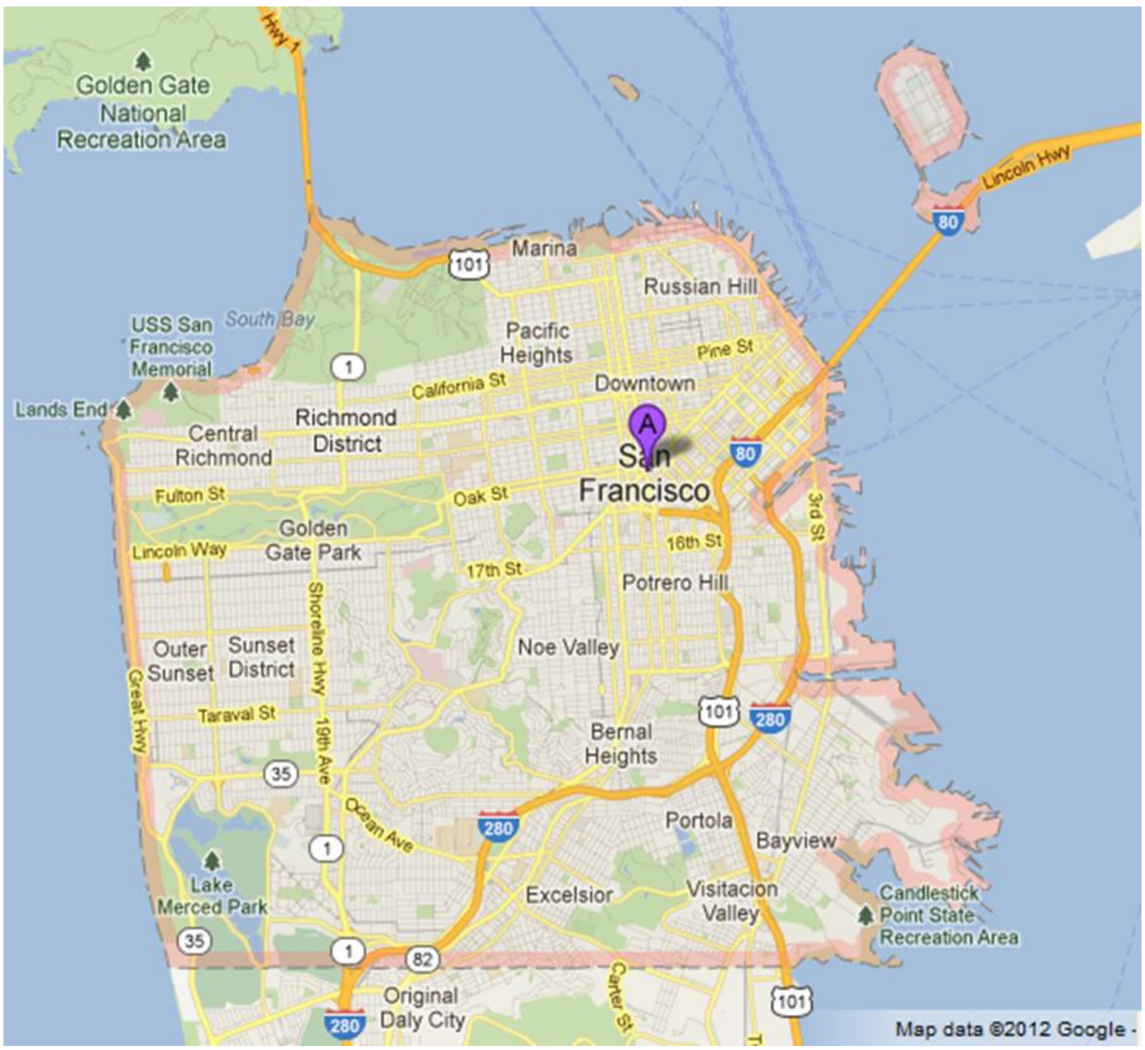


**Figure 1: City and County of San Francisco**

## 1.2 Regional Characteristics and Transportation Issues

San Francisco is the 13th largest city in the United States and has a population of 805,235 according to the 2010 decennial census. In the last couple of decades, the population grew by about 80,000 and is expected to grow by more than 100,000 residents over the next few decades. Bounded on three sides by water, the daytime population of the 49-square mile city is close to 1 million. The city's street network is primarily a regular grid system overlapped by dense local and regional transit networks.

To accommodate its projected economic and demographic growth levels, San Francisco needs to trigger a major modal shift from autos to more 'roadway capacity efficient' modes such as bus, bicycling, and walking. This shift would be in line with the city's "transit first" and greenhouse gas reduction policies. To this end, policies which promote such a shift need to be analyzed. Examples of such policies include congestion pricing, a bus rapid transit (BRT) network, and "road diets" in the very densest parts of San Francisco in order to accommodate bicycle and pedestrian throughput. Presently, there are not many reliable and proven modeling tools to make robust predictions of the behavioral response to such policies. The city needs to spend adequate time and resources to develop the next generation of modeling tools capable of analyzing alternative projects that have potentially significant cost savings and long-term benefits.

# 2.0 Development of the San Francisco County Transportation Authority DTA Model

## 2.1 Introduction

This section of the report provides an overview of the development of the SFCTA DTA model, including a description of the current version of the model, its uses and latest updates. There is also a brief overview of SFCTA's travel demand model to provide some background. Towards the end, this section describes SFCTA's goals for the peer review.

The Authority's official travel demand forecasting tool is called San Francisco Chained Activity Modeling Process (known as SF-CHAMP). It is a state-of-the-art activity-based model that can be used to assess the impacts of land use, socioeconomic, and transportation system changes on the performance of the local transportation system. SF-CHAMP is different from traditional four-step model as it is tour-based and not trip-based. A tour is a chain of trips made by an individual that begins and ends at home with intermediate stops at locations other than home, whereas a trip is a single movement from an origin to a destination. The model structure as such is more complex and is sensitive to a broader set of factors that influence travelers' choices. This tool is used for many Authority planning studies and projects.

In the recent past, SFCTA has been using Dynamic Traffic Assignment (DTA) instead of the traditional Static User Equilibrium (SUE) assignment technique for a few projects in the northwestern section of the city. DTA provides planners with a better understanding of the how-and-why of traffic routing itself around San Francisco. DTA aims to represent the interaction between a time-varying network and demand in a behaviorally sound manner. In static assignment, the congestion or performance properties of a link in a network are described by a volume-delay function (VDF) which provides the relationship between the average or steady-state travel time on the link and the traffic volume of the link. The demand is loaded and routed on a set of shortest paths. Static assignment results in a volume-capacity (V/C) ratio for each link whose value may be well over one for congested links. On the other hand, DTA typically loads the demand as individual vehicles or packets of vehicles on shortest paths, consistent with the fundamental diagram of traffic flow and thus accounting for congestion and spillbacks. Overall, DTA gives planners a more fine-grained view of transportation system performance. Recently, the Authority obtained a grant from the Federal Highway Administration (FHWA) to expand the DTA model to cover the rest of San Francisco under a project nicknamed "DTA Anyway."

