EVALUATING URBAN DOWNTOWN ONE-WAY TO TWO-WAY STREET CONVERSION USING MICROSCOPIC TRAFFIC SIMULATION

A Thesis

presented to

the Faculty of California Polytechnic State University,

San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Civil and Environmental Engineering

by

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December 2019

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ABSTRACT

Evaluating Urban Downtown One-Way to Two-Way Street Conversion Using Microscopic Traffic Simulation

Bernice Liu

Located in the heart of Silicon Valley, Downtown San Jose is attracting new residents, visitors, and businesses. Clearly, the mobility of these residents, visitors, and businesses cannot be accommodated by streets that focus on the single-occupancy automobile mode. To increase the potential for individuals to use non-single-occupancy modes of travel, the downtown area must have a cohesive plan to integrate multimodal use and public life. Complete streets are an integral component of the multi-modal transport system and more livable communities. Complete streets refer to roads designed to accommodate multiple modes, users, and activities including walking, cycling, transit, automobile, and nearby businesses and residents. A one-way to two-way street conversion is an example of a complete streets project. Similarly, tactical urbanism can provide cost-effective modifications (e.g., through temporary road closures for events like the farmers' market) that enrich the public life in an urban environment. The ability to serve current and future transportation needs of residents, businesses and visitors through the creation of pleasant, efficient, and safe multimodal corridors is a guiding principle of a smart city.

This research project addressed questions that guide the implementation of this overarching principle. These questions relate to travel patterns and potential network impacts of the conversion of the corridor(s) into complete streets. Towards that end, core network in downtown San Jose is simulated via a validated VISSIM model for 2015 traffic conditions (i.e., the base case or Scenario 0). Three scenarios are then modeled as variations to this model. The relevant model outputs from the base and scenario models provide easily digestible information the City can convey various impacts and trade-offs to partners and stakeholders prior to implementation of these plans. The scenarios modeled are based on stakeholder input.

Microsimulation allows for detailed modeling and visualization of the transportation networks including movements of individual vehicles and pedestrians. The results based on 2040 traffic volumes provided by the city based on their long-range travel demand model clearly demonstrate that the existing network cannot support the projected level of travel demand. It indicates that the city needs an aggressive travel demand management program to curb the growth of automobile traffic. The output also includes 3-D animations of the traffic flow that can be used in public forums for community outreach. A discussion for such a campaign based on best practices around using these visualizations for public outreach is also provided.

Keywords: Complete Streets, Tactical Urbanism, VISSIM, Microsimulation, Traffic Simulation, Multimodal Network, Measures of Performance, Decision Making, Street Conversion

ACKNOWLEDGMENTS

I would like to gratefully acknowledge and thank the Mineta Transportation Institute (MTI) for their generous support in funding this research. I also wish to acknowledge the support of the City of San Jose, especially Doug Moody, Augustin Cuello Leon, and Wilson Tam from, in providing the data used in this research as well as valuable feedback on the research plan. In addition, I would like to extend my sincerest gratitude to my thesis committee chair, Dr. Pande, committee members, Dr. Molan and Dr. Shams, and transportation professors, Dr. Mastako and Dr. Voulgaris, for their constant guidance, mentoring, and expertise. Thank you also to Alex Hughes and Serena Alexander from the San Jose State University who provided local knowledge of the area and helped with literature review. Many thanks also to Jonathan Howard, a fellow Cal Poly student, who worked with me in developing this large network. Further thanks to Alex Chambers, a Cal Poly alumnus, whose knowledge of VISSIM and introduction of VHelper greatly helped the project. Finally, thank you to my family, boyfriend, Kyle Tom, and friends from the ITE Student Chapter, for their support and encouragement.

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1. INTRODUCTION

As economies grow and populations rise in major cities, city streets focusing on single occupancy vehicles will be unable to support residents, tourists, and businesses. Rather, these streets ought to be designed for everyone – whether young or old, on foot or on the bicycle, in a car or on a bus[i]. According to a recent Future of Transportation National Survey, 66% of Americans want more transportation options so they have the freedom to choose how to get where they need to go, 73% currently feel they have no choice but to drive as much as they do, and 57% would like to spend less time in the car. These figures indicate the need for a cohesive plan to integrate multimodal use and public life.

For these multimodal transportation networks to be implemented, public involvement is a key factor in the planning and decision-making process. This process should involve two-way communication between citizens and government, allowing public transportation agencies to notice, inform, and include the public while using the feedback to develop relationships within the community and build better transportation projects. Lack of public participation can lead to minimal community support, resistance from stakeholders and elected officials, and outcries from the public that could end up in costly project delays or even lawsuits[ii]. To encourage interactive transportation decision making, the Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFETEA-LU) mandated using visualization techniques for describing plans to the public within transportation planning process[iii] [iv]. Visual 3-D animations displaying potential project scenarios, in addition to quantitative analysis and results, can be used to engage and inform the community during public outreach.

This research creates a simulation-based framework to evaluate network-wide implications of a one-way to two-way street conversion. In addition to the quantitative metrics such as travel-time and vehicular throughput, animated 3-D visualizations are also produced for scenarios. Best practices for using these visualizations in the project implementation process is also described.

1.1 STUDY AREA: DOWNTOWN SAN JOSE

Located in the heart of Silicon Valley, San Jose is the 3rd largest city in the state of California and the 10th largest city in the USA, according to the United States Census Bureau[v]. Downtown San Jose continuously attracts new residents, visitors, and businesses while experiencing tremendous growth and providing opportunities to technology professionals and others. As a result, downtown San Jose becomes more crowded by the day. Downtown San Jose also houses several key destinations such as the Diridon station, a crucial central transit hub, and SAP Center, a major event venue. For a city the size of San Jose to be efficient and livable, urban transport systems should be able to accommodate resource-efficient modes of travel such as walking, cycling, and transit more effectively[vi]. One such method is to convert one-way streets to two-way streets, which can allow better local access and slow vehicular traffic[vii]. Similarly, tactical urbanism that can improve social interaction and public life can help in creating demand for these more efficient modes and utilize the urban street space more effectively.

The study area (see Figure 1: Study Area Map) consists of approximately 5 square miles concentrated in the core of downtown San Jose. Within the study area freeways, Interstate 280 (I-280) and California State Route 87 (CA 87) serve as important routes of entry and exit into the downtown area. Parking lots represent key destinations, such as residential and commercial buildings.

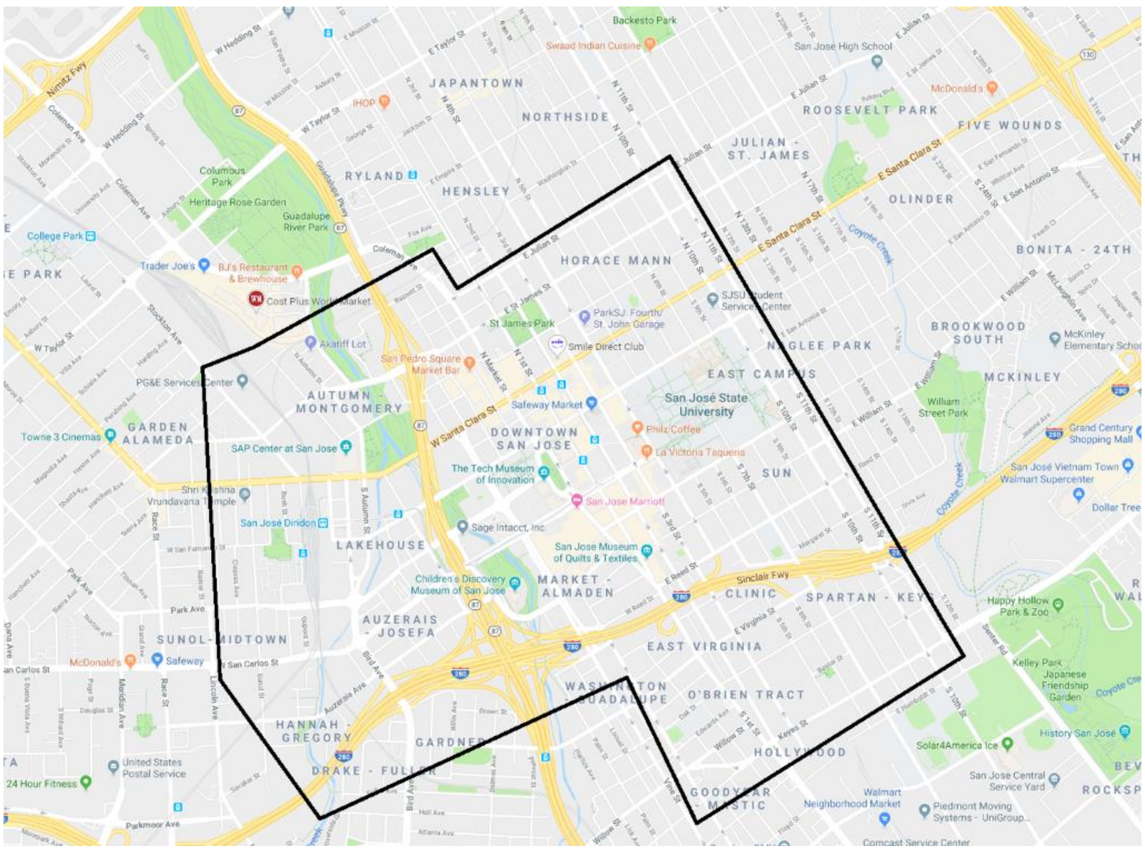

Figure 1: Study Area Map

1.2 STUDY OBJECTIVES

Overall, simulation models can aid transportation planners and designers in assessing the impact of various alternatives on existing systems. The use of simulation can help the City of San Jose visualize and evaluate the collective behaviors and patterns of the travelers as well as the implications these behaviors have for the whole network. Network performance can be analyzed and compared for before and after scenarios to answer “what-if” questions, specifically for automobiles in which drivers tend to feel adverse effects resulting from conversions.

The objectives of this study are to:

- Assess effects of a one-way to two-way street conversion on automobiles as identified by the city of San Jose through microscopic traffic simulation models.
- Test and refine scenario development techniques and develop a micro-simulation evaluation framework that can help be used to evaluate complete streets and tactical urbanism strategies in which other cities may adopt.
- Provide a framework to use the 3-D visualization created from the simulation models for a public information campaign.

1.3 REPORT ORGANIZATION

The remainder of this document presents a literature review of relevant past works, a detailed description of the network’s modeling procedure, an analysis of various scenarios, and a conclusion. Chapter 2, the literature review, provides an introduction on traffic simulation, the basis for ultimately choosing VISSIM as the microsimulation model, information on complete streets, specifically one-way to two-way street conversions, and information on tactical urbanism. Chapter 3 outlines the development and coding for the model, detailing the process of data collection, network coding, calibration, and validation for the base conditions. Chapter 4 describes and compares the results for different scenarios for automobile vehicles including the use of 3-D visualizations for public information campaigns. Finally, Chapter 5 contains a summary of conclusions along with recommendations for future work.

2. LITERATURE REVIEW

This chapter reviews simulation applications and potential advantages and disadvantages that microsimulation offers. It also discusses complete streets and tactical urbanism within the downtown context and the development of large-scale microscopic traffic simulation models.

2.1 TRAFFIC SIMULATION

Simulation modeling is an increasingly popular and effective tool to analyze the behavior and interactions of traffic systems. Traffic simulation is the mathematical modeling of transportation systems using computer software. These models can provide an understanding of cause-and-effect relationships and satisfy a wide range of applications, including evaluation of alternative treatments, testing new designs, training personnel, safety analysis, and as an element of the design process. Simulation models are useful in studying models too complicated for analytical or numerical treatment, where the assumptions underlying a mathematical formulation may affect the results, or where there is a need to view vehicle animation [viii]. Modern simulation models are based on random vehicular movements that aim to "mimic" driver behaviors. Thus, simulation models can answer "what-if" questions to aid system designers in assessing the impact of various changes on existing systems in a cost-effective way [ix]. Based on the simulation model for an underlying transportation network, one can obtain performance measures such as delay, emissions, average speeds, travel time, and others.

2.2 SIMULATION MODEL CHOICES

Depending on the desired level of detail to be studied, simulation models can be classified as microscopic (high fidelity), macroscopic (low fidelity), and mesoscopic (mixed fidelity).

Microscopic models provide a detailed representation of the traffic process, considering the characteristics of individual vehicles and simulating vehicle interactions in the traffic stream based on car-following and lane-changing theories. Microsimulation offers benefits in clarity, accuracy, and flexibility. It can provide a comprehensive real-time visual display to illustrate traffic operations in a readily understandable manner. Individual vehicles make their own decision on speed, lane changing, and route choice. The dynamic evolution of traffic congestion and effectiveness of traffic management strategies can be evaluated with microsimulation. These models are typically used for short term and congestion-related issues. Compared to macroscopic models, microscopic must be kept at a reasonable network size and modeling period due to the high number of data inputs, calibration and validation efforts, and computing power for modeling and analysis [x].

Macroscopic models describe systems and their activities and interactions at a low level of detail. These models utilize land use, socioeconomic demographical data, and travel behaviors to perform operational analysis and long-term forecasting. In a macroscopic model, trips are loaded simultaneously on a link and share the same speed and time period. Lower-fidelity models are easier and less costly to develop, execute, and maintain. However, due to the low level of detail, their representation of the real-world system may be less accurate. Macroscopic models are more appropriate for regional or large-scale systems and can provide predictions of current and future travel patterns and demand[xi].

A mesoscopic model is a hybrid of microscopic and macroscopic models. They "generally represent most entities at a high level of detail but describes their activities and interactions at a much lower level of detail than would a microscopic model" [xii]. These models combine some key components of microscopic simulation, such as intersection operations, with analytical models, such as speed-flow relationships for traffic assignment, to provide more detail than an assignment-only model[xiii].

Models can also be classified by the process represented by the model as deterministic or stochastic. Deterministic models have no random variables and perform the same way for a given set of initial conditions. Stochastic models have processes that include probability functions, introducing randomness into the model. The selection of a model depends on the purposes of the analysis and complexity involved. Microscopic models are useful for preliminary engineering and evaluating alternatives at the local or corridor level. A mesoscopic model may be used to analyze homogeneous transportation elements in small groups, such as vehicle platoon dynamics and household-level travel behavior. Macroscopic planning models are suited for travel demand modeling, conceptual network planning and design, and performing analysis at a regional or state level. Ultimately, the developer must identify the needed sensitivity of the model's performance to the underlying features of the real-world process[xiv].

2.3 ADVANTAGES AND DISADVANTAGES OF TRAFFIC SIMULATION

Traffic simulation models are powerful tools because they provide relatively inexpensive fast, and risk-free evaluation environments. They not only account for a variety of different scenarios that cannot be practically tested in real-world conditions, but also provide various network performance measures, becoming a very useful and widely accepted tool in transportation engineering applications.

Park, Yun, & Choi[xv] (2004) provided an overview of four microscopic traffic models and evaluated their performances using a case study of modeling a coordinated signal system. CORSIM is a microscopic simulation model developed for the Federal Highway Administration (FHWA) and is used mainly in modeling urban traffic conditions [xvi] [xvii]. CORSIM is not a multimodal simulation tool and is difficult to use for obtaining route-based or network-level measures. Paramics, developed by Quadstone Limited, is a suite of high-performance tools that provide, microscopic, time-stepping, and scalable traffic simulation. This software allows an application program interface. However, these are not easily built into the model and the program lacks automatic vehicle diffusion, potentially creating large discrepancy and high variability in data output. SIMTRAFFIC, by Trafficware Inc., is companion software to SYNCHRO, a signal optimization tool, and can only to run

SYNCHRO input files [xviii]. This software focuses on checking and fine-tuning traffic signal operation. The last program evaluated was VISSIM, created by PTV Vision. VISSIM is a microscopic, time step, and a behavior-based simulation model developed to model urban transportation operations [xix]. This program falls short in the lack of a built-in actuated controller program and its inability to produce HCM compatible output. CORSIM and SIMTRAFFIC have network limits, while VISSIM and Paramics do not. The study also concluded that VISSIM and Paramics showed relatively consistent performance trends to all signal timing plan cases while SIMTRAFFIC and CORSIM produced inconsistent performance trends.

VISSIM was chosen for this study primarily due to the program's ability to analyze multimodal traffic (i.e., automobile, bicycles, and pedestrians) as well as transit operations under constraints such as lane configuration, traffic composition, traffic signals, transit stops, and other similar criteria, thus making it a useful tool for the evaluation of various alternatives[xx]. VISSIM also allows the interaction of different modes of transportation, including bicycles, transit, automobiles, and pedestrians. This flexibility of modeling interaction between different modes of transportation is ideal to evaluate the network changes expected in our study.

The shortcomings of traffic simulations include unrealistic driver behavior, amount of time needed to develop a good simulation model, difficulty understanding simulation data, and computer limitations.

Table 1 from Chapter 31 of the Highway Capacity Manual (HCM 2000[xxi]) summarizes the strengths and flaws of the simulation approach to traffic modeling.

Table 1. HCM Simulation Model Analysis

Modeling Strengths	Modeling Shortcomings
Other analytical approaches may not be appropriate	There may be easier ways to solve the problem
Can experiment off-line without using an on-line trial-and-error approach	Simulation models require considerable input characteristics and data, which may be difficult or impossible to obtain
Can experiment with new situations that do not exist today	Simulation models may require verification, calibration, and validation, which, if overlooked, make such models useless or not dependable
Can provide insight into what variables are important and how they interrelate	Development of simulation models requires knowledge in a variety of disciplines, including traffic flow theory, computer programming and operation, probability, decision making, and statistical analysis
Can provide time and space sequence information as well as means and variances	The simulation model may be difficult for analysts to use because of the lack of documentation for unique computer facilities
Can study system in real-time, compressed time, or expanded time	Some users may apply simulation models and not understand what they represent
Can conduct potentially unsafe experiments without risk to system users	Some users may apply simulation models and not know or appreciate model limitations and assumptions
Can replicate base conditions for equitable comparison of improvement alternatives	Results may vary slightly each time a model is run
Can study the effects of changes on the operation of a system	
Can handle interacting queuing processes	
Can transfer unserved queued from one time period to the next	
Can vary demand over time and space	
Can model unusual arrival and service patterns that do not follow more traditional mathematical distributions	

2.4 SIMULATION STUDY STEPS

Understanding a model's operations and input data is necessary to successfully utilize a model. Lieberman and Rathi[xxii] suggested the following process to build and apply traffic simulation models:

1. Define the problem and model objectives.
2. Define the system to be studied.
3. Develop the model.
4. Calibrate the model.
5. Verify the model.
6. Validate the model.
7. Document activities.