## 2.2 History of San Francisco County Transportation Authority DTA Model

San Francisco's tour-based travel demand model, SF-CHAMP, is capable of predicting precise changes in travel behavior in response to policies such as pricing but is limited in its ability to predict responses to operational improvements due to the use of SUE traffic assignment. Hence, to analyze strategies such as transit signal priority and network geometry changes, the city used traffic micro-simulation. However, linking the macro-behavioral sensitivity of demand models with the car-following behavioral sensitivity of traffic micro-simulation models has its own issues due to various reasons:

1) The demand from a static traffic assignment model (or SUE assignment) can be high and simply feeding this into a microsimulation model may lead to unrealistic traffic congestion. This is because the demand level in the static traffic assignment model is

calibrated using its own BPR-type volume-delay function, which is significantly different from the car following and meso-scopic traffic flow models used in DTA. The demand from static assignment does not represent real capacity constraints that should in reality result in switching to other modes, times of day, destinations, or routes. This often leads to the demand being reduced in an ad-hoc manner just to get the microsimulation model to run and produce results.

2) The SUE assignment cannot represent operational improvements that will lead to induced demand or the return of latent demand. Thus, the demand fed into the traffic micro-simulation model does not increase enough and the benefits of these operational improvements are often over-predicted.
3) When analyzing a subarea of the region, the context of the larger trip gets lost. In the case of an auto capacity-reducing project, many of the impacts are felt outside the modeled corridor and in the case of a grid network can be spread across the whole city. Most traffic micro-simulation models are only built for the limited corridor where the change occurs, and are not able to quantify the impacts to streets beyond it. It should however be noted that this is also an issue with subarea travel demand models in general.

The Authority needed a tool that could make robust predictions of the changes in traffic flow as a result of policy or network changes in order to evaluate the effects of various transportation projects being considered. Similar to the way that SF-CHAMP travel demand forecasting model provides a very detailed understanding of the intricate travel demand decisions of individuals for the entire region, DTA models are capable of providing insights into the behavior and flow of traffic and transit vehicles. DTA models incorporate transportation system performance details such as traffic signal timing, queue formation, and route choice decisions—important considerations when analyzing projects in San Francisco. DTA could be robustly used to measure both the local impacts of large, regional projects and also the regional impacts of local projects.

Based on its immediate needs, SFCTA developed a DTA network for the northwestern quadrant of the city. INRO's Dynameq software was chosen as the DTA package since it had a mature user interface and it also provided a highly detailed network representation including lane-based delays and explicit representation of transit vehicles and schedules. The DTA model was used for evaluating the following two projects and questions:

- Introduction of Bus Rapid Transit (BRT) on Geary Boulevard
    - Where do vehicles re-route when a lane is taken away from Geary Blvd.?
    - How do diversions affect other streets?
- Long-term ramp closures due to construction on Presidio Parkway
    - Where do vehicles re-route when intra-SF ramps are taken away on Doyle Drive?

The following issues and observations arose from the use of DTA in the two projects specified above:

- DTA represents and assumes complete knowledge of network level of service (LOS) which results in drastic shifts away from main-line roadways and underestimates congestion on them

- The subarea being analyzed is reliant on demand from external stations
- Validation of turn movements is important
- The results are dependent on centroid-connector placement
- Validation data are generally conflicting

To gain further insight into network supply, the Federal Highway Administration (FHWA) awarded the Authority a grant via a Broad Agency Announcement (BAA) to implement dynamic traffic assignment in San Francisco, and use the DTA for analyzing proposed transit improvements, analyzing traffic diversions caused by those transit improvements, and comparing the effectiveness of roadway pricing alternatives.

## *2.3 Current San Francisco County Transportation Authority DTA Model*

SFCTA's initial objective of the project was to have a working DTA model with results that make sense for the PM Peak period in San Francisco. Other key goals included:

- Establishing a seamless process for integrating of demand model (SF-CHAMP) and the DTA model with minimal person intervention
- Calibrating essential traffic flow parameters such as free flow (FF) speed, saturation flow rate, effective length, and jam density
- Validating the DTA model to the extent that it is robust enough to feed directly into traffic microsimulation models such as VISSIM without needing any adjustments

The following items encapsulate the basic approach of the model development process:

- Creating code and scripts where possible for repetitive tasks to automate the process and minimize human error
- Developing the code base in an open source environment
- Creating a counts database that can be linked with the network
- Using as much actual data as possible – signal timing, transit routes, traffic flow parameters

It is about one year into the project now and SFCTA has developed an automated process that closely knits SF-CHAMP and the DTA model. The code, developed in Python, is capable of executing the following tasks:

- Converting a static network from Cube into a network that can be used by a DTA package
- Importing transit routes into DTA network
- Importing information on traffic signals and stop signs at intersections
- Importing demand matrices from travel model into DTA package
- Attaching traffic counts from a count database (called "Count Dracula") on to the DTA network

The code base is named "DTA Anyway" and is hosted on Google and is open to all for download. All information about the project and its current status can be found at: http://code.google.com/p/dta/. Specific documentation on the DTA data preparation process code and APIs can be found at: http://dta.googlecode.com/git-history/dev/doc/_build/html/index.html#.

The DTA model covers the whole of San Francisco and has 976 TAZs with 22 external stations. As mentioned earlier, the model was developed in INRO's Dynameq software platform. The network has 1,115 signals and 3,726 stop controlled intersections. The DTA model was developed and calibrated for the PM peak period which is from 4:30 PM to 6:30 PM. A 1-hour warm-up time was used along with a 3-hour network clearing time. Due to the 1-hour warm-up period, demand from 3:30 PM to 6:30 PM is loaded at a uniform rate onto the network. The simulation period end 3 hours later at 9:30 PM. This demand includes 385,000 auto and 65,000 truck trips approximately. There are about 270,000 internal trips and about 180,000 trips involving external TAZs.

In adhering to the usage of as much actual data as possible in the development approach, the modeling team conducted a traffic flow survey to measure traffic flow parameters such as free flow speed, jam density, saturation flow rate, backwards wave speed, and driver response time. The parameters derived from the survey were reconciled with default parameters and parameters obtained from existing local traffic data sources such as Caltrans Performance Measurement System (PeMS) and San Francisco Municipal Transportation Agency (SFMTA) Speed Surveys data. Table 1 shows the various data sources used for the required traffic flow parameters.

**Table 1: Data Sources for Parameters by Facility Type**

| Parameters\ Facility type | Free-flow Speed | Saturation Flow | Response Time | Jam Density |
|---|---|---|---|---|
| Freeway | PeMS | PeMS | PeMS | Inferred from CBD arterials |
| Arterial | SFMTA speed surveys | CBD saturation headway observations | CBD queue dissipation observations | CBD arterial queue length observations |
| Local & Collector | Limited SFMTA speed surveys and supplemental observations | Mostly inferred from CBD arterials | Mostly inferred from CBD arterials | Mostly inferred from CBD arterials |

The calibration process for the DTA model involved iteratively fixing network and supply issues in addition to making defensible adjustments to the model parameters. The following are some of the steps taken by SFCTA during calibration of the DTA model:

- Removal of bus-only lanes
- Penalizing collectors and arterials more than other facility types
- Modifying the speed-flow curve

At the time of the peer review meeting, the modeling team at SFCTA felt that the model was reasonably calibrated and noted the following from the calibration exercise:

- Model is sensitive to changes, and can easily regress into gridlock
- Most runs show less congestion than anticipated
- A number of outliers in terms of link volumes appear to be driven by specific network movements—such as freeway on-ramps

Further details about the model development, calibration, and validation process are provided in Appendix D of this document and the project webpage (http://code.google.com/p/dta/).

## *2.4 San Francisco County Transportation Authority Goals for Peer Review*

SFCTA is the designated Congestion Management Agency of San Francisco County and is responsible for developing and maintaining San Francisco's official travel demand model: SF-CHAMP (San Francisco's Chained Activity Modeling Process). Over the past decade, the character of questions posed by San Francisco planners and decision-makers has shifted from "where should we add capacity?" to more nuanced questions revolving around managing capacity among users and modes. The SF-CHAMP model is an advanced activity-based travel demand model that analyzes travel behavior decisions across multiple dimensions, and is capable of evaluating a multitude of policies and investments based on how these policies and investments change various attributes of travel between two points in the region for a given time of day. However, the macroscopic static user equilibrium model currently used within SF-CHAMP needs improvement with respect to the nuances of congestion in the city. These needs resulted in the award of an FHWA grant to implement a DTA model in the city.

The tools developed as a part of this research project are open source, and the findings and lessons learned will be publicly available and open for practitioner discussion and research. Understanding the new territory that the Authority would be charting, the research proposal included a peer review panel partway through the project. The project team has identified the following areas of questioning and discussion with the peer review panel:

- Calibration of DTA and SF-CHAMP model sensitivity to changes such as network geometry, signal control, and demand;
- Appropriate validation standards on the data and model side;
- Integration strategies for feeding back various aspects of network level of service to the SF-CHAMP activity-based demand model; and
- Useful forms of technology transfer for the lessons that have been learned and code developed.

While the Authority and our research team have some experience in each of the above topics, they see this peer review panel as an opportunity to learn about strategies and techniques being employed in other areas across the country and world. Furthermore, they would like to understand how to make their investments in documentation and code more useful to the community at large.

## *2.5 Previous Peer Reviews*

To the knowledge of this panel SFCTA has not previously held a formal TMIP DTA model peer review.

# 3.0 Model Improvement Plan

Implementation of a DTA model for San Francisco was a major step for SFCTA towards analyzing proposed transit improvements, analyzing traffic diversions caused by those transit improvements, and comparing the effectiveness of roadway pricing alternatives. While DTA has been known in research circles for some years, it is only now breaking into practice as a usable tool for planners. Many of its applications thus far have not been focused on dense, transit-rich, congested urban locations such as the San Francisco Bay area. Therefore, this project would serve as a case study for other cities with similar networks which are considering DTA implementation.

The Authority's vision is to improve their travel model in the following ways:

- A DTA implementation in San Francisco will be unique because of the city's rich transit network and dense grid pattern. It will be well-suited for analyzing route diversions on dense grid networks. For example, it can help illustrate the consequences of transit improvements such as bus lane conversions on existing streets. Furthermore, these results could validate and/or modify the way traffic microsimulation analysis is performed on dense grids.
- The tools and methods developed in this project should reduce or possibly eliminate the reliance on modifying demand matrices ("trip tables") that are input to DTA and traffic microsimulation models. Since there is little methodological justification for transferring the demand transformation to future years or scenarios, DTA implementation might eliminate this shortcoming in the current practice.

All tools and methods developed during this project will be open-source and hence will help other regions faced with similar policy questions leverage from them and improve their models.

SFCTA requested an objective assessment of their modeling needs with respect to state of the practice and the modeling goals of the agency. SFCTA looked to the peers for advice on a systematic approach to model enhancements, and technical guidance on modeling processes to address the various policy and investment questions.

SFCTA, along with its partner agencies, will critically assess the feedback from the peers when prioritizing its model development plan. While the advice of the peers is invaluable, there are many factors to work through when considering a model improvement strategy, and therefore the recommendations of the peers should be regarded as recommendations for SFCTA and its partners to consider.

# 4.0 Topics of Interest to San Francisco County Transportation Authority

Prior to the peer review, SFCTA staff identified a list of issues and topics of interest to guide the discussion during the peer review. These issues were presented to the panel members on the day of the review. The specific questions and panel's responses pertaining to the topics of interest are presented in Section 6.

## 4.1 General Strategies

In the shorter term, SFCTA is interested in assessing current state of calibration and the strategies that may be feasible to implement within the scope of the current project. The Authority would also like to consider the following approaches in the long-term if they offer promise for DTA and model improvement:

- Spatial expansion of the model to a bigger subarea/whole region;
- Temporal expansion to 24-hours;
- Influence of non-motorized travel on traffic flow;
- Inclusion of transit modeling in the DTA with software like FAST-TrIPs (Flexible Assignment and Simulation Tool for Transit and Intermodal Passengers);
- Measurement and incorporation of reliability;
- Improving path type (toll vs. no-toll), departure time, mode, and destination choice in travel demand model; and
- Incorporating additional traveler market segmentation into the DTA model.

There are bus-only lanes in the CBD which can be used by other vehicles if they are making a right turn. SFCTA is interested in appropriately modeling this phenomenon. Restricting the bus-only lanes to only buses reduces the capacity of links and results in gridlocks throughout the CBD. To eliminate gridlocks, SFCTA has currently removed restrictions on bus-only lanes and allows their use by all traffic. An idea to split links containing such lanes into a bus-only part and a part with right-turn bay is being explored as an improved method for modeling this. Other complications include violation of these bus-only lanes by other vehicles and the fact that taxis could use these lanes. SFCTA had issues with underestimation of traffic flow on major arterials and overestimation on local and collector roads. To overcome this, the free-flow time on local and collectors roads has been doubled. SFCTA is interested in other approaches to deal with issue of matching observed traffic flow patterns.