The first step in any study is to identify and describe the scope of the problem. This step includes stating the purpose and information needed from the model, such as travel time, travel volume, and queue lengths.

The next step is to determine model boundaries, data input, and control environment. This may include city streets, state highways, highway geometrics, peak hour factor, intersection volumes, and speed data.

After defining the problem, goals, and system, model development begins. This step identifies the type of model that should be used depending on the level of complexity needed to satisfy the objectives. At this point, a model (microscopic, macroscopic, mesoscopic, deterministic, or stochastic) and corresponding software are also selected. Calibration requirements and a logical structure for integrating components are established.

To calibrate the model, the data needed to calibrate the model is collected and introduced into the model. Details such as signal timing, satellite imagery, vehicle composition, speeds, and traffic are all inputted to complete the simulation model. A small area of the model is tested to calibrate the model. This step entails adjusting simulation factors, for instance, perception time, headway allocations, and traffic control device locations, and determines whether the calibration is accurate and adequate.

Verification of the model may include a visual check to monitor for any unrealistic and unusual network behavior. The software may replicate a model component properly as designed but the performance varies with the theoretical expectations or empirical observations. If this occurs, one must determine whether step four of calibration is adequate and accurate.

The following step is to validate the model by collecting, reducing, and organizing data from the model to compare to actual data. At this step, the model is established to describe the real system at an acceptable level of accuracy by applying rigorous statistical tests. Validation is extremely crucial because future results are dependent on replicating the real-world traffic setting with the model. Therefore, one must be attentive to the proper representation of vital processes within the overall model, errors in the input data, reasonable output developed from simulation trials, and potential “bugs” in the model and algorithms utilized. A detailed inspection of the animation is an excellent tool for observing the traffic setting and interpreting the simulation output. Validation often occurs alongside calibration and verification.

The final step described by Liberman and Rathi includes summarizing steps taken to create the model, creating a user manual, and documenting algorithms and software used. Documentation provides future users with a guide to critique and understand the built model and analysis.

2.5 DEVELOPMENT OF LARGE-SCALE MICROSCOPIC TRAFFIC SIMULATION MODEL

Large-scale traffic simulation models require data from many sources in detail, as well as proper calibration and validation. Small errors in microscopic models are exponentially magnified in large networks[xxiii].

Jha et al.[xxiv] developed and calibrated a microscopic traffic simulation model, using MITSIMLab, for the entire metropolitan area of Des Moines, Iowa. OD pairs were assigned with zone aggregations, generating 19,000 to 21,000 OD pairs. Parameters and inputs to be calibrated for this model included parameters of the driving behavior model, parameters of the route choice model, OD flows, and habitual travel times. Although these should all be ideally calibrated jointly, the scale of the model, led them to calibrate driving behavior parameters separately from others. An iterative process was used to calibrate the remaining parameter and inputs. Ultimately, the paper noted that calibration and validation results were promising.

More recently, Bartin et al.[xxv] calibrated and validated a large-scale traffic simulation network with a case study in New Jersey. Their model was developed using PARAMICS and calibrated and validated using throughput, queue lengths, and travel times at selected key locations in the network. Bartin et al. described the calibration and validation process as an iterative process including error-checking, demand estimation, capacity calibration, route choice calibration, and system performance calibration. This paper details the modeling effort required to build a large-scale traffic simulation model, including the available data requirements, generating and OD demand matrix and the results of the calibration and validation process.

Sharma and Edara[xxvi] developed a large-scale traffic simulation model for hurricane evacuation for a case study of Virginia's Hampton roads region using VISSIM. Their approach to the OD demand matrix utilized the ATM (Abbreviated Transportation Model), which is based on tracts and population data from the 2000 U.S. Census. ATM tables are prepared by the U.S. Army Corps of Engineers and referred to for evacuating population of destination. Total evacuating traffic demand and routing assignment were obtained from the ATM.

2.6 COMPLETE STREETS

Complete streets refer to roads designed to accommodate multiple modes, users, and activities including walking, cycling, public transit, automobile, nearby businesses and residents. An example of a downtown street before and after conversion to a complete street is shown in Figure 2[xxvii]. In the 'before' illustration the bus stop is obstructed by an illegally parked car. In the 'after' illustration, a bus bulb is provided to address the issue. It is one example of how complete street conversion supports more efficient modes of travel. There are numerous studies that document the benefits of complete street conversions; however, literature has also noted that the benefits depend heavily on the local context[xxviii].

Figure 2. Illustration of Before (Left) and After (Right) Complete Street Conversion[xxix]

2.6.1 One-way to Two-way Street Conversions

One-way streets to two-way street conversions allow for better local access and reduced speeds[xxx]. The most common reasons for converting one-way to two-way streets include less confusing circulation patterns, increased business exposure and access to passing motorists, slower traffic speeds, and improved pedestrian and bicycle safety. Sisiopiku and Chemmannur[xxxi] studied the conversion of one-way street pairs to two-way operations in downtown Birmingham using Synchro and CORSIM. A comparison of the existing condition baseline against the existing condition with the conversion indicated no major impacts on traffic circulation, such as unfavorable delays or spillbacks. A multiple resolution simulation and assignment approach, entailing a logical integration of two traffic simulation assignment methods, dynamic traffic assignment and microscopic traffic simulation model, was developed by Chiu, Zhou, and Hernandez[xxxii] to estimate traffic and environmental impacts resulting from downtown traffic flow conversions. Their study consisted of a case-study in the City of El Paso, concluding that two-way configurations do not necessarily bring forth desirable traffic performance. However, it was also shown that if carefully analyzed and designed, opportunities exist in order to make a two-way configuration a desirable option.

2.6.2 Road Diet

Road diet conversions are a type of complete street conversion. According to the Federal Highway Administration (FHWA)[xxxiii], road diets are "generally described as removing travel lanes from a roadway and utilizing the space for other uses and travel modes." Road diet reconfigurations typically consist of converting an undivided four-lane roadway to a three-lane undivided roadway made up of two through lanes and a center two-way left-turn lane, as seen in Figure 3. Research on an urban arterial street noted that while road diet conversion may increase travel time due to capacity reduction, the benefits associated with the reduction in traffic crashes overwhelming exceed the costs of delay[xxxiv]. In addition to reducing overall crashes, road diets improve safety by reducing vehicle speed differential and vehicle interactions. The reduction of one lane per direction of traffic limits the speed differential to the speed of the lead vehicle[xxxv]. Litman[xxxvi] has also mentioned that post- road diet conversion off-peak traffic may move slower but peak-period traffic may move faster. Nixon et al.[xxxvii], however, noted the need to study the impact of the road diet programs on the diet location as well as on the neighborhood streets.

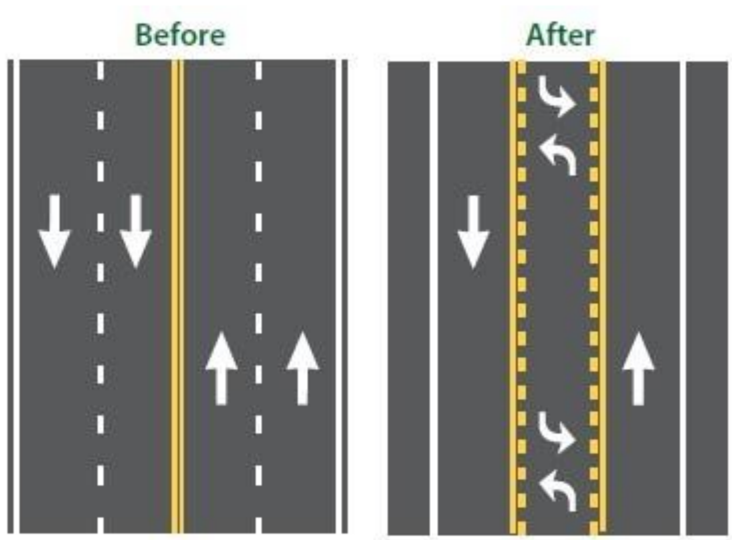

Figure 3. Typical Road Diet Basic Design from FHWA[xxxviii]

2.6.3 Complete Street Effects on Neighboring Streets

As previously mentioned, numerous studies demonstrate the benefits of complete streets conversions. However, these studies are restricted to the corridor of the conversion with the exception of Nixon et al.[xxxix] and did not analyze the effects on the surrounding network including neighboring streets. These effects are critical to compare to assess if traffic and safety issues have migrated to adjacent streets. Smart Growth America showcased a project in Seattle, Washington where the redesign of Stone Way North dropped speeds, increased bicycle traffic, and decreased collisions while peak traffic volumes city-wide remained consistent and no traffic diversion to parallel streets occurred[xl]. Zhu et al.[xli] studied the effects of complete streets on travel behavior, specifically in the Los Angeles area, by comparing complete to incomplete streets. Zhu and Wang noted that “three out of six sites had lower total traffic volume on the complete streets compared with the incomplete streets, while two other sites showed just the opposite, and one site showed no significant difference.” Their study suggests that the differences between complete and incomplete streets are site-specific and results can vary greatly depending on the location and function of complete streets. Barnes at 2019 Western District ITE Meeting[xlii] noted in a case study in Oakland, California that a complete street project on Telegraph Avenue resulted in a 6% decrease on trips along Telegraph Avenue, a 5% increase on trips on the adjacent west freeway, and 1% increase on trips on the adjacent east corridor. This study demonstrates the shift in traveler choice as a result of a complete street project. In their recommendation for the evaluation of any road diet project Nixon et al.[xliii] noted the need to examine the impact on the surrounding street network. These studies indicate that a pre-implementation assessment of network effects of complete street conversion may support agencies contemplating these changes.

2.7 TACTICAL URBANISM

Tactical urbanism refers to low-cost, temporary interventions such as temporary street closures for farmers markets and/or public pedestrian plazas, intended to improve local neighborhoods and city gathering places[xliv]. More specifically, the Street Plans Collaborative defines "tactical urbanism" as an approach to urban change that features the following five characteristics:

1. A deliberate phased approach to instigating change;
2. The offering of local solutions for local planning challenges;
3. Short-term commitment and realistic expectations;
4. Low risks, with a possibility of high reward; and
5. The development of social capital between citizens and the building of organizational capacity between public-private institutions, non-profits, and their constituents.

Examples of tactical urbanism include ad hoc conversion of on-street parking spaces to dining or seating areas and filling of awkward corners where the excess pavement is unused among others[xlv]. The cities see the benefits that these projects bring to communities and appreciate their relatively low cost and impact. Tactical urbanism projects also generate data and public feedback of built out strategies. This allows cities and the public to test out and improve upon ideas before they invest in more costly, permanent solutions.

2.7.1 Pop-up Bikeways

Pop-up bikeways are temporary bikeways installed as a result of community interest and/or to gather community feedback on new bike infrastructure. The Scott Street Pop-up Bikeway Demonstration in May 2016 resulted from residents and business owners in West San Carlos and South Bascom Urban Villages of San Jose calling for streets that are safer for people walking and biking.

Community members and partners created a 2-day “demonstration project” showing what a safer Scott Street could look like[xlvi]. The two-day project featured temporary sharrow markings on the street created with sidewalk chalk, as shown in Figure 4, free bike repair, bicycle safety classes, and free yoga, and games for families.

Figure 4. Scott Street Pop-up Bikeway Demonstration

To evaluate the long-term goal to have a series of protected bikeways, the City of San Jose had another “pop-up” bikeway in 2017. From August 7 to August 13, the City created a protected bikeway, shown in Figure 5**.** 4th Street and bikers were encouraged to fill out brief surveys about their experience [xlvii]. Overall, survey results indicate that most respondents had an overall positive impression of the bikeway, including 61% of respondents who experienced the bikeway by automobile [xlviii].

Figure 5. Different Complete Street Treatments in Downtown San Jose[xlix]

2.8 CONCLUSIONS FROM LITERATURE REVIEW

This literature review provides preliminary information on the development of a traffic simulation model and complete street strategies. Complete streets are an integral component of the multi-modal transport systems and more livable communities. Tactical urbanism provides a low-cost, temporary solution for local planning challenges. Microsimulation allows for detailed modeling and visualization of the transportation networks. Based on the recommendation from Nixon et al. [l] it is clear that complete street conversions have a network-wide impact and some recent research has started examining the network-wide impacts post-implementation. The simulation approach allows for studying the network-wide impacts of complete street strategies. Studying network-wide impacts is critical to assess the potential migration of safety and traffic issues onto neighboring streets. Our study aims to provide network output evaluation metrics on one-way to two-way street conversions before the project implementation to help agencies select optimal strategies for their downtown plan.

3. NETWORK MODELING

The investigators worked with the City's transportation planning and traffic engineering division to create the model for downtown San Jose. Towards that end, the city identified the downtown core to be modeled in VISSIM.

To replicate the most congested period downtown San Jose experiences, the downtown core network was modeled with the weekday afternoon peak hour travel demand. This chapter explains the network modeling procedure, including data collection, model building, and calibration and validation. The peak hour counts for different modes were obtained from the city. Figure 6 shows the map for the downtown core and frame.

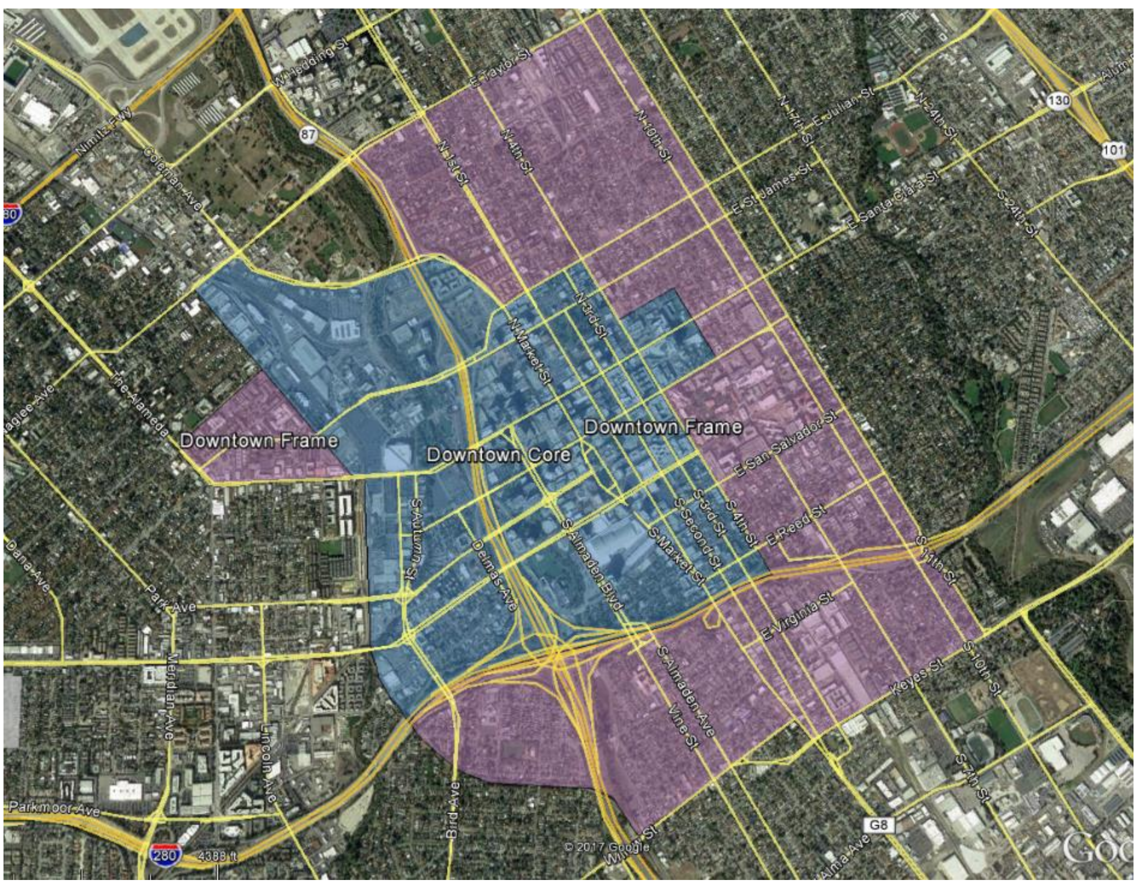

Figure 6. Map with Downtown San Jose Core and Frame

3.1 CREATING THE NETWORK

3.1.1 Road Network

VISSIM has built-in satellite imagery from Microsoft's Bing Maps, which was used as a basis for tracing the traffic network for the City of San Jose downtown core. Specific lane geometry, including those for automobile and bike lanes, was verified through satellite images and street views in Google Maps. Cars and heavy good vehicles (HGV) were prohibited from Class 1 and 2 bike lanes. The complete network consisted of 104 intersections, 1,264 links, and 2,303 connectors for a total length of 571,000 feet in the network shown in Figure 7. Since the focus was to model complete street strategies in the downtown, freeways mainline segments were not included in the model. In addition to parking lots, off-ramps and on-ramps to the regional freeways that connected with the downtown core served as origins and destinations in the VISSIM model.