## 4.2 Model Formulation

SFCTA would like to identify best generalized cost formulations and optimal DTA run settings for the model.

## 4.3 Traffic Flow Parameters

Having collected its own data for estimating traffic flow parameters for the DTA model, SFCTA has a strong interest in finding out other data collection methods that might help improve the accuracy of the parameters. SFCTA used data from three sources – PeMS, SFMTA speed surveys, and SFCTA traffic flow surveys to help answer the following questions:

- Do default traffic flow settings reflect local conditions?

- Are traffic flow parameter differences between facility and area classifications accurate?
- Do the slopes of San Francisco's hilly streets significantly affect traffic flow conditions?

SFCTA also noted the following challenges it faced while conducting the traffic flow surveys:

- Low facility type (local\collector) and steep streets lack adequate volume;
- Multiple lanes need to be present on a link to observe through movement lanes only;
- Gaps between vehicles tighten even after stopping, complicating the calculation of effective length;
- Vehicles creep forward at start of green phase before car in front accelerates which may be an issue for response time calculation; and
- Distracted drivers don't notice the car in front has proceeded.

## *4.4 Validation Targets*

The Authority is highly interested in standard validation practices used for DTA models.

## *4.5 Integration Strategies*

Integration strategies for demand (SF-CHAMP) and supply (DTA microsimulation) models are a primary focus issue for SFCTA. The goal is to achieve better consistency between supply & demand models to avoid unreasonable gridlock. As mentioned earlier, demand matrices from SF-CHAMP are directly loaded into the DTA model without any "adjustments" or "alterations". SFCTA would like to improve the level of consistency by creating better LOS information for demand models and creating better demand information for DTA models. The following are some specific topics of interest in this regard.

### 4.5.1 Extraction of LOS data from DTA

- Evaluation of levels of temporal resolution
  - At what level do travelers think about time and cost? 1 hour? 15 minutes?
- Consider spatial and temporal expansion
  - SF-CHAMP covers 9-county area, so currently there is a need to merge DTA skims with static skims
  - Consider 24-hour DTA for feedback of all periods
- Measure reliability
  - Attempt to measure either within time periods or across days Reference SHRP2-L04

### 4.5.2 Feeding LOS to SF-CHAMP (demand model)

- Integration with trip time-of-day model
  - Existing trip TOD model is based on time shift from preferred departure time
  - TOD model could be modified to use imputed half-hour auto skims which could be substituted with dynamic skims

- Feedback skims in five time intervals
  - SF-CHAMP's tour TOD model has the same resolution with Early AM, AM Peak, Midday, PM Peak, Night periods
  - DTA times could be averaged to the five time periods
  - Alternately, logsums from a trip TOD model could be used and fed back to SF-CHAMP at this resolution
- Feedback skims at a higher temporal resolution
  - 1 hour, 30 minute, or 15 minute periods
  - Would require replacing SF-CHAMP's tour time-of-day model
  - Provides additional sensitivity to time-of-day differences in upstream models
- Fully disaggregate ABM-DTA integration
  - Fully consistent daily schedule for each traveler, adapting to differences in planned versus actual travel times
  - Moving unit of analysis in DTA from trip to a tour, allowing for the timing of stops to be accounted for in the DTA
  - Possible representation of user heterogeneity in DTA
  - Sampling of alternatives removes dependency on TAZs and allows any level of spatial disaggregation

Other practical considerations include the stability of results across scenarios resulting from the disaggregation options specified above and convergence strategies. The level of disaggregation could also be dependent on the policies being considered.

### 4.5.3 Transit Integration

- Use existing transit pathbuilder
  - Attach average DTA link travel time to static network used for building transit skims
  - Parse out transit trajectories to individual links
  - Modify SF-CHAMP to accept transit skims for shorter time periods
  - Incorporate a transit trip departure time model
- Implement dynamic transit assignment
  - Use of FAST-TrIPs
  - Incorporating dwell times based on boardings and alightings
  - Bus bunching and delays due to roadway congestion

### 4.5.4 Feeding Additional Information to DTA

In addition to all travel demand information, DTA could also use user heterogeneity that is available from the demand model. In SF-CHAMP, each traveler has their own value of time which could be incorporated into DTA through additional user classes. This would require additional time and restructuring DTA software.

## *4.6 Technology Transfer*

One of the goals of the DTA project was to provide a good starting point to other MPOs and agencies which may be embarking on a similar endeavor. SFCTA is very keen on knowing how the knowledge gained through this project may be effectively disseminated through the modeling community. The Authority is interested identifying various components of this project that may be more useful such as data processes, code bases, user guides and other documents.

## *4.7 Research*

SFCTA is also interested in finding out if there are any research questions that could be answered during the course of this project.

# 5.0 Peer Review Panel Responses to Technical Questions

Based on the topics of interest described in the previous section, SFCTA staff formulated a set of specific questions which were sent to the panel members prior to the peer review meeting. These questions formed the basis of the peers' discussion and are listed below with the panel's responses. The major headings in this section match those in Section 5 above for easy cross-reference.

## *5.1 General Strategies*

### 5.1.1 Are the strategies that we've already employed appropriate?

*The panel thought that the overall approach to this project has been great. The data driven approach to modeling traffic flow and signal timing makes a lot of sense. The open source code-base makes the whole process very transparent for other agencies and the modeling community in general. This is a good example of a true collaborative team effort.*

### 5.1.2 Are there any tricks or strategies that we should be trying that we haven't yet?

*The peer review panel offered a number of suggestions related to the simulation time period. It was suggested that the overall simulation period could be extended and potentially incorporate demand from the midday time period immediately preceding the PM peak. It was also suggested that the simulation validation period could be extended from 2 hours (4:30-6:30 PM) to 3 hours (3:30-6:30 PM) in order to provide consistency with and facilitate comparisons to the current 3-hour period used in SF-CHAMP demand assignment components. Finally, depending on the performance measures of greatest interest to the SFCTA, it was suggested that the actual demand associated with the cool down period be incorporated in the model. It may not be very important to impose the condition that all of the demand should clear the network at the end of simulation.*

*The panel felt that the current process of loading demand could be improved by creating a temporal profile for external gateways and also internal zones. The current flat demand profile or uniform loading of demand over the simulation period is not realistic. The panel suggested that traffic counts data on the bridges could potentially be used as a source for creating a temporal profile for external demand. For temporal profile of internal zones, it was suggested that either link traffic count on internal links or distribution of departure times from the household survey could be used. Alternatively, to improve the loading of external demand, the panel suggested that geographic information associated with external zones could be preserved. This could result in a more realistic representation of the temporal distribution of demand from different parts of the region. For example, if the model is run for simulating demand between 4:30 PM and 6:30 PM, it might contain trips that have started much earlier from an external TAZ to reach the model gateway at 4:30 PM.*

*Regarding the modeling of bus-only lanes in CBD, the panel felt that the current approach of splitting links into a bus-only part and a right-turn only bay was promising. A similar approach had been used in the DTA model developed for Manhattan. The panel noted that it might be better to code the bus stops on the bus-only parts of the split links. If not, during simulation, vehicles might be stuck behind a bus which has made a stop on the right-turn only part of the link. Another suggestion provided by the panel was that reaction time could be adjusted to be lower so that there is more throughput in the general purpose lanes. The panel felt that in the longer term, taxis should be accounted for separately in the model. Even though taxis are a separate mode in the model, the demand has not been validated. The panel suggested that a placeholder could be created to incorporate taxis in the nearer term.*

*The panel suggested that including information on the availability and restrictions on commercial vehicle or truck traffic in the model may be important. In the peak period, trucks do not appear on main streets but for the off-peak period inclusion of these restrictions may be important.*

### 5.1.3 How should we prioritize our effort for calibration moving forward?

*As the model team had previously done, the panel suggested that an overall bias factor (e.g., average simulated link volume / observed link volume) be looked at first. This might indicate possible systematic errors in a simulated scenario. The next step could be to try and identify possible measurement bias in the sensor data, and use the mean absolute error (MAE) to avoid the influence of bad data. It was indicated that RMSE is too sensitive to measurement errors and bad data. The panel noted that MAE has been widely recognized as a more robust statistic.*

*The panel also suggested that more sensitivity tests could be designed around future and alternative policy scenarios. It might help to perform targeted policy tests. The panel encouraged the SFCTA modeling team to continue analyzing the test results qualitatively at first. An example that the panel gave was to delete a link from the network and check if the changes in traffic volumes around that link are reasonable and check if no drastic changes in volume have occurred in other parts of the network. The panel noted that it might not be very straightforward to quantitatively validate such sensitivity tests without before and after data. It was also noted that constructing the traffic flow and signal timing settings for the future-year conditions might be very challenging.*

*In addition, the panel recommended conducting sensitivity tests around traffic flow parameters such as jam density and also flow averaging parameters. Since sensitivity is contextual, the panel suggested analyzing if the ranking of investments might change due to certain changes in these parameters. Based on which parameters affect the ranking of investments to what extent, the modeling team may be able to focus more on those parameters during calibration and validation.*

*Specifically, try adjustments to reaction time and jam density (150,180 etc.) for surface streets.*

#### 5.1.4 Is there a way to deal with movement-specific yellow time in signal phases where there is another movement that has continuing green time?

*Due to the discussion of other issues that took priority and time, the panel could not specifically respond to this question.*

### *5.2 Model Formulation*

#### 5.2.1 What are the best strategies for estimating or calibrating a generalized cost function? In the long term, we will have observed route choice data available to us soon from 2012 California Household Travel Survey.

*It was suggested that inclusion of distance term in the generalized cost formulation for routing behavior for trucks may be a good approach to make the path finding in the DTA model more realistic. It may not have a big impact for autos though.*

#### 5.2.2 Do the DTA settings that we have chosen make sense?

*The DTA settings currently used appeared to make sense to the panel. It was suggested that further changes to these settings may be guided by the calibration and sensitivity tests conducted.*

#### 5.2.3 How sensitive should the model be to these settings?

*The panel thought that there are no standards as to how sensitive a model is to the DTA settings since the sensitivity might be dependent on the DTA package being used and modeling assumptions made in them.*

#### 5.2.4 What others should we test out and why?

*The panel suggested trying incremental loading strategies which can provide a better starting point for path building. For example, 20% of the total demand may first be loaded to obtain a set of reasonable paths which could then be used as a starting point for the full run.*

### *5.3 Traffic Flow Parameters*

#### 5.3.1 Does our data collection methodology and associated results make sense?

*The panel felt that the current data driven approach for estimating traffic flow parameters is quite logical and the modeling team should continue to refine the approach in this direction. It also felt that SFCTA should try to re-evaluate traffic flow parameters for local streets, to ensure that the data sample includes low volume local streets locations.*

*The jam density resulting from the effective length (EL) used was more than typical, which may be because narrow streets promote more spacing between vehicles. EL affects the jam density and the panel suggested that SFCTA consider using different jam densities instead of a fixed value. Jam density may vary by facility type. The panel also observed that reaction times in the range of 1.3 to 1.5 were reasonable. Finally, the panel encouraged SFCTA to make sure that the free flow speed assumptions are consistent in both static and DTA models. It was indicated that free flow speed should reflect the average travel time over a link.*

*SFCTA used curve-fitting to the observed traffic flow data to obtain the triangular fundamental diagram depicting the relationship between density and flow. The panel encouraged SFCTA to view the fundamental diagram as an envelope around the flow data rather than something fitting lines through them.*

*During the presentation, SFCTA noted that traffic volumes on local streets were being overestimated and the modeling team doubled the free flow time on those streets during calibration. The panel suggested confirming the effect of stop signs in local streets to rule out coding errors. Once that has been confirmed, it was recommended that a perception penalty be introduced in the form of a reaction time factor since it is possible that reaction times are longer on such streets.*

*SFCTA expressed an interest in accounting for friction in traffic flow due to the presence of pedestrians in some areas. The panel suggested that adjusting the average reaction time might help accounting for pedestrian friction. Since this only occurs in specific areas, the panel recommended developing link/node specific adjustments which are informed by pedestrian demand (the demand could be aggregated within a buffer distance of the link/node).*

*Finally, the panel indicated that SFCTA could also look at meso-scopic models such as DYNASMART, Dynus-T or DTALite which requires less calibration, as they are based on spatial queuing models for arterial streets, and density-speed based flow models for freeway links.*

### 5.3.2 Are there other observed data that we should be trying to collect?

*The panel felt that obtaining free flow speeds from spot speeds may not be ideal since actual free flow speeds tend to be lower. The free flow speeds should reflect travel time over a segment rather than at a location. Nevertheless, they should not include signal delay, in contrast with travel demand models, since signals are explicitly coded in meso and micro models. In the long term, it was suggested that using Bluetooth devices to obtain experienced travel times and corresponding speeds be considered.*

*In the current model, effective length (EL) is calculated from data collected on arterials and local streets. For calculating EL on freeways, the panel recommended using the aerial photo technique.*

## *5.4 Validation Targets*

### 5.4.1 Are there any validation standards for a large-scale DTA? When is 'enough'?

*In the collective experience of the panel members, it was felt that there may not be any validation standards that are broadly accepted and also there may be no national benchmark for root mean squared error (RMSE) of flows and speeds. The panel thought the reason for this may be the limited number of studies currently existing in the DTA arena and different limitations being associated with various DTA packages used in these studies.*

*The panel members recommended that regular Caltrans static validation standards could be used as a starting point and then extended for more refined time periods. It was noted here again that a 3-hour validation period would facilitate a more direct comparison with the static model. The panel members also stressed the consistency of reporting structure that needs to be maintained for such a comparison.*

*The panel felt that validation standards for large-scale DTA should not be as stringent as microsimulation models (such as VISSIM, Paramics, etc.). It also indicated that speeds may then be more difficult to match. It was thought that calibration and validation to the turn movement level would probably be overkill for application purposes except in targeted corridors.*

### 5.4.2 How should we measure the "stability" of the results? What should we be looking at other than relative travel time gaps?