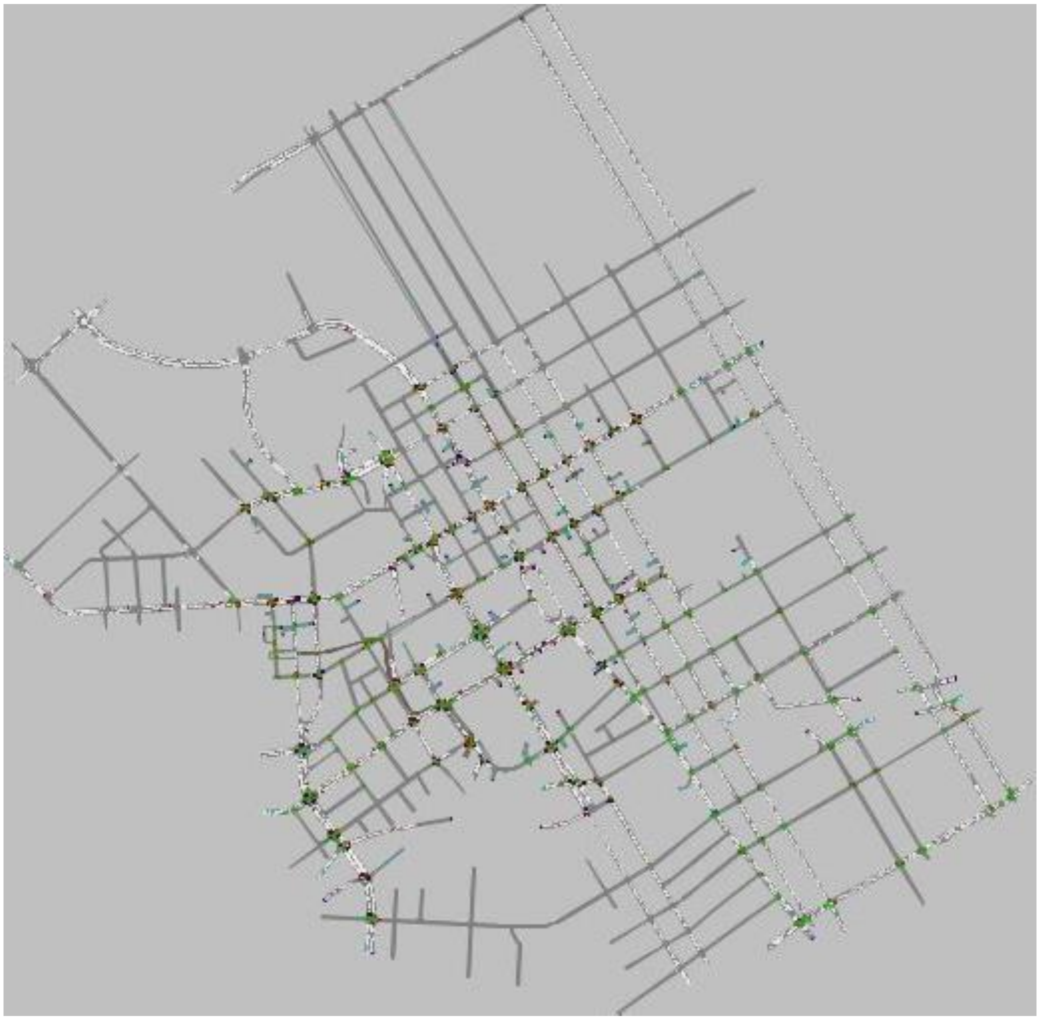

Figure 7. VISSIM Model for the Downtown Core

3.1.2 Vehicle Data and Composition

To create an accurate existing baseline PM peak scenario model, the City of San Jose provided intersection turning movement data for downtown surface streets and a list of parking lots within the downtown area. The number of parking spaces in the lot was used as preliminary volume inputs at the parking lot exits. In addition, off-ramp volumes provided by Caltrans in the forms of ADT were converted to the peak hour volumes using Equation 1 for preliminary volume inputs.

$$\text{Peak Hour Volume} = (\text{ADT}) * (\text{K} - \text{factor}) \qquad (1)$$

where:

ADT: Annual daily traffic

K-factor*:* Peak factor

The methodology for determining preliminary input volumes in VISSIM involved the following steps:

1. Convert off-ramp ADT to peak hour volumes using Equation 1, assuming a K-factor of 10%
2. For parking lots, use 50% of available parking spaces as PM peak hour volume input.

Based on the discussions with the city staff, vehicle compositions remained as VISSIM default values of 98% cars and 2% HGVs (heavy goods vehicles or Trucks).

3.1.3 Speed Data

VISSIM requires speed distributions to be defined for all vehicle classes. Speed survey data (see Appendix E) was provided for key corridors in downtown San Jose. Using this data, a minimum speed, 15^{th} percentile speed, 85^{th} percentile speed mph, and a maximum desired speed was set for each corridor (see Figure 8 for an example input for the speed profile in VISSIM).

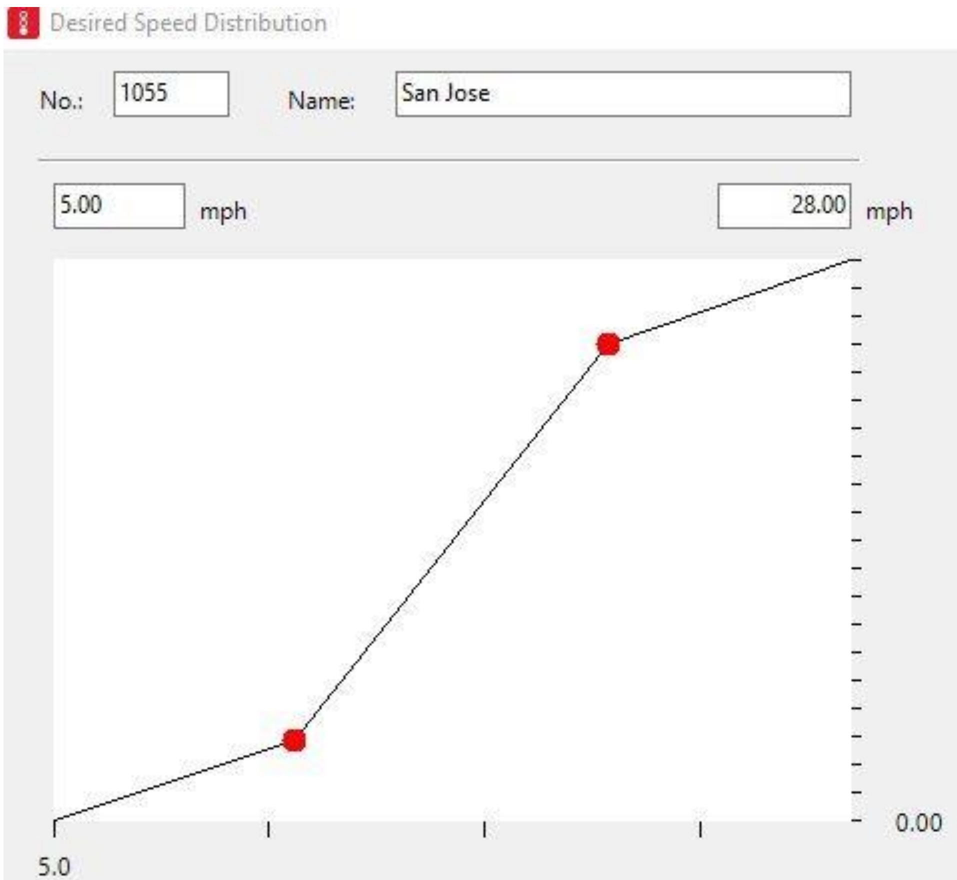

Figure 8. Speed Distribution for Vehicles

3.1.4 Conflict Areas

Conflict areas are areas of overlapping links and connectors within the VISSIM network. To prevent vehicles, cyclists, and pedestrians from appearing to be colliding or moving over each other in simulation; conflict areas need to be managed by assigning the prioritized movements. These movement priorities were assigned at merge points for vehicles exiting the parking lots and at intersections for left and right turn movements yielding to through traffic. Conflict area priorities were also assigned at locations where the tram line intersected the road, giving priority to the tram transit vehicles.

3.1.5 Signal Timing Data

After setting up the network geometry, vehicle inputs and composition, speed data, and conflict areas, the next step involved setting up the traffic signals with signal timing sheets provided by the City of San Jose. All signals were modeled by as Ring Barrier Controller (RBC) in VISSIM, which can model actuated signal timing pattern as well as coordination. Signal heads and signal controllers were created and assigned to each other through the RBC interface of VISSIM. This type of controller fulfilled our needs of protecting left turns, vehicle extensions, and vehicle detections. A total of 90 signal controllers were added to the model. Figure 9 shows an example of a standard signal timing template. Coordination was added to the corridors where the signal systems operate on a coordinated signal timing plan during afternoon peak-hour.

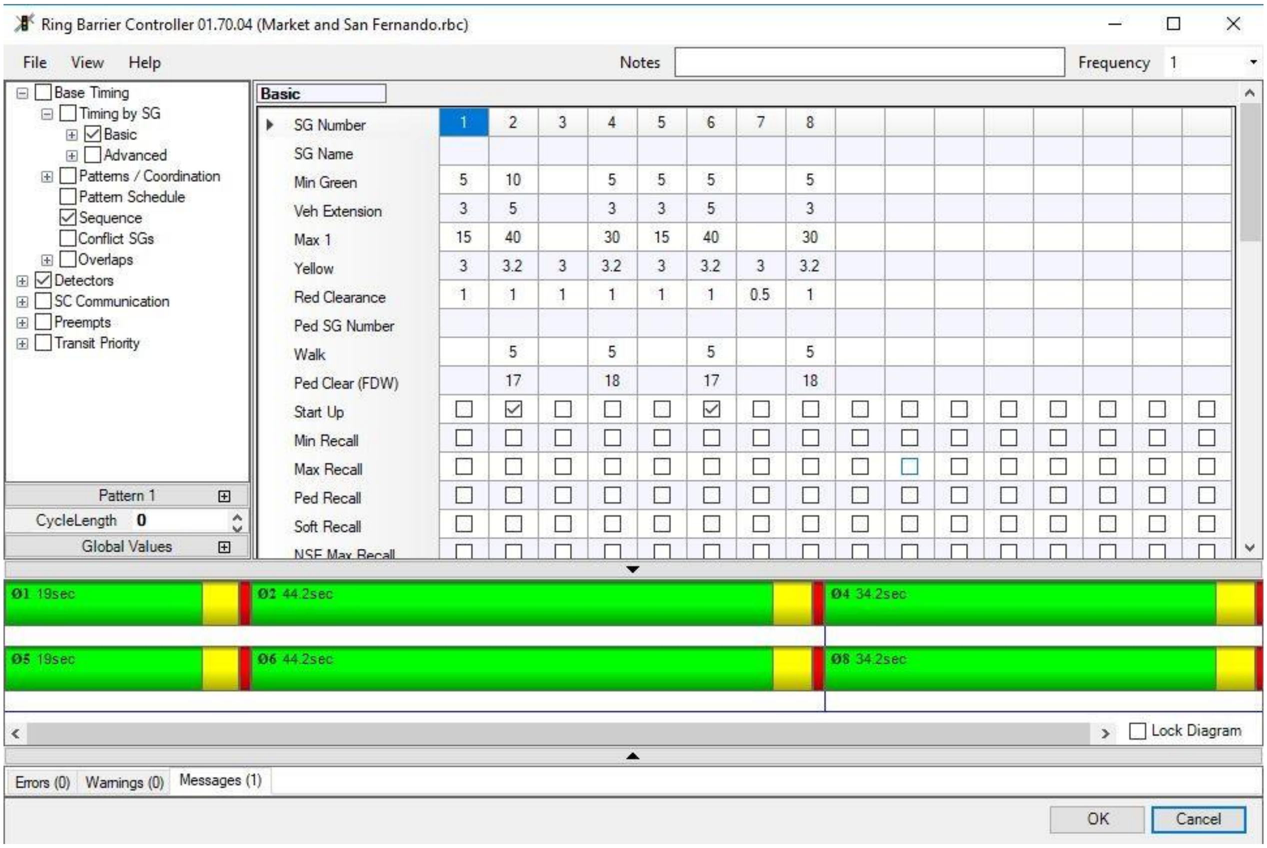

Figure 9. Ring Barrier Controller Timing Interface for VISSIM

3.1.6 Vehicle Routes

With parking lots and on-ramps as origins and the same parking lots and off-ramps as destinations, routing decisions were generated using travel time from Google Maps for a Wednesday between 5:00 – 6:00 PM, the PM peak period. Google Maps produced a minimum of one and maximum of three possible routes with every origin-destination pair and their travel time. The total input flow at the origins to destinations was divided into all routes based on travel time. Routes between OD pairs that utilized a freeway mainline were not coded into the network since the network of interest did not have any freeways. All other routes provided by Google Maps were coded into the network. Figure 10 shows an example of a route decision generated by Google Maps and how it was coded into the network.

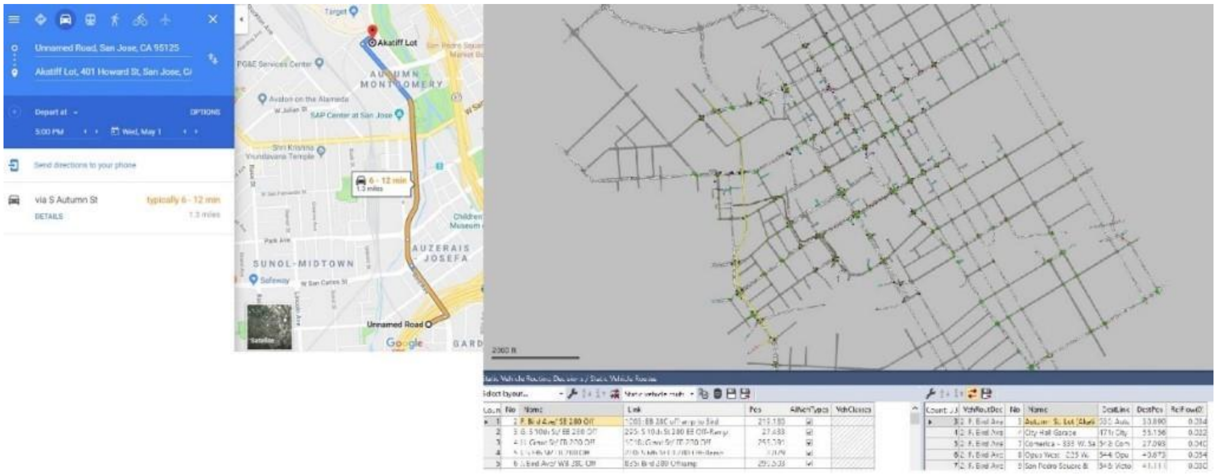

Figure 10. Route Decision from Google Maps and its Coding in the Network

3.1.7 Transit

Public transport lines were incorporated into the model in the same manner as static vehicle routes. According to PTV VISSIM[li], "a PT (Public Transport) line consists of buses or trams serving a fixed sequence PT stops according to a timetable."

3.1.8 Cyclists

Cyclists were coded into the model as their own vehicle class and routed through corridors with Class 2 bike lanes, listed in Table 2. These corridors were identified based on the data provided by the city. An estimate of 30 cyclists per hour for each corridor was coded into the network. Cyclists' speed ranged from 9.32 to 12.43 MPH.

Table 2. Cyclists Corridors

Streets with most significant bicycle traffic
San Fernando Street
3rd Street
4th Street
7th Street
Paseo de San Antonio

3.1.9 Pedestrians Cyclists

Pedestrians were coded into the model using pedestrian areas and inputs. Pedestrian signal heads and detectors were placed at each end of the footpath link crosswalk and OD matrices for each individual intersection. An estimate of 100 pedestrians per hour per origin was coded into the network. Pedestrian input composed of 50% males (1022: IMO-M 30-50) and 50% females (1023: IMO-F 30-50) with speeds ranging from 2.17-3.62 MPH and 1.59-2.66 MPH, respectively. Pedestrians were coded in the intersections listed in Table 3 based on turning movement counts data obtained from the city.

Table 3. Intersections with Significant Pedestrian Traffic

Intersections with Pedestrians
1st Street/Santa Clara Street
1st Street/San Fernando Street
1st Street/St. John Street
1st Street/St. James Street
2nd Street/Santa Clara Street
2nd Street/San Fernando Street
2nd Street/St. John Street
2nd Street/St. James Street
3rd Street/Santa Clara Street
3rd Street/San Fernando Street
4th Street/Santa Clara Street
4th Street/San Fernando Street

3.2 ORIGIN – DESTINATION MATRIX

An origin-destination matrix (OD matrix) is a trip table displaying the number of trips going from each origin to each destination. This is how VISSIM assigns traffic to the network. As previously mentioned, vehicle routes were generated for a weekday PM peak with Google Maps, utilizing parking lot exits and off-ramps as origins and the same parking lot entrances and on-ramps as destinations. Appendix A: Origin-Destination Matrices shows the final OD matrices for the base network. The process for obtaining the final OD matrix is described in the next section.

3.3 CALIBRATING THE NETWORK

As the most prominent user of the network, results from this network focused on the automobile mode. Drivers gravitate toward negative feelings regarding such conversions and are often very vocal during public outreach. Thus, to reassure these stakeholders, the study was aimed at the automobile mode.

Calibration and validation are necessary steps to ensure the model's reliability and accuracy. Calibrating involves polishing and adjusting the network to replicate observed traffic conditions[lii]. In conjunction with validation, calibration is an iterative process that adjusts the network and compares actual traffic information to the simulated traffic information for various links of the network till measures of performance, such as turning movement volumes, car-following model parameters, traffic speeds, and travel times, are satisfied. A well-calibrated model is essential to the studied system because it increases reliability of the predicted traffic patterns and scenarios. Calibration efforts included comparing the model's traffic volumes to those of the City of San Jose, comparing the model's average speed to the distribution of speed observed in the real world, and comparing estimated travel times to the distribution of the travel times observed on Google Maps. Behavior parameters were iteratively modified such that the model's data closely resemble the actual data.

3.3.1 Driving Behavior Parameters

The network consisted only of local streets that utilized one driving behavior parameter set. This set used the unaltered “Urban (motorized)” driving behavior default values in VISSIM. Figure 11 below shows a screenshot of the final parameter set for the city of San Jose network.

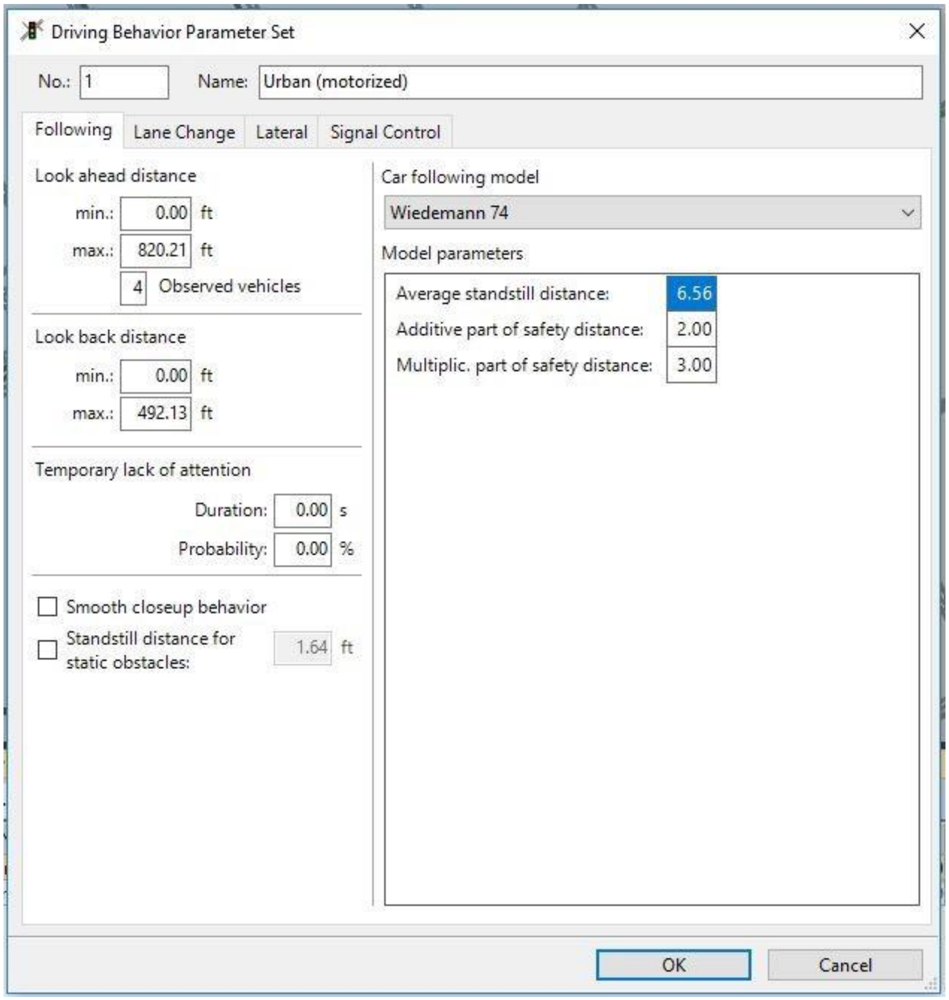

Figure 11. Driving Behavior Parameter for the Model

3.3.2 Vehicle Record Data

The validation was based on traffic data from the VISSIM model using elements named “data collection points”, “queue counters”, and “travel time measurements". Data collection points and queue counters were placed at study area intersections while travel time measurements were placed on key corridor segments. These three data collection methods and measures were initially selected as best suited to measure the modeled network's similarity to the real-world data collected in San Jose. Data collectors tallied every vehicle passing through it for the analysis period of 3600 seconds. The analysis period did not involve the first 1500 seconds of warm-up or seeding time and final 900 seconds of clearing time, as suggested by the Maryland Department of Transportation (MDOT)[liii]. Data collectors also measured spot speed for each individual vehicle passing through their location and output the average spot speed. VHelper, a VISSIM utility program, was used as a preliminary calibration and validation tool to catch coding mistakes and estimate/visualize intersection turning volumes[liv]. Although not used as a validation measure due to the lack of actual data, queue counters provide average queue length, maximum queue length, and number of vehicle-stops within the queue as outputs. Queues are counted from the location of the queue counter on the link upstream to the final vehicle that is in queue condition. If the queue backs up from multiple different approaches, the total queue will be the sum for all of queues at all approaches and be reported as the longest maximum queue length. Travel times are measured as the average travel time, including waiting or dwell times, for vehicles to cross the first (start) and second (destination) cross-sections specified for the travel time measurement placed on the key corridors. Delay can be found for any selected segment where travel time is measured. A delay time measurement determines the mean time delay calculated from all vehicles observed on a single or several link sections. Table 4 displays the locations of data collectors, queue counters, and travel time corridors.

Table 4. Data Collectors, Queue Counters, and Travel Time Corridor Locations

Data Collectors	Queue Counters	Travel / Delay Time Corridors
Market Street/Santa Clara Street	Market Street/Santa Clara Street	EB Santa Clara Street
Market Street/San Fernando Street	Market Street/San Fernando Street	WB Santa Clara Street
Market Street/San Carlos Street	Market Street/San Carlos Street	NB Market Street
3rd Street/Santa Clara Street	3rd Street/Santa Clara Street	SB Market Street
3rd Street/San Fernando Street	3rd Street/San Fernando Street	NB 3rd Street
3rd Street/San Carlos Street	3rd Street/San Carlos Street	SB 4th Street
3rd Street/San Salvador Street	3rd Street/San Salvador Street	EB San Fernando Street
3rd Street/Reed Street	3rd Street/Reed Street	WB San Fernando Street
4th Street/Santa Clara Street	4th Street/Santa Clara Street	NB Almaden
4th Street/San Fernando Street	4th Street/San Fernando Street	SB Almaden
4th Street/San Carlos Street	4th Street/San Carlos Street	
4th Street/William Street	4th Street/William Street	
4th Street/San Salvador Street	4th Street/San Salvador Street	
4th Street/Reed Street	4th Street/Reed Street	
Almaden Boulevard (W)/Santa Clara Street	Almaden Boulevard (W)/Santa Clara Street	
Almaden Boulevard (E)/Santa Clara Street	Almaden Boulevard (E)/Santa Clara Street	

Almaden Boulevard/San Fernando Street	Almaden Boulevard/San Fernando Street
Almaden Boulevard/Park Avenue	Almaden Boulevard/Park Avenue
Almaden Boulevard/San Carlos Street	Almaden Boulevard/San Carlos Street
Almaden Boulevard/Woz Way	Almaden Boulevard/Woz Way

3.3.3 Validating the Network

The validation process compares output data for automobiles from multiple runs of the well-calibrated network to the data from the real-world. This process requires estimation of the GEH statistic[lv]. A validated network justifies the simulation's usage in different future scenarios.

3.3.4 Seed Numbers

Validation requires multiple runs of the simulation model at different seed numbers. Random seed numbers in VISSIM affect the start values of random generators used internally in the model. These values influence the arrival times of vehicles in the networks and stochastic variability of the driving behaviors, allowing for the comparison of daily changes in traffic patterns at the same location[lvi]. Running the simulation with the same seed number would produce the same exact data for volumes, speeds, queue lengths, and travel times at all network locations. Changing the seed number would output differing results based on the actual values of the driving behavior parameters derived from the specified distribution for these parameters. For this project, validation of the base network was based on 10 simulation runs. MDOT recommends a minimum of 5 simulation runs and up to 15 runs before average outputs of all runs can be used for analysis[lvii].

3.3.5 GEH Statistics Validation for Turning Movement Counts

The Geoffrey E. Havers (GEH) Statistic is a formula commonly used in transportation analysis to compare two sets of traffic volumes. The GEH Statistic was used to compare field counts by the City of San Jose found in Appendix F to simulation turning volumes. The empirically derived formula is defined by Equation 2.

$$GEH = \sqrt{\frac{2\,(M-C)^2}{M+C}} \qquad (2)$$

where:

M: Traffic count from the simulation model

C: Traffic count observed in the real world

The GEH statistic is useful in comparing traffic volumes because the formula does not follow a linear pattern, avoiding common pitfalls witnessed in using simple percentage comparisons[lviii]. For traffic modeling work in the existing base scenario, a GEH of less than 5.0 is considered a good match between the model and observed volumes. The measurements with GEHs in the range 5.0 to 10.0 have a medium chance of error and those with GEHs greater than 10.0 have a high probability of error[lix]. Data collected from model runs using 10 different seed number runs were averaged and used to calculate the GEH statistic for each turning movement of the previously identified key intersections.

With 75.78% of GEH statistics lower than 5.0 and 5.81% of GEH statistics more than 10.0, as well as accounting for the large size of the network, these values are consistent with the following approach derived from the Washington State Department of Transportation (WSDOT)[lx]:

1. A minimum of two-thirds of GEH statistics for turning movements less than 5.0
2. A minimum of ninety percent of GEH statistics for turning movements less than 10.0

Complete statistics detailing average vehicle counts for turning movements from 10 different seed number runs, the field data values, and the corresponding calculated GEH statistic can be found in Appendix B.

3.3.6 Speed Validation

The City of San Jose provided peak hourly average speed data on key corridors. This information was compared and matched with spot speed data from VISSIM to ensure the replication of the drivers' behavior. As a calibration target, the average speed of straight-through movements at intersections in the corridor must fall in the range of speeds provided by the City. Table 5 summarizes average speed data from 10 runs compared to corridor speed data from the City. Speed data provided by the City can be found in Appendix E.

Table 5. Existing Baseline Speed Summary

	Average from Model (mph)	Range from City Data (mph)
Market Street	11.8	7-18
Almaden Boulevard	12.0	10-16
3rd Street	12.4	12-25
4th Street	8.9	6-16
San Carlos Street	13.9	5-11
St. James Street	10.2	8-20
Santa Clara Street	11.7	11-23

3.3.7 Travel Time Validation

In addition to the GEH statistic for traffic counts and speed validation, travel times were recorded for key corridors. Since no real travel time data was available, 'actual' travel times for comparison were obtained from Google Maps during a Wednesday PM peak. 80% of travel times along the key corridors are within Google Maps' estimated travel time range. Table 6 summarizes travel times in the model and from Google Maps. Travel time for each run can be found in Appendix D.

Table 6. Existing Baseline Travel Time Summary

Travel Time Corridors	Vehicles	Existing Baseline (min)	Google Range (min)
EB Santa Clara Street	134	6.9	4 - 12
WB Santa Clara Street	141	5.9	2 - 8
NB Market Street	2	6.1	3 - 9
SB Market Street	69	8.7	4 - 12
NB 3rd Street	83	6.2	2 - 7
SB 4th Street	288	12.3	3 - 8
EB San Fernando Street	52	13.7	5
WB San Fernando Street	15	7.1	3 - 6
NB Almaden	57	5.0	2 - 6
SB Almaden	235	8.7	2 - 8

3.4 RESULTS FROM NETWORK MODELING

Based on the validation data, the base model was well-calibrated based on the guidelines derived from WSDOT. In certain locations, there are some specific movements that did not calibrate quite as well, including:

- EB movements at 4th Street/San Fernando Street – modeled travel times were much longer than observed travel times, likely due to queues on San Fernando Street resulting from modeled vehicles waiting to change lanes to turn right.
- SB movements on 4th Street– modeled travel times were much longer than observed travel times, likely due to queues on 4th Street resulting from vehicle slowdown in conflict areas despite having priority.

The travel times that did not calibrate have a lower, yet, acceptable volume and are less-critical movements from a network perspective. As such, these discrepancies are not anticipated to have a significant impact on the analysis for future scenarios discussed in forthcoming chapters.

3.4.1 Analysis and Network Measures of Effectiveness

Table 7 shows the network measures of effectiveness (MOEs), including vehicles, travel time, speed, delay, and stops, derived from the Existing Condition Baseline VISSIM model. Network measures of effectiveness for each run can be found in Appendix C.

Table 7. Existing Baseline Network Measures of Effectiveness

Network	
Number of Vehicles	15,250
Total Travel Time (h)	9,325,456
Total Distance (mi)	16,647
Total Delay (h)	5,171,654
Per Vehicle	
Average Speed (mph)	6
Average Delay (s)	286
Average Number of Stops	6
Average Stop Delay (s)	157

The numbers in Table 7 are compared to the scenarios discussed in the next chapter to assess the network-wide impacts of the multimodal/complete street strategies evaluated in the next section.

4. ALTERNATIVE SCENARIOS

After calibrating and validating the existing condition baseline, referred to as Scenario 0 in the remainder of this report, complete street conversion scenarios were discussed with the city and implemented in VISSIM to analyze changes in the overall MOEs listed in Table 7. The impact of complete street conversions on the overall network is a major contribution of the study.

4.1 2040 TRAFFIC VOLUMES

The initial plan was to test each of the conversion scenarios with 2015 and 2040 volumes. The city provided the 2040 volume from the travel demand forecasting models. These traffic volumes were in the form of zonal OD matrices. The zones for the city of San Jose are shown in the figure below.

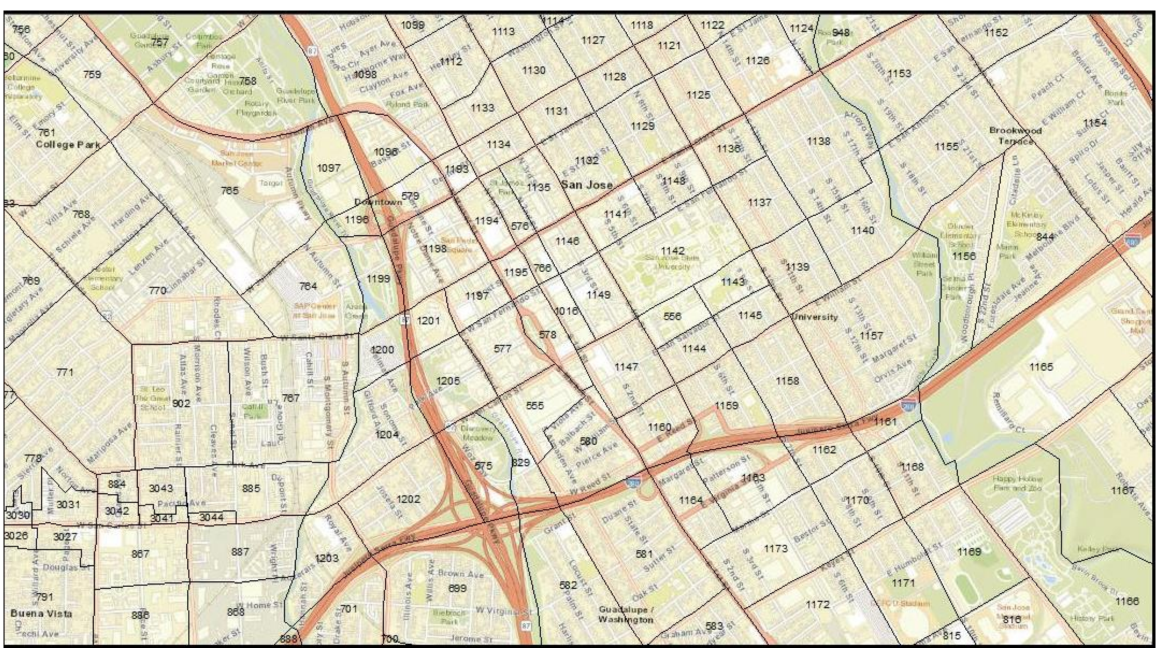

Figure 12. Zones for the OD Matrices (Year 2015 and 2040)

Note that the region shown in Figure 12 is larger than the downtown core modeled in VISSIM. In comparing the OD matrices for the year 2015 (Scenario 0) vs. 2040 it was apparent that the city's travel demand model is forecasting a large increase in automobile traffic. Several zones according to the model are expected to have the automobile volume increase by a factor as much as 20. Clearly, the projected increase in automobile travel demand is not sustainable. Inputting traffic volumes anywhere close to that in the VISSIM O-D led to complete gridlock in the scenario network.

The alternative approach adopted for this work was then to model the scenario provided with varying traffic volume to provide the city with an estimate on what the network might look like with a modest increase (in the range of 5 to 10%) in automobile demand. A total of four scenarios are analyzed in this report (including scenario 0 which is the base case). Each scenario is described along with the network metrics collected using VISSIM for it in the subsequent sections of this chapter.

4.2 SCENARIO 1: ALMADEN BOULEVARD CONVERSION W/ 2015 DEMAND LEVEL

4.2.1 Assumptions

In the existing condition baseline (Scenario 0), Almaden Boulevard between St. John Street and Santa Clara Street is a one-way southbound street. This scenario converted this 770-foot section of Almaden Boulevard to a two-way street, allowing left and right turns from Santa Clara Street to Almaden Boulevard (Figure 13). Additional turning movements added include right turns onto Carlysle Street and St. John Street. Literature has shown that converting streets from one way to two-way operations has a positive impact on the livability of a community[lxi].

Figure 13. Before (Left) and After (Right) of Almaden Street Conversion

4.2.2 Vehicle Routes

A total of 56 vehicle routes were adjusted to utilize the added northbound Almaden Boulevard between St. John Street and Santa Clara Street. The routes were also selected for adjustment based on the vehicles' ability to traverse more effectively to their destination. Appendix G lists routes adjusted for the Almaden Boulevard Conversion scenario. Modifications to the routes allow us to examine the impact of the conversion on the overall network beyond just the street corridor being converted.

4.2.3 Analysis and Network Measures of Effectiveness (MOEs)

Table 8 below shows the network measures of effectiveness for Scenario 1 and compares it to the base case (Scenario 0). It may be observed that the conversion of Almaden Street to the two-way operation has no noticeable impact on the average speeds at key data collection locations and in fact, some of the peak hour speeds have marginally increased (e.g., at St. James Street) potentially due to smoother flow of traffic.

Table 8. Almaden Conversion Speed Summary

	Almaden Conversion (mph)	**Existing Baseline (mph)**
Market Street	12.3	11.8
Almaden Boulevard	12.0	12.0
3rd Street	12.3	12.4
4th Street	8.9	8.9
San Carlos Street	14.2	13.9
St. James Street	12.8	10.2
Santa Clara Street	11.7	11.7

Table 9. Almaden Conversion Travel Time Summary

Travel Time Corridors	Almaden Conversion (min)	Existing Baseline (min)
EB Santa Clara Street	6.6	6.9
WB Santa Clara Street	5.8	5.9
NB Market Street	6.1	6.1
SB Market Street	8.5	8.7
NB 3rd Street	6.1	6.2
SB 4th Street	12.2	12.3
EB San Fernando Street	13.4	13.7
WB San Fernando Street	7.1	7.1
NB Almaden	4.7	5.0
SB Almaden	9.3	8.7

Table 9 shows the travel-time comparisons and it may be observed that travel time average for Scenario 1 and Scenario 0 on all major corridors of the downtown core are essentially unchanged.