*The panel noted that specific value of relative travel time gap in may not be as important as the stability of the relative travel time gap.*

*Maximums and minimums of traffic characteristics such as speeds may be checked to see if those have stabilized over iterations.*

*The panel suggested that it might also be helpful to look at variation in vehicle miles traveled (VMT) and vehicle hours traveled (VHT) as additional measures of stability.*

### 5.4.3 Similarly, how should we test the model's sensitivity to changes in: network geometry; signal operations; other?

*The panel offered various methods to check the model's sensitivity to network changes. At first, it was suggested that progression of traffic on major arterials be confirmed. Another basic test would be to visually inspect the relevant paths for reasonableness. Finally, the panel recommended examining areas in the network that are specifically affected by bottlenecks and queues. These are the areas where static model would be significantly inaccurate in predicting the traffic flow patterns.*

*The panel mentioned that rounding of fractional trips may also be a source of issues in traffic prediction. Even if there are no trips lost in total, there may be significant loss of trips in specific zones. The panel recommended that bucket rounding be used over arithmetic rounding.*

### 5.4.4 How do you validate to conflicting data?

*The general response of the panel to this was to obtain more data so that more cross-checking can be done. The panel felt more observed traffic data on local streets would be useful for validation given that there appears to be considerable overestimation of traffic. Expanding the number of observed traffic count locations was also offered as a long term consideration. The panel felt that the current number of 200 locations may not be sufficient for a city the size of San Francisco. The panel noted that there are 400 count locations (or 800 directional counts) in the SACOG area per one million population and that counts should be distributed geographically and across functional classes of roadways, and not correlated. Because SFCTA models all streets, and because of the suspected over-assignment to local streets, the panel suggested that more counts be taken to ensure that a sufficient cross section of local street locations are included in validation.*

## *5.5 Integration Strategies*

### 5.5.1 How should we prioritize the strategies listed in the integration memo both for "Demand Information for DTA" and "DTA Information for Demand?

*Demand model information for DTA*

*The panel suggested that refining the market segments of the demand being input into the DTA model may be the next logical step of improvement in this area. It was recommended that segmenting by value of time (VOT) may be tried first considering that SFCTA would like to use the model for evaluating pricing policies. The panel noted that this segmentation may not be critical for initial testing but when more sophisticated scenarios are required to be analyzed this might become necessary. Another suggestion that was offered for the longer term was the separation of parking and activity locations which would also be important in analyzing pricing scenarios.*

*DTA information for demand model*

*The panel recommended that SFCTA explore ways to hybridize skims from the DTA model (at San Francisco city level) and static model (at the regional level). The panel felt that in this way temporal expansion of the DTA model could be achieved more gradually and systematically. However, the panel noted that a full day DTA model may need to be run for his approach and there may be model run time implications to consider in advance.*

*The panel suggested that the next step after the development of hybrid approach to obtain skims for the whole region would be adding temporal detail. This would also require changes in temporal resolution to be made to models in SF-CHAMP (tour time model, trip departure time model etc.).*

*The panel recommended that SFCTA may consider developing a full-scale regional level DTA only after some of the above improvements mentioned improvements to the model have been made. It was suggested incorporating reliability may also be something to be considered in the long term only.*

### 5.5.2 What thoughts or cautions would you give to simultaneously pursuing person-based dynamic transit assignment a la Fast-TrIPs?

*The panel suggested that it may be more appropriate to finish developing a full day DTA model before pursuing person-based dynamic transit assignment or integrating with Fast-TrIPs.*

## *5.6 Technology Transfer*

### 5.6.1 What (if anything) about this process/project would be useful for other agencies to learn and hear about? In what format?

*The panel felt that the overall approach of minimizing manual intervention by way of coding and automating the various tasks involved is something that other agencies would benefit from greatly. Automation may not be important in smaller sized networks but becomes key when large and dense networks are involved.*

*Apart from the approach, the panel thought that the process and scripts for converting a static assignment network to a DTA network could be adapted by other agencies and help them gain efficiency in their model development process.*

*Finally, the panel suggested that the methodology of estimating traffic flow parameters and in some cases the parameters themselves may be transferable to other regions around the country.*

### 5.6.2 What parts of the code base that we have developed (if any) would be useful to operationalize for others?

*As mentioned previously, the panel recommended that the code-base for automatic conversion from a static network to a DTA network be made as general as possible. The panel commended SFCTA for developing the code-base in an open-source environment.*

## 5.7 Research

### 5.7.1 Are there any research or application questions that it seems like we should be able to answer with this project?

*The panel noted that the processes and strategies for integrating activity-based demand and DTA supply models were probably of most research value in this project.*

# 6.0 Panel Discussion and Recommendations

The following text summarizes the panel's discussion on the topics of interest to SFCTA and the audience. The summary of this discussion follows the panel's final presentation back to SFCTA. The discussion begins with some general observations made by the panel on the overall modeling process followed by short and long-term recommendations. Section 6 includes a point-by-point response to the questions the SFCTA posed to the panel at the outset of the meeting. The summary in this section is a consistent summary of the detailed responses in the form of a recommended action plan.

## *6.1 Observations: General Comments*

The panel applauded the overall effort made by SFCTA to systematically develop and calibrate a DTA model, and specifically on the SFCTA's focus on the calibration of the traffic flow model parameters using observed data. They understand that this is a non-trivial endeavor and are not aware of many efforts that have been made in this direction and at such detail. The panel recognizes that this has been a truly collaborative effort with committed staff from SFCTA, the consultant team, and partner agencies which has laid a foundation for further research and application in this area of travel modeling. The panel also commended SFCTA's commitment to the development of an open-source code-base that can help other agencies who would like to develop DTA models in the future. The data driven approach taken by SFCTA towards this project has in the panel's collective experience been known to be a very effective approach, rather than synthesizing inputs or using a default set of parameters. The panel suggested that it would be useful to always keep the applications of this tool in perspective, which would then guide the expansion of its capabilities and sophistication.