Table 10. Almaden Conversion Network Measures of Effectiveness

	Network	
	Almaden Conversion	**Existing Baseline**
Number of Vehicles	15,177	15,250
Total Travel Time (h)	9,264,036	9,325,456
Total Distance (mi)	16,531	16,647
Total Delay (h)	5,137,334	5,171,654
	Per Vehicle	
	Almaden Conversion	**Existing Baseline**
Average Speed (mph)	6	6
Average Delay (s)	285	286
Average Number of Stops	6	6
Average Stop Delay (s)	156	157

Table 10 shows the average delays for automobile traffic, which on average is not adversely affected by the conversion.

4.3 SCENARIO 2: ALMADEN BOULEVARD CONVERSION AND INCREASE AUTOMOBILE DEMAND 5%

4.3.1 Assumptions

In this scenario, Scenario 1, Almaden Boulevard Conversion, was replicated with input volume increasing by 5% throughout the network to evaluate how the network may look like with a modest increase in automobile demand. Demand was increased by 5% increments to identify the demand points in which the network would break down. As future growth trends become readily available, the city may experiment with increasing demand based on those trends.

4.3.2 Analysis and Network Measures of Effectiveness (MOEs)

As shown in Table 11, travel time mostly increased on EB Santa Clara and NB 3rd St by nearly 12%.

Table 11. Almaden Conversion plus 5% Demand Speed Summary

	Almaden plus 5% Demand (mph)	Almaden Conversion (mph)	Existing Baseline (mph)
Market Street	12.2	12.3	11.8
Almaden Boulevard	12.0	12.0	12.0
3rd Street	12.3	12.3	12.4
4th Street	8.7	8.9	8.9
San Carlos Street	14.1	14.2	13.9
St. James Street	12.8	12.8	10.2
Santa Clara Street	11.4	11.7	11.7

Table 12. Almaden Conversion plus 5% Demand Travel Time Summary

Travel Time Corridors	Almaden Conversion plus 5% Demand (min)	Almaden Conversion (min)	Existing Baseline (min)
EB Santa Clara Street	7.4	6.6	6.9
WB Santa Clara Street	5.8	5.8	5.9
NB Market Street	6.5	6.1	6.1
SB Market Street	8.7	8.5	8.7
NB 3rd Street	6.9	6.1	6.2
SB 4th Street	13.1	12.2	12.3
EB San Fernando Street	14.5	13.4	13.7
WB San Fernando Street	7.0	7.1	7.1
NB Almaden	4.6	4.7	5.0
SB Almaden	9.4	9.3	8.7

Table 13 below shows that the network-level indicators have deteriorated due to increased automobile demand with average delay per vehicle increasing from 285 s to 310 s, an almost 9% increase. It is apparent that while the speed at some of the locations is reduced by a small amount; the overall network can handle 5% increase in automobile demand. The same pattern is observed in terms of travel time in Table 12 (above) even as increases in corridor travel times are not as severe. The highest percentage increase compared to Scenario 1 is on EB Santa Clara and NB 3rd Street, with 12% and 13%, respectively.

Table 13. Almaden Conversion plus 5% Demand Network Measures of Effectiveness

Network			
	Almaden plus 5% Demand	**Almaden**	**Existing Baseline**
Number of Vehicles	15,527	15,177	15,250
Total Travel Time (h)	10,031,002	9,264,036	9,325,456
Total Distance (mi)	16,937	16,531	16,647
Total Delay (h)	5,799,015	5,137,334	5,171,654
Per Vehicle			
	Almaden plus 5% Demand	**Almaden**	**Existing Baseline**
Average Speed (mph)	6	6	6
Average Delay (s)	310	285	286
Average Number of Stops	6	6	6
Average Stop Delay (s)	174	156	157

4.4 SCENARIO 3: ALMADEN BOULEVARD CONVERSION AND INCREASE AUTOMOBILE DEMAND 10%

4.4.1 Assumptions

In this scenario, Scenario 1: Almaden Boulevard Conversion was replicated with automobile demand increasing by 10%.

4.4.2 Analysis and Network Measures of Effectiveness (MOEs)

Table 14 below shows the speed summary for Scenario 3. It is apparent that the average speed at key network locations is affected and is reduced by a small amount.

Table 14. Almaden Conversion plus 10% Demand Speed Summary

	Almaden plus 10 % Demand (mph)	Almaden plus 5% Demand (mph)	Almaden Conversion (mph)	Existing Baseline (mph)
Market Street	12.0	12.2	12.3	11.8
Almaden Boulevard	11.8	12.0	12.0	12.0
3rd Street	12.2	12.3	12.3	12.4
4th Street	8.6	8.7	8.9	8.9
San Carlos Street	14.1	14.1	14.2	13.9
St. James Street	9.8	12.8	12.8	10.2
Santa Clara Street	11.4	11.4	11.7	11.7

Table 15. Almaden Conversion plus 10% Demand Travel Time Summary

Travel Time Corridors	Almaden Conversion plus 10% Demand (min)	Almaden Conversion plus 5% Demand (min)	Almaden Conversion (min)	Existing Baseline (min)
EB Santa Clara Street	7.6	7.4	6.6	6.9
WB Santa Clara Street	6.1	5.8	5.8	5.9
NB Market Street	5.7	6.5	6.1	6.1
SB Market Street	8.7	8.7	8.5	8.7
NB 3rd Street	6.1	6.9	6.1	6.2
SB 4th Street	13.5	13.1	12.2	12.3
EB San Fernando Street	16.5	14.5	13.4	13.7
WB San Fernando Street	7.2	7.0	7.1	7.1
NB Almaden	4.5	4.6	4.7	5.0
SB Almaden	9.4	9.4	9.3	8.7

As shown in Table 15, travel time has increased by two whole minutes on Fernando St compared to the 5% traffic volume increase scenario. The network-wide metrics in Table 16 show that the average delay for this scenario has increased by 14.2% compared to the base case.

Table 16. Almaden Conversion plus 10% Demand Network Measures of Effectiveness

	Almaden plus 10% Demand	Almaden plus 5% Demand	Almaden	Existing Baseline
Network				
Number of Vehicles	14,801	15,527	15,177	15,250
Total Travel Time (h)	9,949,705	10,031,002	9,264,036	9,325,456
Total Distance (mi)	16,142	16,937	16,531	16,647
Total Delay (h)	5,901,180	5,799,015	5,137,334	5,171,654
Per Vehicle				
	Almaden plus 10% Demand	**Almaden plus 5% Demand**	**Almaden**	**Existing Baseline**
Average Speed (mph)	5.8	6.1	6.4	6.4
Average Delay (s)	326.5	310.7	285.1	285.9
Average Number of Stops	7.1	6.8	6.4	6.2
Average Stop Delay (s)	186.2	173.9	156.4	157.4

4.5 SCENARIO VISUALS AND PUBLIC OUTREACH

It is clear from scenarios and the analysis of the data from the 2040 Envision San Jose Plan[lxii] that the conversion scenarios success may depend on the TDM measures the city is able to adopt. In this case, the public outreach is even more critical to the success of realizing a multimodal downtown core. The Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFETEA-LU) mandated using visualization techniques for describing plans to the public within the transportation planning process[lxiii] [lxiv]. Accordingly, the agencies (e.g., cities, and Metropolitan Planning Organizations (MPOs)) involved in the implementation of projects, similar to the ones modeled for various scenarios in this chapter, organize a public meeting to publicize plans and get feedback from them. For each of the scenarios tested in the report, a 3D video was developed that may be used in public meetings prior to real-world implementation. Difference between scenarios with varying demands may be used to get stakeholders' buy-in for the transportation demand management programs. Previous studies [lxv] [lxvi] indicated that visualization techniques are useful for public and most participants want transportation agencies to spend more time and budget on video simulation and public involvement. Visualization helps audience to picture transportation plans and associated impacts, using composite images, video overlay, and animations.

There is some evidence in the literature for a lower participation rate of female and young residents in public meetings, therefore conducting outreach activities at schools, youth centers, shopping malls, etc. could increase the rate of female and young resident participation. The internet would be an effective medium to keep the younger participants involved [lxvii].

To increase the public involvement, the city of San Jose may leverage from the credibility of individual(s) who play the role of a bridge between residents and other project partners[lxviii], such as superintendent of schools and/or San Jose State University faculty. Also, articles or advertisements in a neighborhood newspaper as well as use of social media could increase public engagement.

Finally, it is not only about public opinion, but also the deliberation on the course of action through partnership and communication that could gather multidisciplinary organizations with diverse interests to provide a robust strategy and practical action plan[lxix]. Communicating with planners, designers, and developers at early conceptual stage maximizes the benefits of the project, because both planners and designers are more open to modify plans before making considerable design changes. The city is welcome to use the videos provided for any of its outreach plans. Moreover, since the modeled networks for each scenario have been provided to the city, they can create appropriate scenarios and create customized videos to use for public outreach.

5. CONCLUSION

5.1 SUMMARY AND EVALUATION OF RESULTS

This study addressed the needs identified by the City of San Jose and the project team has been in direct contact with the City. The City can use the results from the model to a) evaluate the strategies specifically evaluated and tested as part of this effort; b) demonstrate the transportation network operations before and after implementation of the strategies to stakeholders, including the community and businesses, via 3D animation; and c) run and evaluate future scenarios through the simulation model provided to the City by the project team. The evaluation focused on the automobile mode because these stakeholders are adversely affected in complete street projects. To the broader research community, the proposed effort will provide a framework to evaluate combinations of strategies aimed at improved multimodal mobility and public life. The research will help communities around North America that have been reluctant to develop scenarios due to the lack of resources, capacity, or expertise by offering a more effective method to illustrate the impact of policy/planning changes. According to FHWA guidelines for applying microscopic traffic simulation[lxx], to develop a reliable model one needs to "evaluate the calibration and fidelity of the model to real-world conditions present in the project analysis study area."

5.2 RELIABILITY OF DATA

For the 2015 base case model, the speed from the VISSIM model was within the range of the data provided by the city. Travel time through major corridors in the city were also well-validated. GEH statistics for turning movement counts at intersections were also in the acceptable range and within the guidance provided by organizations such as the WSDOT. Hence, we are confident that the model is capturing the real-world OD patterns as well as road user behavior in the base case appropriately. The evaluation for the 2040 data was based on the city's output from the regional travel demand model. It accounts for the Envision San Jose 2040 general plan. Based on the regional travel demand model, the automobile demand estimated and inputted into traffic model overwhelmed the network. Therefore, the project team recommends to the city the need to reduce automobile demand through extensive TDM measures.

5.3 RECOMMENDATION FOR IMPROVEMENT AND FURTHER RESEARCH

This research provided a framework to examine the network-wide impacts of one-way to two-way street conversions. Most of the previous research focused on the impact only on the streets being converted. For the broader research community, the research shows the way to move towards evaluation of complete networks and not just complete streets. The abrupt ending of sidewalks and lack of integration of pedestrian routes is often cited as a reason for low pedestrian travel mode share and only complete networks can help address this issue. Although only results for the automobile mode were analyzed in this study, the model has the capability to produce measures of performance for all other modes included in the network (i.e. busses, trams, bicycles, and pedestrians). For the key stakeholders, the city of San Jose, the added value of this work is in the results documented in this report and the VISSIM models provided to the city. The city staff can use the downtown core network provided by the research team and address future scenarios as they are proposed. This will be especially critical for future tactical urbanism strategies that the city develops for using city streets for public interactions during events such as a street fair or farmer's market.

Future scenarios may also include autonomous vehicles as they grow in popularity. Zielder et al. simulated autonomous vehicles based on Wiedemann's car following modeling in PTV Vissim and found that the simulation reproduced behavior of autonomous vehicles communicating with leading vehicles well[lxxi]. CoEXist, a

European project, has also documented a micro-simulation guide for automated vehicles using VISSIM [lxxii].

With more data, consideration may also be given to other calibration and validation methods for the model, such as calibrating headway/time gap as recommended by Dong et al.[lxxiii] or using mobile devices to develop an estimation for the O-D matrix, as shown by Caceras, Wideberg, and Benitz[lxxiv]**.** In addition, actual tracked and forecasted demand increases, compared to the 5 and 10% demand increase analyzed in this study, can also be used to more accurately analyze future scenarios, if desired. A well-calibrated model can lead to a higher level of detail and functionality in modeling travel behavior, which in turn can aide transportation planners with balancing between need and investment.

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APPENDICES

APPENDIX A. ORIGIN-DESTINATION MATRIX

Origin-Destination Matrix from Off-Ramps to Parking Lots

	F. Bird Ave/ SB 280 Off	G. S 10th St/ EB 280 Off	H. Grant St/ EB 280 Off	I. S 6th St/ EB 280 Off	J. Bird Ave/ WB 280 Off	K. S 11th St/ WB 280 Off	L. Margaret St/ WB 280 Off	M. W Santa Clara St/ NB 87 Off	N. Woz Way/ NB 87 Off	O. W Julian St/ NB 87 Off	P. Park Ave/ SB 87 Off	Q. W Julian St/ SB 87 Off
1. San Jose Water Lot #2 (East)	11.0	7.6	17.8	-	17.2	-	6.7	17.9	16.6	10.7	17.4	6.9
2. SJ State University 7th Street	-	28.3	8.9	16.0	7.6	57.0	17.0	38.7	42.0	23.9	28.0	11.8
3. SJ State University 10th Street Garage	-	135.0	5.3	94.4	-	53.7	41.3	24.6	12.6	17.7	18.3	11.4
4. Caltrain Parking Lot #2	7.9	-	7.1	-	13.8	-	-	29.9	13.1	7.7	14.1	4.9
5. Autumn St. Lot (Akatiff Lot)	4.8	-	-	-	8.3	-	-	10.9	7.2	4.6	8.6	3.0
6. City Hall Garage	3.2	17.9	3.6	26.6	5.6	13.8	11.0	7.3	4.8	3.1	5.7	2.0
7. (City View Plaza Garage) Park Center Plaza I	-	2.3	10.7	6.7	12.9	4.7	17.0	24.0	10.2	10.2	0.4	6.6
8. 10 Almaden	-	6.0	8.9	4.5	6.2	-	7.5	16.2	-	3.4	1.3	4.4
9. Comerica - 333 W. Santa Clara	5.7	1.5	3.6	-	9.4	2.7	6.7	1.1	5.5	5.5	7.0	3.5
10. Opus West - 225 W. Santa Clara	7.7	-	5.3	-	4.8	-	5.2	1.6	3.4	7.5	15.2	4.8
11. Victory Parking Lot	4.2	16.6	8.9	11.2	7.4	-	6.7	8.1	6.4	4.1	7.5	2.6
12. 3rd Street Garage	-	33.2	6.2	7.5	14.0	27.6	9.4	18.4	10.3	7.8	13.0	5.0
13. Koll Building Garage	-	6.0	16.6	20.2	13.4	63.7	10.1	17.6	9.1	7.5	10.3	4.8
14. 160 W. Santa Clara	5.1	1.5	0.9	-	8.9	-	5.0	11.6	5.2	4.9	9.1	3.2
15. Hyatt Place Hotel Garage	2.1	5.0	5.2	4.2	22.0	2.9	2.3	6.1	1.0	0.7	15.3	0.4
16. Market & San Carlos (Block 8)	1.2	8.6	11.5	9.5	2.0	5.0	4.0	2.6	1.7	1.1	44.1	0.7
17. Pavilion Parking Garage	3.2	8.3	17.8	8.3	5.5	13.7	7.8	7.3	4.8	9.2	5.7	2.0
18. Riverpark	1.4	3.0	8.9	12.4	45.9	3.4	1.5	2.7	20.3	6.5	0.4	4.5

	Origin-Destination Matrix from Off-Ramps to Parking Lots											
	F. Bird Ave/ SB 280 Off	G. S 10th St/ EB 280 Off	H. Grant St/ EB 280 Off	I. S 6th St/ EB 280 Off	J. Bird Ave/ WB 280 Off	K. S 11th St/ WB 280 Off	L. Margaret St/ WB 280 Off	M. W Santa Clara St/ NB 87 Off	N. Woz Way/ NB 87 Off	O. W Julian St/ NB 87 Off	P. Park Ave/ SB 87 Off	Q. W Julian St/ SB 87 Off
19. San Fernando & South Second Street Lot	1.5	11.4	11.8	10.6	2.7	6.7	5.3	3.5	2.3	5.5	6.4	3.7
20. 4th Street Garage	7.2	42.3	19.6	5.3	12.6	30.9	10.4	16.4	10.8	6.9	7.7	4.5
21. Ernst & Young Garage	3.9	-	1.8	2.2	6.7	-	0.7	6.6	5.8	3.7	6.9	2.4
22. Almaden Bl & Woz Wy Lot	-	1.5	3.6	8.0	6.5	1.3	10.0	0.5	7.5	3.6	6.7	0.7
23. 2nd & San Carlos Garage	-	9.1	19.6	8.3	8.5	14.2	11.0	11.1	7.4	4.7	10.3	116.2
24.Colonnade (201 S. Fourth)	1.4	10.1	13.9	6.4	4.7	10.7	4.7	4.8	2.1	1.3	6.4	0.9
25. Sentry Lot (nw c/o Notre Dame/	0.5	-	3.7	-	0.8	-	1.7	1.1	0.7	0.5	0.9	0.3
26. Community Towers	0.7	5.0	5.2	-	1.2	2.9	2.3	1.5	1.2	0.7	1.2	0.4
27. Valley Title	-	17.5	19.6	18.0	5.1	12.4	8.0	6.6	4.4	5.2	5.2	9.8
28. Fountain Alley	1.8	13.5	22.2	3.0	9.6	7.9	6.3	4.2	2.8	1.8	23.6	1.1
29. 95 S. Market Street	0.9	4.9	7.1	5.7	1.6	4.0	3.2	2.1	1.4	0.9	1.7	0.6
30. San Jose Hilton Towers and Garage	1.9	8.7	7.1	11.9	3.4	1.3	6.6	4.4	2.9	1.9	3.4	1.2
31. I-280/1st St	1.1	8.1	8.3	6.7	1.9	4.7	3.8	6.1	1.6	57.6	1.9	-
32. Adobe Systems Inc Garage	2.4	1.5	1.8	9.8	4.1	1.3	5.5	0.5	3.6	2.3	4.2	1.5
33. 4th & St. John Garage	-	48.2	3.6	3.0	18.7	35.1	12.2	24.5	11.5	10.4	12.5	6.7
34. Convention Center	-	22.7	8.9	23.7	11.3	9.4	17.9	16.3	0.4	35.6	18.3	24.2
35. Woz/87 Surface Lot	-	14.1	1.8	15.7	4.5	-	1.0	5.9	3.9	2.5	4.6	1.6
36. Almaden/Balbach Lot	-	3.2	3.3	2.7	0.8	1.9	4.8	1.0	0.7	1.8	0.8	0.3
37. Fairmont Plaza Garage	0.3	3.0	14.2	5.6	10.2	7.4	7.9	-	9.5	7.1	9.5	4.6
38. 1st & San Salvador Lot	-	5.0	2.6	2.1	0.6	12.7	8.0	3.3	0.5	1.8	1.3	22.2

	Origin-Destination Matrix from Off-Ramps to Parking Lots											
	F. Bird Ave/ SB 280 Off	G. S 10th St/ EB 280 Off	H. Grant St/ EB 280 Off	I. S 6th St/ EB 280 Off	J. Bird Ave/ WB 280 Off	K. S 11th St/ WB 280 Off	L. Margaret St/ WB 280 Off	M. W Santa Clara St/ NB 87 Off	N. Woz Way/ NB 87 Off	O. W Julian St/ NB 87 Off	P. Park Ave/ SB 87 Off	Q. W Julian St/ SB 87 Off
39. Arena Lot D	1.9	-	5.3	11.9	3.4	-	-	4.4	2.9	1.9	3.4	1.2
40. Arena Lots A, B and C	6.0	-	3.6	-	10.4	-	-	81.5	9.1	5.8	10.7	3.7
41. South Hall Surface Lot	-	6.3	11.4	9.2	2.6	6.4	9.5	3.4	2.3	1.4	2.7	1.3
42. Financial Plaza Garage	4.1	10.6	8.9	-	7.1	-	2.2	9.4	5.9	4.6	7.3	2.6
43. Notre Dame/Carlyse Lot	2.1	1.5	1.8	-	3.7	-	8.6	4.9	3.2	2.1	3.8	1.3
44. Park and Go	-	4.6	6.2	3.8	2.3	7.8	9.6	1.4	2.5	2.7	7.0	0.4
45. Market & San Pedro Garage	-	15.1	11.0	19.1	23.4	-	1.0	27.2	20.3	13.0	12.4	8.4
46. Second and San Salvador Lot	0.6	4.3	4.4	3.6	6.6	7.0	2.5	1.3	0.9	2.6	1.3	0.4
47. Second and St. James Lot	1.3	-	15.9	8.1	4.0	5.7	4.5	3.0	2.0	1.3	2.3	0.8
48. Third and Santa Clara Garage	-	10.9	4.9	4.0	2.3	8.0	11.2	1.5	2.5	2.7	7.1	1.5

Origin-Destination Matrix Parking Lots to On-Ramps

	1. San Jose Water Lot #2 (East)	2. SJ State University 7th Street	3. SJ State University 10th Street Garage	4. Caltrain Parking Lot #2	5. Autumn St. Lot (Akatiff Lot)	6. City Hall Garage	7. (City View Plaza Garage) Park Center Plaza I	8. 10 Almaden	9. Comerica - 333 W. Santa Clara	10. Opus West - 225 W. Santa Clara	11. Victory Parking Lot	12. 3rd Street Garage
R: S 1st St/ EB 280 On	10.9	24.0	3.8	25.5	-	11.9	84.3	38.5	23.0	17.0	259.7	12.5
S: S 7th St/ EB 280 On	21.1	105.6	57.9	16.4	-	21.0	3.8	8.1	-	-	5.1	22.5
T: S 11th St/ EB 280 On	-	39.0	83.8	-	-	26.5	-	-	-	-	0.7	63.6
U: Bird Ave/ EB 280 On	16.2	-	-	24.7	28.0	-	30.6	32.4	24.0	9.1	-	-
V: S 10th St/ WB 280 On	26.4	50.0	83.1	40.4	24.8	26.3	3.8	0.8	-	-	22.2	48.9
W: E Reed St/ WB 280 On	22.5	207.1	46.3	26.4	26.3	22.4	30.6	2.4	9.4	40.8	23.4	20.5
X: Vine St/ WB 280 On	16.6	23.7	3.8	36.9	23.1	11.7	3.8	13.0	31.3	48.0	6.5	15.7
Y: Bird Ave/ WB 280 On	28.0	-	-	42.8	48.4	-	26.8	16.2	10.4	0.9	2.9	68.4
Z: Park Ave/ NB 87 On	11.2	12.9	0.6	17.2	11.4	9.1	19.2	18.3	7.3	12.7	14.4	3.0
AA: W Julian St/ NB 87 On	13.6	16.7	43.0	20.8	23.5	9.1	3.8	5.7	5.2	61.4	18.5	44.1
AB: W Julian St/ SB 87 On 1 (Loop)	15.0	21.5	46.9	22.9	25.9	10.5	7.7	22.2	1.0	67.7	15.5	48.5
AC: W Julian St/ SB 87 On 2	8.4	18.0	28.2	13.2	14.5	8.3	7.7	3.2	14.9	37.8	13.4	27.1
AD: Delmas Ave/ SB 87 On	10.1	13.5	2.5	16.9	19.1	9.1	49.8	23.1	23.4	4.5	17.7	-

Origin-Destination Matrix Parking Lots to On-Ramps

	13. Koll Building Garage	14. 160 W. Santa Clara	15. Hyatt Place Hotel Garage	16. Market & San Carlos (Block 8)	17. Pavilion Parking Garage	18. Riverpark	19. San Fernando & South Second Street Lot	20. 4th Street Garage	21. Ernst & Young Garage	22. Almaden Bl & Woz Wy Lot	23. 2nd & San Carlos Garage	24.Colonnade (201 S. Fourth)
R: S 1st St/ EB 280 On	28.1	16.7	2.2	4.1	38.1	4.4	3.3	16.5	22.4	12.7	16.6	4.4
S: S 7th St/ EB 280 On	28.5	32.5	4.2	3.8	61.0	10.1	6.5	47.1	31.8	45.2	32.3	-
T: S 11th St/ EB 280 On	35.4	24.5	-	4.8	46.0	-	8.2	41.2	-	-	30.2	1.0
U: Bird Ave/ EB 280 On	-	24.9	3.2	3.1	-	13.5	5.0	-	33.4	34.6	-	-
V: S 10th St/ WB 280 On	17.7	17.5	-	4.8	40.7	3.8	10.4	93.1	11.3	0.7	30.1	12.7
W: E Reed St/ WB 280 On	14.1	25.8	4.9	8.4	40.3	10.5	7.6	53.0	9.1	13.3	58.2	9.1
X: Vine St/ WB 280 On	21.0	40.6	3.3	8.4	27.1	7.3	10.3	10.0	34.2	35.5	33.9	6.7
Y: Bird Ave/ WB 280 On	-	27.6	5.6	5.4	-	19.2	8.6	1.8	0.4	-	-	-
Z: Park Ave/ NB 87 On	7.7	9.0	2.2	2.2	16.9	37.2	5.4	14.2	27.0	24.1	18.0	9.8
AA: W Julian St/ NB 87 On	8.3	15.7	2.7	5.4	28.5	0.4	4.2	57.3	1.2	1.1	30.6	8.5
AB: W Julian St/ SB 87 On 1 (Loop)	5.9	12.6	3.0	5.6	8.7	0.5	4.6	11.8	4.6	0.7	26.8	9.8
AC: W Julian St/ SB 87 On 2	10.1	7.8	1.7	2.0	23.6	2.8	2.6	-	1.7	3.3	58.6	4.6
AD: Delmas Ave/ SB 87 On	23.3	8.8	2.2	2.1	26.1	15.4	3.4	14.1	22.8	23.7	18.6	120.5

Origin-Destination Matrix Parking Lots to On-Ramps

	25. Sentry Lot (nw c/o Notre Dame/	26. Community Towers	27. Valley Title	28. Fountain Alley	29. 95 S. Market Street	30. San Jose Hilton Towers and Garage	31. I-280/1st St	32. Adobe Systems Inc Garage	33. 4th & St. John Garage	34. Convention Center	35. Woz/87 Surface Lot	36. Almaden/Balbach Lot
R: S 1st St/ EB 280 On	3.0	2.1	15.6	5.4	2.4	9.5	2.9	7.5	33.4	57.1	6.6	5.3
S: S 7th St/ EB 280 On	2.4	4.0	30.4	10.4	4.6	6.3	5.6	14.6	112.8	78.1	30.8	3.4
T: S 11th St/ EB 280 On	-	5.1	18.5	13.2	0.2	14.0	7.0	-	120.4	13.4	-	2.4
U: Bird Ave/ EB 280 On	1.9	-	-	3.9	3.5	-	4.3	11.2	-	-	11.0	-
V: S 10th St/ WB 280 On	3.1	5.0	6.9	13.1	5.7	10.5	8.1	5.0	123.1	9.3	13.1	2.4
W: E Reed St/ WB 280 On	2.6	4.5	25.0	11.1	4.9	10.5	14.1	9.4	288.6	17.8	0.6	2.0
X: Vine St/ WB 280 On	1.9	3.0	9.9	8.2	5.2	6.0	4.4	20.7	39.0	11.8	61.6	1.5
Y: Bird Ave/ WB 280 On	3.2	-	-	-	6.1	-	-	19.3	-	-	17.2	-
Z: Park Ave/ NB 87 On	1.3	2.1	9.2	5.6	4.9	8.2	1.6	7.8	16.9	24.5	0.6	1.0
AA: W Julian St/ NB 87 On	1.6	2.6	12.6	6.7	3.0	9.9	3.6	3.4	78.1	38.2	0.7	1.2
AB: W Julian St/ SB 87 On 1 (Loop)	1.7	2.9	0.8	7.4	3.3	10.9	4.0	6.6	95.3	18.5	0.9	1.4
AC: W Julian St/ SB 87 On 2	1.0	1.6	12.1	4.1	1.8	6.1	-	5.8	37.4	3.8	0.5	0.8
AD: Delmas Ave/ SB 87 On	1.3	2.1	10.1	5.5	2.4	8.0	1.1	10.9	20.0	37.3	5.4	1.0

Origin-Destination Matrix Parking Lots to On-Ramps

	37. Fairmont Plaza Garage	38. 1st & San Salvador Lot	39. Arena Lot D	40. Arena Lots A, B and C	41. South Hall Surface Lot	42. Financial Plaza Garage	43. Notre Dame/ Carlyse Lot	44. Park and Go	45. Market & San Pedro Garage	46. Second and San Salvador Lot	47. Second and St. James Lot	48. Third and Santa Clara Garage
R: S 1st St/ EB 280 On	24.3	1.2	5.6	23.6	12.9	13.2	7.6	3.8	63.8	6.6	8.1	4.0
S: S 7th St/ EB 280 On	15.4	1.0	5.2	-	13.9	6.7	0.7	2.8	34.2	9.4	7.3	4.5
T: S 11th St/ EB 280 On	18.8	1.7	-	-	-	-	7.4	3.5	99.3	13.1	9.2	3.6
U: Bird Ave/ EB 280 On	-	-	8.4	35.1	-	19.7	-	-	51.5	-	-	-
V: S 10th St/ WB 280 On	15.0	1.7	13.8	-	0.2	17.5	18.5	3.5	55.0	12.5	9.2	3.5
W: E Reed St/ WB 280 On	14.3	2.0	11.7	48.8	6.8	17.6	10.2	3.0	71.8	12.0	7.8	3.0
X: Vine St/ WB 280 On	51.2	3.4	11.4	20.5	19.7	51.3	22.9	2.2	51.6	6.7	5.8	2.2
Y: Bird Ave/ WB 280 On	-	-	14.6	60.8	1.1	34.1	1.8	3.7	42.2	-	-	3.8
Z: Park Ave/ NB 87 On	11.0	2.4	4.2	15.7	13.4	13.7	7.9	1.5	39.4	5.4	3.9	1.9
AA: W Julian St/ NB 87 On	24.3	0.9	7.1	29.6	6.0	5.4	9.5	1.8	34.1	5.5	4.7	1.8
AB: W Julian St/ SB 87 On 1 (Loop)	39.3	1.0	7.8	32.6	1.3	13.3	10.5	2.0	57.5	6.0	5.2	2.0
AC: W Julian St/ SB 87 On 2	16.2	1.5	4.4	18.2	0.9	10.2	5.9	1.9	49.3	3.4	2.9	1.1
AD: Delmas Ave/ SB 87 On	32.1	0.7	5.8	25.6	1.3	11.5	7.7	2.2	46.4	4.4	3.8	2.0

APPENDIX B. GEH STATISTICS

GEH Statistic Existing Baseline Summary

Intersection	Movement Direction	Simulation	Actual	GEH Statistic	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
Market/Santa Clara	NBL	44	69	3.33	50	42	44	39	47	41	39	52	46	39
	NBT	228	225	0.20	224	231	221	230	213	229	245	204	256	232
	NBR	24	80	7.77	14	24	29	31	31	20	30	16	21	22
	EBL	61	65	0.50	56	70	62	64	64	56	57	58	64	58
	EBT	524	591	2.84	526	512	512	520	531	550	536	498	534	530
	EBR	82	93	1.18	77	110	77	65	78	88	75	84	82	73
	SBL	169	161	0.62	191	174	163	161	161	158	170	183	163	167
	SBT	711	820	3.94	709	757	764	716	706	723	714	651	661	705
	SBR	100	109	0.88	101	92	109	83	84	105	97	105	121	104
	WBL	26	78	7.21	23	24	30	24	22	26	31	30	26	23
	WBT	421	400	1.04	418	394	414	420	439	429	405	425	441	431
	WBR	55	81	3.15	51	63	57	61	51	68	54	47	45	62
Market/San Fernando	NBL	39	32	1.17	42	34	38	37	41	34	51	32	41	31
	NBT	208	226	1.22	219	217	179	202	202	212	210	216	213	186
	NBR	47	34	2.04	57	48	48	50	40	28	52	45	52	36
	EBL	52	37	2.25	41	52	47	64	59	51	69	31	55	49
	EBT	205	234	1.96	220	206	186	245	230	163	226	138	234	209
	EBR	56	129	7.59	62	54	52	56	69	40	69	39	64	60

GEH Statistic Existing Baseline Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	SBL	57	98	4.66	46	60	74	57	55	50	54	48	68	51
	SBT	854	918	2.15	873	922	890	863	856	886	831	783	778	826
	SBR	43	49	0.88	41	41	42	39	42	54	38	37	50	43
	WBL	46	54	1.13	51	53	41	48	33	54	50	31	57	45
	WBT	131	177	3.71	130	116	145	125	122	139	138	109	153	136
	WBR	19	54	5.79	15	11	42	19	6	26	16	11	22	33
Market/San Carlos	NBL	95	112	1.67	84	85	96	109	93	89	96	101	98	111
	NBT	255	246	0.57	273	266	238	242	244	259	251	256	264	259
	NBR	10	15	1.41	11	10	12	13	8	10	14	9	7	11
	EBL	78	67	1.29	99	68	67	73	88	65	82	70	86	35
	EBT	329	270	3.41	329	332	332	326	309	315	354	332	330	109
	EBR	153	188	2.68	152	152	162	161	149	154	158	135	151	55
	SBL	72	62	1.22	76	59	72	72	98	67	70	55	81	63
	SBT	729	938	7.24	772	794	740	737	721	734	690	707	666	705
	SBR	62	108	4.99	67	59	63	59	65	68	70	44	62	84
	WBT	165	169	0.31	136	167	159	181	162	181	179	142	175	156
	WBR	53	31	3.39	59	40	57	52	68	54	46	43	54	44
3rd/Santa Clara	NBL	99	86	1.35	98	86	107	86	114	104	99	98	95	89
	NBT	230	289	3.66	213	243	208	231	238	225	252	211	248	228

GEH Statistic Existing Baseline Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	NBR	45	174	12.33	44	41	51	37	46	54	35	49	47	57
	EBL	82	74	0.91	90	72	72	91	81	86	95	73	75	71
	EBT	611	749	5.29	603	589	596	574	636	609	668	585	643	603
	WBT	431	483	2.43	436	438	408	437	437	448	417	438	424	480
	WBR	72	67	0.60	77	69	73	72	83	55	80	67	71	82
3rd/San Fernando	NBL	88	80	0.87	89	63	85	88	100	93	82	105	86	88
	NBT	388	489	4.82	380	383	372	350	396	422	392	393	403	386
	NBR	201	255	3.58	212	193	188	187	220	202	208	195	202	155
	EBL	25	67	6.19	22	22	24	30	30	20	28	19	31	28
	EBT	201	223	1.51	191	179	176	231	226	162	245	181	222	195
	WBT	140	226	6.36	147	130	132	121	137	139	177	129	144	136
	WBR	14	85	10.09	12	16	17	17	19	7	17	10	13	20
3rd/San Carlos	NBL	67	65	0.25	60	84	64	54	69	75	62	75	64	79
	NBT	505	501	0.18	488	492	513	462	528	547	488	503	521	483
	NBR	48	89	4.95	51	35	49	57	41	44	48	50	53	55
	EBL	175	176	0.08	191	178	178	164	153	165	192	184	171	83
	EBT	95	76	2.05	98	88	89	100	104	100	98	82	98	65
	WBT	23	72	7.11	27	17	29	23	31	22	27	11	16	22
	WBR	16	71	8.34	17	5	14	16	24	18	30	8	14	6