## *6.2 Recommended Shorter-Term Priorities*

SFCTA requested that the panel's recommendation focus on what can be achieved in the next few months before the end of the current project. The panel feels that the SFCTA should focus on the following items in the relatively near term:

- **Improve subarea extraction:** The panel thought that the demand carving for a subarea was a non-trivial process and there should be some more focus on that. External geographical information could be preserved and the demand from external stations could be offset temporally based on the travel time to the model subarea.

  In addition, a temporal profile at external gateways and in internal zones could be created to avoid a flat or uniform loading profile to the DTA model. Since traffic counts are available, they may be used to create the temporal profile. Alternatively, departure times from the household survey could also be processed to obtain a temporal profile.

- **Expand DTA simulation period:** The panel felt that a longer warm-up period may be needed to improve the accuracy of the simulated traffic in the current modeling period (4:30 – 6:30 PM). This could also incorporate a portion of mid-day demand to create background traffic which would already be present before the model period. Further, there might be some value in simulating the entire 3-hour period (3:30 – 6:30 PM) in the DTA model to facilitate a straightforward comparison to the static model.

- **Devise and perform more sensitivity tests:** To aid calibration and validation, the panel recommended conducting more sensitivity tests from the perspective of future and alternative policy scenarios. It might help to devise some future scenarios tests and targeted policy tests. Since SFCTA already has an idea about the initial policies that it would like to use this model for, it might be useful to build some tests around them and evaluate the results qualitatively first. Sensitivity tests on both demand and traffic flow parameters would help understanding of which parameters affect which, and to what extent. This in turn could help identify the parameters on which to focus.
- **Adjust traffic flow parameters for local streets:** For the overestimation issue on local streets, the panel thought imposing twice the free flow time may not be ideal. The panel indicated that there might also be an aversion component in addition to the time component. It might be better to try and tweak the traffic flow parameters such as reaction time. This factor could act as a "perception penalty" and could be a function of the number of stop signs.

  Alternatively, a separate facility type for residential low-volume streets could be created. In addition to this, a reaction time factor that includes friction due to pedestrian traffic on such streets could be tested.
- **Inclusion of distance term in generalized cost function:** The panel felt that including distance in the generalized cost function for routing behavior might help towards the traffic overestimation issue on local streets. It is probably more applicable for truck traffic than autos.
- **Adjust traffic flow parameters to reflect influence of pedestrians:** The panel indicated that there might be value in developing link/node specific reaction time factors targeted at specific areas in the network where this could be important. The factors could also be derived in a systematic way by using information on aggregate pedestrian demand within a radius of a node (buffering). For intersections with a high concentration of pedestrian-generating land uses within a short distance (say one-quarter mile), it was suggested that delay due to pedestrian volumes be increased.

  In addition to area type and facility type currently being used to classify the various parameters, there is potential to use a third dimension – "intersection type" that would allow for targeted improvements.
- **Calibration of turn movements may be overkill:** It was mentioned during the presentation that turn movements were important. The panel thought that calibrating and validating turn movements at a system level might not be needed. It could be done for targeted areas based on specific corridor level applications of the model.
- **Traffic flow parameters for bus-lane modeling:** The modeling team described a method of splitting a bus-lane link and making one-half of the link right-turn only to deal with bus lanes in the model. The panel encouraged SFCTA to pursue that link splitting method but also suggested that targeted reaction time factors adjustments could potentially be used to accommodate more throughput going through the general purpose lanes and better represent the traffic flow on these lanes.

## *6.3 Recommended Longer-Term Priorities*

The panel urged SFCTA to focus on the above priorities and to undertake other potentially good ideas over the longer term. These longer-term priorities are:

- **Collecting more data:** The panel felt that there may not be enough traffic count data available. Counts from 200 locations may be a bit low for a city of this size. The SACOG model with about a million people uses counts from about 400 locations. The panel recommended that SFCTA collect more counts that are not correlated with the existing ones and also that are geographically distributed.

  For freeways, effective length was derived from data collected on local and arterial streets. The panel suggested that SFCTA could try using aerial photos for estimating effective length on freeways.

  The panel noted that data on local streets would also be useful since at present, it may not be very clear as to why the predictions from the model are not validating very well against the counts. It is possible that the traffic volumes being simulated on local streets by the DTA model are reasonably accurate but are not being supported by the limited data currently available.

- **Demand model information for DTA:** The panel suggested that distinction between parking location and activity location may need to be made in the longer term. This might not be very important during the initial phase, but will probably be essential during the evaluation of various congestion pricing policies.

  The panel felt that market segmentation of the demand being passed on to the DTA model could be refined further to include an additional dimension based on value of time (VOT). The panel acknowledged that there will possibly be run time implications of this step.

  The panel recommends that reliability only be considered after model linkage has been well established at a reasonable level of temporal detail.

- **DTA information for demand model:** As a first step, the panels recommends that the modeling team work on developing a hybrid approach that combines static skims regionally and DTA skims locally to be fed back into the demand model.

  The DTA model could eventually be temporally expanded to simulate a full day. The panel felt that it may be better to prefer temporal over spatial detail while increasing the scope and sophistication of the model. A fully disaggregate DTA-ABM integration could then be considered at a later stage, which would require a significant amount of restructuring to both ABM (SF-CHAMP) and the DTA model. The panel felt that a regional level DTA model might involve a huge amount of work and may even be unnecessary

- **SF-CHAMP:** The panel recommends that temporal resolution of SF-CHAMP be increased from the current 5 time periods. Again, it may be better to give priority to adding temporal detail to SF-CHAMP before spatial detail. The panel noted that changes to the resolution of skims would probably require a number of changes to other model components in SF-CHAMP such as tour time of day and trip departure time models.

- **Person-based transit assignment (Transit DTA):** The panel recommends that only after adding temporal and spatial detail to the model should SFCTA consider transit DTA using packages like FAST-TrIPs.

The panel feels the SFCTA may not choose to implement some of the long term recommendations because they may be beyond the scope of the current DTA project.

# Appendix A List of Peer Review Panel Participants

This section contains a list of the peer review participants, including the panel members, local agency staff, and TMIP documentation support staff.