GEH Statistic Existing Baseline Summary															
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
3rd/San Salvador	NBL	11	36	5.16	10	11	10	5	16	10	11	8	14	13
	NBT	468	412	2.67	445	469	459	425	497	503	442	489	487	471
	NBR	22	31	1.75	28	25	23	26	17	21	21	16	24	25
	EBL	56	55	0.13	73	56	66	49	59	64	46	44	51	40
	EBT	99	107	0.79	106	101	97	88	93	100	110	95	98	74
	WBT	152	172	1.57	145	164	164	156	156	121	163	157	143	139
	WBR	95	136	3.81	79	83	92	106	91	101	100	102	97	103
3rd/Reed	NBL	44	22	3.83	38	48	42	42	42	54	52	43	31	48
	NBT	238	278	2.49	218	238	247	224	278	256	227	239	212	239
	NBR	189	201	0.86	191	183	223	207	190	191	163	180	169	191
	EBL	27	28	0.19	25	33	30	26	21	26	24	31	31	24
	EBT	264	219	2.90	283	255	257	276	270	254	264	243	278	250
	WBT	510	554	1.91	494	526	552	511	496	527	508	466	511	466
	WBR	169	148	1.67	157	160	150	156	182	184	162	175	191	172
4th/Santa Clara	EBT	465	705	9.92	475	453	460	421	455	461	505	461	491	475
	EBR	192	192	0.00	177	183	202	186	215	210	178	185	191	187
	SBL	91	151	5.45	112	87	110	98	80	68	89	71	102	87
	SBT	731	805	2.67	731	779	727	726	760	712	704	719	723	720
	SBR	26	114	10.52	26	30	32	22	28	24	27	19	24	29

GEH Statistic Existing Baseline Summary															
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	WBL	89	114	2.48	77	83	88	98	99	91	94	93	78	95
	WBT	476	430	2.16	487	473	464	485	485	489	454	487	457	532
4th/San Fernando	EBT	201	286	5.45	190	185	191	227	214	161	236	197	206	172
	EBR	179	194	1.10	180	166	156	178	209	172	193	157	202	159
	SBL	26	109	10.10	22	17	25	30	32	26	33	18	28	27
	SBT	810	990	6.00	822	825	815	836	872	801	781	787	755	830
	SBR	88	112	2.40	79	85	65	127	131	74	102	53	77	105
	WBL	129	193	5.04	135	126	119	117	132	125	170	115	125	124
	WBT	89	212	10.03	84	84	81	99	77	79	102	86	105	75
4th/San Carlos	EBR	90	159	6.18	91	93	88	90	97	89	91	78	93	67
	SBT	979	1252	8.17	994	962	967	1024	1038	971	963	940	954	954
	SBR	38	149	11.48	40	23	42	38	55	40	55	19	27	28
4th/Williams	EBT	146	115	2.71	153	140	129	155	131	157	151	165	132	142
	EBR	29	54	3.88	27	21	25	24	35	36	31	31	32	27
	SBL	68	84	1.84	67	62	61	78	66	70	61	79	70	65
	SBT	1011	1273	7.75	1003	1010	1032	1038	1032	1009	1013	977	986	1006
	SBR	17	55	6.33	17	17	22	16	20	7	21	17	19	10

GEH Statistic Existing Baseline Summary															
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	WBL	13	66	8.43	23	15	10	8	7	11	16	10	15	10
	WBT	104	123	1.78	99	111	92	106	123	108	88	101	110	123
	EBT	70	101	3.35	77	75	59	73	67	67	80	62	69	55
	EBR	51	38	1.95	58	51	58	41	42	54	50	50	57	43
	SBL	182	229	3.28	170	198	200	176	189	186	169	169	181	181
4th/San Salvador	SBT	879	1254	11.48	888	875	850	911	926	868	880	850	860	842
	SBR	61	125	6.64	65	46	70	74	64	49	64	59	62	65
	WBL	185	196	0.80	158	199	186	188	184	170	202	200	177	177
	WBT	165	208	3.15	151	167	194	169	150	182	151	164	154	189
	EBT	115	151	3.12	111	105	109	110	132	125	118	117	109	110
	EBR	342	276	3.75	369	329	373	364	336	329	321	317	340	332
	SBL	168	242	5.17	168	166	151	190	184	140	177	151	181	147
4th/Reed	SBT	786	989	6.81	773	802	801	759	792	802	785	776	786	786
	SBR	192	263	4.71	164	167	218	198	183	198	214	182	201	143
	WBL	171	207	2.62	187	159	179	161	155	181	173	201	146	212
	WBT	495	399	4.54	492	519	503	475	496	512	469	474	513	491
	EBT	663	884	7.95	669	638	621	669	693	696	677	630	672	610
	EBR	223	268	2.87	231	250	220	196	234	202	215	236	225	195

GEH Statistic Existing Baseline Summary															
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
Almaden/Santa Clara (W)	SBL	29	30	0.18	28	33	28	34	31	26	35	22	20	20
	SBT	249	191	3.91	229	261	270	247	245	246	255	249	236	216
	SBR	59	76	2.07	61	67	56	54	49	67	54	72	54	43
	WBT	416	472	2.66	428	381	387	401	393	416	436	424	481	410
Almaden/Santa Clara (E)	NBL	90	92	0.21	101	102	86	87	75	89	86	77	104	89
	NBT	201	194	0.50	184	234	171	223	225	192	248	104	229	171
	NBR	40	95	6.69	41	51	37	41	49	31	44	22	48	42
	EBL	143	101	3.80	135	142	148	142	141	155	149	144	134	117
	EBT	548	806	9.92	560	532	501	564	581	564	568	509	554	518
	WBL	120	118	0.18	122	127	135	106	119	120	106	108	138	125
	WBT	324	385	3.24	323	277	302	311	313	324	349	344	370	322
	WBR	138	111	2.42	140	136	140	119	172	125	130	140	140	136
Almaden/San Fernando	NBL	5	21	4.44	5	5	5	7	5	4	10	1	5	5
	NBT	210	275	4.17	196	244	172	268	260	164	240	85	257	155
	NBR	103	123	1.88	95	92	102	128	120	95	129	47	121	102
	EBL	27	27	0.00	33	28	29	24	20	26	36	17	28	23
	EBT	163	107	4.82	159	174	152	187	179	138	181	108	185	158
	EBR	93	162	6.11	95	87	77	114	106	72	113	74	97	83
	SBL	64	101	4.07	72	57	54	69	78	49	64	66	69	48

GEH Statistic Existing Baseline Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	SBT	512	499	0.58	498	557	551	482	513	498	494	502	510	414
	SBR	24	10	3.40	21	21	32	19	23	23	23	28	25	16
	WBL	109	256	10.88	93	103	124	119	115	107	114	88	119	110
	WBT	125	148	1.97	132	103	115	128	128	120	145	99	157	127
	WBR	35	46	1.73	35	32	33	28	38	34	51	27	38	33
Almaden/Park	NBL	56	58	0.26	54	70	56	56	65	51	64	26	59	59
	NBT	187	183	0.29	191	227	155	217	200	174	208	93	221	122
	NBR	15	17	0.50	22	18	17	16	14	13	13	5	16	6
	EBL	124	95	2.77	124	124	136	137	140	107	137	78	135	108
	EBT	94	75	2.07	91	84	110	101	108	88	71	82	110	69
	EBR	93	148	5.01	104	80	99	94	87	95	104	79	96	58
	SBL	30	39	1.53	30	32	24	28	39	30	35	21	30	24
	SBT	655	887	8.36	683	655	626	641	671	658	657	704	600	475
	SBR	120	106	1.32	115	120	132	115	125	113	123	119	117	109
	WBL	147	195	3.67	157	140	151	150	140	159	169	102	155	115
	WBT	190	154	2.74	188	196	193	183	214	191	216	152	178	167
	WBR	33	55	3.32	29	29	32	41	47	30	34	18	37	23
Almaden/San Carlos	NBL	41	61	2.80	38	43	38	49	46	49	35	29	39	22
	NBT	190	196	0.43	208	204	188	190	192	206	182	126	211	92

GEH Statistic Existing Baseline Summary														
Intersection	Movement Direction	Simulation	Actual	GEH Statistic	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
	NBR	106	61	4.92	119	113	97	104	106	107	115	73	123	53
	EBL	91	116	2.46	94	89	98	95	92	84	103	65	93	53
	EBT	440	458	0.85	455	437	427	445	432	415	452	431	463	229
	EBR	126	142	1.38	103	119	150	119	149	115	135	107	134	54
	SBL	104	137	3.01	116	98	116	104	93	102	115	85	106	48
	SBT	696	1102	13.54	720	681	678	689	724	693	704	727	651	511
	SBR	68	63	0.62	71	66	66	67	61	83	65	60	72	62
	WBL	80	98	1.91	76	85	77	83	85	97	81	64	73	80
	WBT	186	232	3.18	172	167	189	206	187	178	197	170	204	208
	WBR	86	68	2.05	88	103	73	94	86	82	100	53	91	98
Almaden/Woz Way	NBL	60	36	3.46	54	54	68	59	65	68	54	52	66	57
	NBT	276	175	6.73	315	288	258	263	278	274	267	265	279	211
	NBR	76	63	1.56	76	84	62	75	66	86	83	83	66	55
	EBL	46	25	3.52	52	37	45	54	41	51	45	42	45	38
	EBT	140	184	3.46	137	136	138	148	134	125	138	151	151	112
	EBR	234	224	0.66	244	214	239	237	215	268	213	236	242	244
	SBL	73	110	3.87	71	80	80	84	76	54	78	65	72	63

GEH Statistic Existing Baseline Summary															
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	SBT	822	1179	11.29	835	822	806	799	868	850	850	828	737	583
	SBR	11	14	0.85	8	18	12	10	10	10	14	7	10	9
	WBL	78	168	8.12	82	73	72	65	106	77	77	81	72	59
	WBT	71	45	3.41	70	62	72	64	82	71	70	69	78	47
	WBR	33	47	2.21	28	37	21	32	33	35	32	31	45	27

GEH Statistic Almaden Conversion Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
Market/Santa Clara	NBL	45	69	3.18	50	51	41	45	36	47	41	40	53	43
	NBT	220	225	0.34	216	236	236	217	229	214	217	231	193	237
	NBR	24	80	7.77	14	14	24	29	31	31	18	28	24	28
	EBL	59	65	0.76	52	57	68	63	65	69	60	56	49	62
	EBT	504	591	3.72	497	508	499	518	523	530	547	544	422	529
	EBR	75	93	1.96	65	75	112	78	67	76	88	77	59	72
	SBL	160	161	0.08	159	186	169	162	164	151	153	178	141	158
	SBT	712	820	3.90	593	692	756	769	736	698	718	724	731	687
	SBR	98	109	1.08	74	102	96	110	86	81	106	97	110	108
	WBL	25	78	7.39	21	23	24	30	24	22	27	32	22	31
	WBT	414	400	0.69	410	409	393	419	428	445	426	399	398	431
	WBR	57	81	2.89	51	51	64	57	63	49	68	53	55	62
Market/San Fernando	NBL	41	32	1.49	39	43	35	40	36	42	33	50	43	43
	NBT	203	226	1.57	205	217	218	181	202	206	213	208	193	198
	NBR	48	34	2.19	51	53	45	56	51	47	35	52	45	46
	EBL	50	37	1.97	39	39	56	49	64	57	44	64	37	63
	EBT	206	234	1.89	213	204	213	197	254	219	159	198	200	204
	EBR	55	129	7.72	56	59	54	54	59	64	37	58	58	49
	SBL	52	98	5.31	38	46	58	75	57	54	51	53	46	47

GEH Statistic Almaden Conversion Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	SBT	852	918	2.22	676	859	905	912	883	840	872	848	870	835
	SBR	40	49	1.35	30	39	41	43	40	37	54	36	41	43
	WBL	46	54	1.13	48	61	61	42	47	32	56	50	35	42
	WBT	129	177	3.88	138	153	117	141	122	117	117	129	113	157
	WBR	17	54	6.21	18	24	9	38	17	6	17	13	9	22
Market/San Carlos	NBL	90	112	2.19	85	87	84	95	107	91	90	97	80	92
	NBT	251	246	0.32	268	268	267	234	247	247	261	250	243	236
	NBR	10	15	1.41	11	10	10	13	13	8	9	14	7	10
	EBL	81	67	1.63	92	101	69	64	75	88	63	84	85	82
	EBT	336	270	3.79	329	340	330	333	324	310	330	355	362	317
	EBR	151	188	2.84	146	149	154	154	154	152	155	150	149	145
	SBL	73	62	1.34	70	81	61	76	71	92	66	71	64	84
	SBT	722	938	7.50	590	747	777	758	762	713	732	691	723	726
	SBR	64	108	4.74	56	75	57	64	59	64	68	69	65	66
	WBT	164	169	0.39	144	145	172	163	181	154	177	171	170	158
	WBR	52	31	3.26	55	60	38	59	51	65	55	46	40	61
3rd/Santa Clara	NBL	98	86	1.25	101	101	84	108	85	112	101	99	91	103
	NBT	219	289	4.39	216	217	248	228	234	239	215	255	174	214
	NBR	46	174	12.20	43	43	40	52	39	48	53	35	54	43

GEH Statistic Almaden Conversion Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	EBL	80	74	0.68	88	94	79	64	90	82	82	91	65	83
	EBT	590	749	6.14	595	635	593	577	588	621	640	670	495	585
	WBT	433	483	2.34	432	425	428	415	433	435	449	409	433	470
	WBR	71	67	0.48	77	76	69	74	72	82	56	78	68	65
3rd/San Fernando	NBL	85	80	0.55	89	87	64	91	87	101	83	81	80	93
	NBT	370	489	5.74	383	384	380	397	348	390	373	399	313	387
	NBR	197	255	3.86	199	200	192	200	189	211	191	221	185	194
	EBL	24	67	6.37	19	22	26	25	31	29	22	21	22	24
	EBT	193	223	2.08	175	184	195	179	235	216	149	224	194	183
	WBT	142	226	6.19	149	149	133	127	122	131	142	173	142	148
	WBR	16	85	9.71	12	13	21	17	17	17	7	16	20	11
3rd/San Carlos	NBL	68	65	0.37	63	64	83	63	53	72	74	62	65	79
	NBT	503	501	0.09	504	507	484	512	465	529	545	484	505	491
	NBR	45	89	5.38	48	53	35	45	51	37	41	43	46	50
	EBL	173	176	0.23	179	192	177	176	163	153	167	190	160	184
	EBT	101	76	2.66	98	100	95	92	104	103	97	100	108	110
	WBT	25	72	6.75	35	35	24	28	22	27	20	25	19	26
	WBR	14	71	8.74	23	23	9	15	14	19	12	20	5	13
	NBL	10	36	5.42	11	11	11	10	5	16	10	11	9	12

GEH Statistic Almaden Conversion Summary															
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
3rd/San Salvador	NBT	466	412	2.58	463	468	466	457	424	499	505	444	469	463
	NBR	23	31	1.54	25	29	25	24	24	16	22	21	26	18
	EBL	61	55	0.79	73	73	55	66	49	58	64	46	65	54
	EBT	99	107	0.79	103	109	100	103	84	91	100	106	103	84
	WBT	154	172	1.41	147	145	168	163	156	158	121	164	150	174
	WBR	91	136	4.22	79	77	84	89	102	87	100	95	88	109
3rd/Reed	NBL	44	22	3.83	45	45	48	42	42	42	55	52	41	32
	NBT	249	278	1.79	249	249	237	246	223	278	255	227	260	260
	NBR	195	201	0.43	204	205	176	220	210	196	193	159	201	176
	EBL	26	28	0.38	27	24	33	26	26	21	27	24	31	19
	EBT	261	219	2.71	269	255	261	253	272	271	258	260	248	274
	WBT	524	554	1.29	499	510	566	534	510	504	507	524	534	537
	WBR	163	148	1.20	155	157	164	149	155	184	184	162	165	155
4th/Santa Clara	EBT	447	705	10.75	466	496	449	443	445	431	472	505	378	452
	EBR	186	192	0.00	180	175	182	192	190	215	215	186	172	172
	SBL	93	151	5.25	108	109	92	106	98	80	71	89	87	101
	SBT	732	805	2.63	712	723	789	713	715	734	728	702	731	774
	SBR	27	114	10.36	26	26	30	31	22	27	25	27	25	30
	WBL	86	114	2.80	75	75	76	88	101	104	89	96	84	72

GEH Statistic Almaden Conversion Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	WBT	477	430	2.21	486	483	471	466	482	487	477	450	472	503
4th/San Fernando	EBT	194	286	5.94	178	186	187	193	229	207	146	233	192	192
	EBR	177	194	1.25	175	178	181	163	179	201	170	190	168	173
	SBL	26	109	10.10	23	23	24	27	30	27	25	30	29	22
	SBT	823	990	5.55	849	833	878	803	819	856	798	770	807	838
	SBR	98	112	1.37	128	100	115	70	125	117	67	96	87	84
	WBL	133	193	4.70	137	136	127	119	116	132	125	168	133	141
	WBT	85	212	10.42	84	84	82	82	100	76	79	100	85	78
4th/San Carlos	EBR	95	159	5.68	95	95	93	89	92	95	89	95	93	111
	SBT	989	1252	7.86	1009	1000	1023	950	1008	1028	969	953	966	1003
	SBR	39	149	11.35	55	57	32	43	36	45	30	45	24	38
4th/Williams	EBT	144	115	2.55	146	151	141	128	154	131	157	154	140	140
	EBR	29	54	3.88	27	25	22	25	24	36	35	31	36	23
	SBL	64	84	2.32	63	66	61	60	73	72	70	62	51	73
	SBT	1023	1273	7.38	1031	1014	1059	1010	1026	1016	1027	1014	1015	1028
	SBR	17	55	6.33	20	18	17	22	15	20	7	22	18	12
	WBL	14	66	8.22	23	23	15	12	8	7	11	16	16	12

GEH Statistic Almaden Conversion Summary														
Intersection	Movement Direction	Simulation	Actual	GEH Statistic	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
	WBT	102	123	1.98	97	97	108	92	107	123	107	87	104	94
	EBT	72	101	3.12	72	82	77	65	67	66	67	77	79	58
	EBR	50	38	1.81	57	58	49	57	41	42	54	50	51	44
	SBL	188	229	2.84	182	179	208	195	178	186	182	167	204	188
4th/San Salvador	SBT	888	1254	11.18	915	902	917	841	900	902	888	875	863	898
	SBR	60	125	6.76	66	64	48	67	69	56	45	59	62	64
	WBL	184	196	0.87	161	157	203	185	189	188	170	200	178	219
	WBT	165	208	3.15	154	150	169	189	169	153	182	152	165	162
	EBT	108	151	3.78	103	100	108	106	113	131	126	121	86	110
	EBR	349	276	4.13	377	364	331	361	366	342	332	304	363	336
	SBL	171	242	4.94	179	177	176	148	187	179	149	175	178	159
4th/Reed	SBT	798	989	6.39	797	787	832	806	760	794	817	779	801	799
	SBR	196	263	4.42	171	180	202	200	206	193	182	220	197	206
	WBL	175	207	2.32	186	186	163	178	160	161	182	174	174	183
	WBT	494	399	4.50	492	488	522	496	476	513	499	472	497	484
		57	-		55	55	56	51	56	50	64	58	56	72
	EBT	597	884	10.55	598	600	569	571	606	635	632	610	574	599
	EBR	222	268	2.94	225	227	247	219	196	236	202	218	221	228