## *A.1 Peer Review Panel Members*

| Panel Member | Affiliation |
|---|---|
| Joe Castiglione | Resource Systems Group |
| Xuesong Zhou | University of Utah |
| David Stanek | Fehr & Peers |
| Bruce Griesenbeck | Sacramento Area Council of Governments |
| Vassilis Papayannoulis | IBI Group |

## *A.2 Local Agency and Partner Agency Staff*

| Name | Affiliation |
|---|---|
| Elizabeth Sall | SFCTA |
| Lisa Zorn | SFCTA |
| Daniel Tischler | SFCTA |
| Neema Nassir | SFCTA Intern |
| Jennifer Ziebarth | SFCTA Intern |
| Alireza Khani | SFCTA Intern |
| Billy Charlton | Ex-SFCTA |
| Michael Mahut | INRO |

## *A.3 Consultant Staff*

| Name | Affiliation |
|---|---|
| Greg Erhardt | Parsons Brinckerhoff |
| Renee Alsup | Parsons Brinckerhoff |

## *A.4 TMIP Peer Review Support Staff*

| Name | Affiliation |
|---|---|
| Bhargava Sana | Resource Systems Group |

# Appendix B Peer Review Panel Meeting Agenda

## *B.1 San Francisco County Transportation Authority Model Peer Review*

**July 25, 2012**

| | |
|---|---|
| 8:45 - 9:00 a.m. | 1. Introductions and Logistics |
| 9:00 - 9:30 a.m. | 2. Background<br>a. Agency Role and History (SFCTA)<br>b. Modeling tool suite / SF-CHAMP overview (SFCTA)<br>c. Purpose of the models / Applications (SFCTA)<br>d. Questions we want the panel to address (SFCTA) |
| 9:30 - 10:15 a.m. | 3. Technical Overview - Part 1<br>a. DTA Model Development Process (SFCTA)<br>b. “DTA Anyway” Code Base (SFCTA) |
| 10:15 - 10:30 a.m. | 4. Break |
| 10:30 a.m. - Noon | 5. Technical Overview - Part 2<br>a. Calibration Strategies and Validation Results Thus Far (PB)<br>b. Integration Strategies (PB) |
| 12:00 - 1:30 p.m. | 6. Working Lunch / Discussion and Q&A |
| 1:30 - 2:00 p.m. | 7. Further Q&A / Reiteration of Questions for the panel |
| 2:00 - 3:30 p.m. | 8. Panel Caucus |
| 3:30 - 5:30 p.m. | 9. Panel Report |
| 5:30 p.m. onwards | 10. Discuss Next Steps / Adjourn |

# Appendix C Peer Review Panel Biographies

## *C.1 Joe Castiglione (Resource Systems Group)*

Joe Castiglione is a senior consultant at RSG, and has served for over 13 years in a variety of technical roles on travel forecasting and transportation planning projects both as an independent consultant and in the public and private sectors. He has managed the development, application, and refinement of state-of-the-art, activity-based travel demand forecasting models, and has extensive experiencing linking these demand models with advanced traffic microsimulation models.

## *C.2 Xuesong Zhou (University of Utah)*

Dr. Xuesong Zhou is currently an Assistant Professor in the Department of Civil and Environmental Engineering at the University of Utah. Prior to joining the University of Utah, he served as a Traffic Data Architect and Senior Software Engineer at Dash Navigation, Inc, designing and developing the first commercialized internet-connected GPS navigation system in the U.S. He is also the co-inventor of Key2SafeDriving technologies, which has been reported by more than 300 media outlets including New York Times, Wall Street Journal and National Public Radio. Dr. Zhou's research interests include dynamic traffic assignment, traffic estimation and prediction, large-scale routing and rail scheduling. He has been assisting the Federal Highway Administration (FHWA) to develop and provide technical support for large-scale simulation-based dynamic traffic assignment systems for the past 10 years. Dr. Zhou's research work has been published in highly cited scholarly journals such as Transportation Research Part B, Transportation Science, IEEE Transactions in Intelligent Transportation Systems. He is the Co-Chair of the IEEE ITS Society Technical Committee on Traffic and Travel Management and serves as a Committee Member for TRB Committee on Transportation Network Modeling (ADB30).

## *C.3 David Stanek (Fehr & Peers )*

David Stanek, P.E., is an Associate Engineer with Fehr & Peers' Roseville office and has over 12 years of transportation engineering experience. With his experience at Caltrans District 3, Mr. Stanek is familiar with the project development process and traffic operations analysis as applied to freeway improvement projects including interchange reconstruction, HOV lanes, and ramp metering. He has expertise in applying arterial corridor analysis (Synchro and Transyt7F) and traffic simulation software (SimTraffic, CORSIM, VISSIM, and Paramics) to analyze complex traffic operations such as single-point interchanges, roundabouts, and bus rapid transit operations. Mr. Stanek serves as a company-wide resource for traffic operations analysis and teaches training courses on intersection analysis and roundabouts.

## *C.4 Bruce Griesenbeck (Sacramento Area Council of Governments)*

Mr. Griesenbeck has 25 years of experience in transportation planning and travel demand modeling, working directly for public agencies (City of Hayward, CA; Sacramento Area Council of Governments) and as a consultant (Wilbur Smith Associates' San Francisco office; DKS Associates' Sacramento office). He is currently the Principal Transportation Analyst for the Sacramento Area Council of Governments, the MPO for the six-county Sacramento region, where he leads the transportation forecasting and analysis team, and transportation monitoring team. He led the development of SACOG's activity-based travel demand simulation model (SACSIM), the first such regional model to be based on parcel-level land use data. He participated in a statewide MPO effort to support and advise California Air Resources Board in its implementation of SB375, the land use / transportation portion of the state's greenhouse gas reduction policy. SACSIM was the basis of the travel demand analysis and forecasts for the adopted 2008 and 2012 long range transportation plans, as well as its requisite air quality conformity analysis for the plan. The 2012 LRTP was the first SB375 "Sustainable Community Strategy" for SACOG. He has served as an advisor on two National Cooperative Highway Research Program panels, and is a member of the Transportation Research Board Travel Demand Forecasting Committee.

### *C.5 Vassilis Papayannoulis (IBI Group)*

Dr. Papayannoulis has 27 years of experience and recently joined IBI as a Regional Manager for Transportation Planning. Previously, Dr. Papayannoulis was a Principal and the New York Office Travel Demand Forecasting Regional Manager for Cambridge Systematics (CS). From 1990 to 2008, Dr. Papayannoulis worked at Urbitran Associates, Inc. (UAI), where as a Senior Vice President he directed the Transportation Modeling group. Dr. Papayannoulis' areas of expertise include travel demand forecasting, traffic operation simulation, database management systems, safety, system performance measures, software development and Geographic Information Systems (GIS). Dr. Papayannoulis' technical knowledge and in-depth understanding of the issues related to traffic simulation has engaged him in the development of numerous complex models, including NYCODT's Manhattan Traffic Model, where a platform supporting corridor management planning, design, and operations based on a multi-resolution model (interfacing travel demand models, mesoscopic simulation models, and microscopic simulation models) was developed. He has worked for Federal, state, regional, and local agencies and he has taught transportation courses at both Polytechnic University and City College of New York.

# Appendix D San Francisco DTA Project Calibration and Validation Report

The report is attached with this document.

# Appendix E San Francisco DTA Project Model Integration Options Report

The report is attached with this document.

## NOTICE



This report is being distributed through the Travel Model Improvement Program (TMIP).

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