GEH Statistic Almaden Conversion Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
Almaden/Santa Clara (W)	SBL	12	30	3.93	10	10	12	4	18	15	8	14	13	10
	SBT	247	191	3.78	240	240	247	276	252	248	245	249	242	231
	SBR	58	76	2.20	64	63	64	56	55	48	67	53	53	67
	WBT	401	472	3.40	407	421	387	379	388	387	411	426	384	439
		57			57	55	62	49	54	56	48	65	60	64
Almaden/Santa Clara (E)	NBL	121	92	2.81	126	128	139	103	119	97	115	112	123	149
	NBT	178	194	1.17	154	162	207	142	189	193	150	178	195	188
	NBR	45	95	5.98	41	42	54	44	41	48	31	40	51	49
	EBL	70	101	3.35	62	63	59	72	70	73	77	73	77	65
	EBT	539	806	10.30	548	551	528	502	554	576	569	560	496	546
	WBL	117	118	0.09	113	115	125	135	101	117	117	104	118	119
	WBT	336	385	2.58	337	348	309	325	321	349	337	374	322	356
	WBR	117	111	0.56	116	118	112	120	103	138	113	107	121	121
Almaden/San Fernando	NBL	5	21	4.44	6	7	3	5	7	4	3	8	6	4
	NBT	214	275	3.90	192	221	263	167	259	246	152	193	216	228
	NBR	104	123	1.78	91	96	108	109	129	117	83	97	99	111
	EBL	29	27	0.38	33	33	28	30	25	18	26	34	27	35
	EBT	164	107	4.90	164	162	175	158	190	173	128	178	156	169
	EBR	99	162	5.51	93	94	92	86	115	98	78	116	107	100

GEH Statistic Almaden Conversion Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	SBL	64	101	4.07	71	70	58	53	72	80	47	63	64	62
	SBT	504	499	0.22	484	500	540	558	478	508	491	490	497	504
	SBR	24	10	3.40	21	22	22	32	19	23	23	23	23	28
	WBL	103	256	11.42	99	105	93	120	121	99	94	97	96	112
	WBT	121	148	2.33	133	146	100	114	126	117	115	122	114	133
	WBR	36	46	1.56	34	35	31	31	29	36	34	48	34	49
Almaden/Park	NBL	66	58	1.02	64	64	74	63	55	67	54	70	68	80
	NBT	191	183	0.59	194	203	223	163	209	198	160	185	176	212
	NBR	16	17	0.25	24	24	18	18	16	14	13	12	11	14
	EBL	133	95	3.56	101	123	126	141	138	142	108	130	159	133
	EBT	93	75	1.96	89	99	84	111	100	106	87	73	88	100
	EBR	97	148	4.61	89	106	81	101	94	91	92	110	103	100
	SBL	33	39	1.00	31	34	32	29	28	39	29	34	33	38
	SBT	622	887	9.65	601	635	675	637	620	672	691	576	564	603
	SBR	120	106	1.32	106	111	117	131	111	118	108	115	138	126
	WBL	151	195	3.35	150	155	138	155	154	138	143	167	149	158
	WBT	192	154	2.89	166	187	197	196	177	214	183	217	197	179
	WBR	34	55	3.15	37	29	31	36	41	46	26	30	34	32
	NBL	43	61	2.50	42	39	44	40	48	46	42	35	47	37

GEH Statistic Almaden Conversion Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
Almaden/San Carlos	NBT	195	196	0.07	208	211	202	190	187	195	202	181	174	222
	NBR	110	61	5.30	124	120	116	97	105	104	107	117	108	107
	EBL	94	116	2.15	87	94	99	95	89	97	85	102	92	107
	EBT	442	458	0.75	417	456	437	421	447	428	428	460	456	459
	EBR	127	142	1.29	102	103	118	158	122	151	112	134	142	115
	SBL	108	137	2.62	107	113	100	107	102	99	101	114	110	118
	SBT	663	1102	14.78	634	689	710	677	667	730	708	635	605	630
	SBR	73	63	1.21	68	69	65	70	70	65	78	63	82	90
	WBL	85	98	1.36	71	77	89	78	82	86	97	79	93	84
	WBT	178	232	3.77	169	181	170	198	203	179	169	193	162	173
	WBR	91	68	2.58	88	88	100	76	95	85	80	97	98	91
Almaden/Woz Way	NBL	60	36	3.46	50	55	53	69	59	65	69	53	59	72
	NBT	280	175	6.96	319	315	289	258	258	282	274	268	258	306
	NBR	78	63	1.79	76	76	83	62	76	67	86	83	93	68
	EBL	46	25	3.52	53	59	38	45	54	45	46	43	45	37
	EBT	135	184	3.88	114	132	144	139	146	131	125	136	142	135
	EBR	231	224	0.46	259	258	220	242	225	227	223	200	238	210
	SBL	71	110	4.10	65	77	81	78	82	76	59	69	66	63

GEH Statistic Almaden Conversion Summary														
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**	**Seed 10**	**Seed 13**	**Seed 16**	**Seed 19**	**Seed 22**	**Seed 25**	**Seed 28**
	SBT	787	1179	12.50	651	790	840	821	765	854	862	798	757	759
	SBR	10	14	1.15	5	9	17	12	10	10	10	15	7	8
	WBL	76	168	8.33	74	81	75	73	66	107	77	76	67	71
	WBT	72	45	3.53	64	71	63	72	64	83	73	70	76	80
	WBR	31	47	2.56	28	28	39	20	32	33	35	30	32	33

GEH Statistic Almaden Plus 10% Conversion Summary							
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**
Market/Santa Clara	NBL	42	69	3.62	30	54	43
	NBT	216	225	0.61	169	238	242
	NBR	17	80	9.05	15	13	24
	EBL	60	65	0.63	45	62	74
	EBT	503	591	3.76	413	555	541
	EBR	89	93	0.42	65	81	122
	SBL	165	161	0.31	139	194	162
	SBT	632	820	6.98	548	663	684
	SBR	92	109	1.70	81	103	93
	WBL	24	78	7.56	22	25	24
	WBT	416	400	0.79	372	445	431
	WBR	51	81	3.69	39	54	61
Market/San Fernando	NBL	40	32	1.33	32	50	38
	NBT	218	226	0.54	179	240	234
	NBR	45	34	1.75	40	58	36
	EBL	36	37	0.17	23	36	49
	EBT	175	234	4.13	127	199	198
	EBR	53	129	7.97	47	58	55
	SBL	55	98	4.92	47	51	67
	SBT	774	918	4.95	654	817	851

GEH Statistic Almaden Plus 10% Conversion Summary							
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**
	SBR	41	49	1.19	38	40	45
	WBL	41	54	1.89	27	49	47
	WBT	119	177	4.77	119	131	106
	WBR	7	54	8.51	4	12	5
Market/San Carlos	NBL	86	112	2.61	72	93	94
	NBT	273	246	1.68	249	286	285
	NBR	10	15	1.41	7	10	14
	EBL	85	67	2.06	69	110	75
	EBT	358	270	4.97	330	371	372
	EBR	157	188	2.36	143	161	168
	SBL	66	62	0.50	59	73	65
	SBT	649	938	10.26	540	706	701
	SBR	63	108	4.87	60	71	57
	WBT	164	169	0.39	162	146	185
	WBR	51	31	3.12	50	60	43
3rd/Santa Clara	NBL	91	86	0.53	86	99	87
	NBT	226	289	3.93	202	208	267
	NBR	43	174	12.58	38	49	42
	EBL	80	74	0.68	63	96	82
	EBT	594	749	5.98	499	651	631

GEH Statistic Almaden Plus 10% Conversion Summary

Intersection	Movement Direction	Simulation	Actual	GEH Statistic	Seed 1	Seed 4	Seed 7
	WBT	430	483	2.48	366	458	466
	WBR	69	67	0.24	59	80	68
3rd/San Fernando	NBL	74	80	0.68	83	67	72
	NBT	379	489	5.28	367	349	420
	NBR	192	255	4.21	176	192	207
	EBL	21	67	6.93	19	22	23
	EBT	171	223	3.70	158	187	169
	WBT	136	226	6.69	115	162	132
	WBR	11	85	10.68	13	8	12
3rd/San Carlos	NBL	73	65	0.96	68	57	95
	NBT	495	501	0.27	457	498	530
	NBR	37	89	6.55	25	50	36
	EBL	185	176	0.67	163	202	190
	EBT	99	76	2.46	92	105	101
	WBT	17	72	8.24	12	22	18
	WBR	8	71	10.02	9	10	5
3rd/San Salvador	NBL	9	36	5.69	7	9	10
	NBT	469	412	2.72	438	446	523
	NBR	26	31	0.94	21	30	27
	EBL	67	55	1.54	55	84	62

GEH Statistic Almaden Plus 10% Conversion Summary							
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**
	EBT	97	107	0.99	75	110	107
	WBT	150	172	1.73	131	150	170
	WBR	72	136	6.28	57	80	80
3rd/Reed	NBL	39	22	3.08	34	33	50
	NBT	217	278	3.88	200	196	255
	NBR	178	201	1.67	171	176	188
	EBL	30	28	0.37	21	27	41
	EBT	260	219	2.65	202	301	278
	WBT	510	554	1.91	455	503	573
	WBR	174	148	2.05	165	173	185
4th/Santa Clara	EBT	462	705	10.06	393	515	477
	EBR	176	192	0.00	153	183	192
	SBL	89	151	5.66	74	109	85
	SBT	688	805	4.28	552	733	778
	SBR	27	114	10.36	25	26	29
	WBL	84	114	3.02	84	83	86
	WBT	465	430	1.65	385	514	496
4th/San Fernando	EBT	184	286	6.65	177	184	190
	EBR	160	194	2.56	143	166	171
	SBL	16	109	11.76	19	15	13

GEH Statistic Almaden Plus 10% Conversion Summary							
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**
	SBT	743	990	8.39	623	779	826
	SBR	62	112	5.36	61	50	76
	WBL	127	193	5.22	103	148	130
	WBT	84	212	10.52	80	91	81
4th/San Carlos	EBR	90	159	6.18	81	96	94
	SBT	882	1252	11.33	747	939	960
	SBR	25	149	13.29	21	32	23
4th/Williams	EBT	150	115	3.04	132	169	148
	EBR	25	54	4.61	22	30	23
	SBL	54	84	3.61	39	65	57
	SBT	964	1273	9.24	839	997	1055
	SBR	14	55	6.98	14	13	16
	WBL	19	66	7.21	16	25	16
	WBT	116	123	0.64	125	108	114
4th/San Salvador	EBT	72	101	3.12	56	81	79
	EBR	52	38	2.09	40	58	57
	SBL	179	229	3.50	162	173	202
	SBT	809	1254	13.86	702	852	872
	SBR	46	125	8.54	32	61	44
	WBL	177	196	1.39	156	169	206

GEH Statistic Almaden Plus 10% Conversion Summary							
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**
	WBT	166	208	3.07	153	167	179
4th/Reed	EBT	113	151	3.31	101	117	122
	EBR	328	276	2.99	273	364	346
	SBL	145	242	6.97	112	154	169
	SBT	765	989	7.56	667	810	817
	SBR	173	263	6.10	167	141	210
	WBL	166	207	3.00	138	203	157
	WBT	516	399	5.47	446	550	552
Almaden/Santa Clara (W)		62	N/A		63	59	64
	EBT	605	884	10.23	517	651	647
	EBR	248	268	1.25	203	261	279
	SBL	10	30	4.47	8	10	12
	SBT	227	191	2.49	198	227	255
	SBR	61	76	1.81	52	63	68
	WBT	398	472	3.55	325	438	430
		55	N/A		46	57	61
Almaden/Santa Clara (E)	NBL	121	92	2.81	84	132	146
	NBT	148	194	3.52	113	143	188
	NBR	40	95	6.69	30	35	55
	EBL	67	101	3.71	66	65	70

GEH Statistic Almaden Plus 10% Conversion Summary							
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**
	EBT	545	806	10.04	459	592	585
	WBL	113	118	0.47	94	121	124
	WBT	329	385	2.96	289	363	336
	WBR	113	111	0.19	94	125	119
Almaden/San Fernando	NBL	2	21	5.60	1	2	4
	NBT	170	275	7.04	108	165	237
	NBR	70	123	5.40	40	86	85
	EBL	26	27	0.19	16	34	27
	EBT	146	107	3.47	119	156	163
	EBR	84	162	7.03	66	96	89
	SBL	70	101	3.35	64	81	64
	SBT	491	499	0.36	400	504	568
	SBR	24	10	3.40	20	23	28
	WBL	97	256	11.97	67	116	107
	WBT	113	148	3.06	103	136	101
	WBR	34	46	1.90	42	32	29
Almaden/Park	NBL	60	58	0.26	54	54	73
	NBT	163	183	1.52	120	153	216
	NBR	17	17	0.00	13	20	17
	EBL	102	95	0.71	73	116	118

GEH Statistic Almaden Plus 10% Conversion Summary							
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**
	EBT	84	75	1.01	70	95	86
	EBR	89	148	5.42	78	102	88
	SBL	28	39	1.90	22	28	35
	SBT	597	887	10.65	518	652	620
	SBR	111	106	0.48	89	127	118
	WBL	135	195	4.67	103	151	152
	WBT	180	154	2.01	150	184	206
	WBR	23	55	5.12	14	26	30
Almaden/San Carlos	NBL	36	61	3.59	34	36	38
	NBT	198	196	0.14	164	213	217
	NBR	110	61	5.30	84	118	127
	EBL	90	116	2.56	71	95	103
	EBT	466	458	0.37	425	499	473
	EBR	112	142	2.66	103	104	130
	SBL	111	137	2.33	100	120	115
	SBT	633	1102	15.92	552	699	649
	SBR	70	63	0.86	60	74	77
	WBL	82	98	1.69	76	76	92
	WBT	170	232	4.37	164	168	177
	WBR	83	68	1.73	61	80	109

GEH Statistic Almaden Plus 10% Conversion Summary							
Intersection	**Movement Direction**	**Simulation**	**Actual**	**GEH Statistic**	**Seed 1**	**Seed 4**	**Seed 7**
Almaden/Woz Way	NBL	56	36	2.95	49	54	64
	NBT	306	175	8.45	240	346	331
	NBR	83	63	2.34	76	84	89
	EBL	41	25	2.79	32	55	37
	EBT	134	184	3.97	111	140	152
	EBR	193	224	2.15	160	230	189
	SBL	69	110	4.33	51	75	81
	SBT	739	1179	14.21	633	795	788
	SBR	12	14	0.55	7	10	18
	WBL	75	168	8.44	57	87	80
	WBT	64	45	2.57	52	70	70
	WBR	36	47	1.71	41	29	37

APPENDIX C. NETWORK EVALUATION PERFORMANCE MEASURES

Network											
	Existing Baseline	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
Number of Vehicles	15,250	15,274	15,123	15,171	15,252	15,586	15,242	15,387	14,876	15,337	14,161
Total Travel Time (h)	9,325,456	9,144,229	9,179,212	9,457,626	9,057,988	9,403,192	9,565,522	8,953,946	9,765,196	9,402,190	9,753,426
Total Distance (mi)	16,647	16,699	16,583	16,474	16,672	16,998	16,562	16,875	16,204	16,751	15,677
Total Delay (h)	5,171,654	4,972,059	5,043,151	5,342,906	4,894,770	5,139,563	5,448,645	4,755,920	5,729,112	5,218,762	5,839,475
Per Vehicle											
	Existing Baseline	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
Average Speed (mph)	6.4	6.6	6.5	6.3	6.6	6.5	6.2	6.8	6.0	6.4	5.8
Average Delay (s)	285.9	275.0	282.1	294.5	272.5	280.0	300.7	263.4	317.8	287.2	330.8
Average Number of Stops	6.2	6.0	6.4	6.5	6.1	6.3	6.3	5.9	6.3	6.3	6.0
Average Stop Delay (s)	157.4	152.6	154.0	165.2	141.2	145.9	172.3	139.1	193.9	152.4	205.6

Network											
	Almaden	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
Number of Vehicles	15,177	14,788	15,337	15,345	15,240	15,316	15,452	15,147	15,267	14,917	15,222
Total Travel Time (h)	9,264,036	9,246,354	9,131,078	9,002,356	9,465,632	8,993,877	9,312,797	9,449,477	9,155,768	9,410,976	9,325,102
Total Distance (mi)	16,531	16,238	16,766	16,741	16,482	16,666	16,825	16,418	16,671	16,238	16,562
Total Delay (h)	5,137,334	5,189,846	4,947,629	4,827,375	5,350,491	4,834,328	5,090,650	5,365,567	5,001,494	5,354,637	5,194,021
Per Vehicle											
	Almaden	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
Average Speed (mph)	6.4	6.3	6.6	6.7	6.3	6.7	6.5	6.3	6.6	6.2	6.4
Average Delay (s)	285.1	290.6	272.8	268.1	294.3	269.2	279.3	297.7	278.1	297.6	290.9

Average Number of Stops	6.4	6.1	6.2	6.3	6.7	6.2	6.4	6.4	6.3	6.4	6.7
Average Stop Delay (s)	174.0	171.0	148.2	139.9	161.9	138.6	146.1	172.1	150.0	166.1	159.8

Network											
	Almaden plus 5% Demand	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
Number of Vehicles	15,527	15,385	15,532	15,441	15,706	14,968	15,973	15,243	15,584	15,663	15,776
Total Travel Time (h)	10,031,002	10,114,041	9,689,818	10,073,770	9,530,102	10,547,546	9,934,489	10,481,100	9,835,387	9,862,602	10,241,164
Total Distance (mi)	16,937	16,855	16,960	16,748	16,997	16,575	17,356	16,790	17,055	17,018	17,013
Total Delay (h)	5,799,015	5,899,757	5,451,437	5,887,399	5,279,649	6,385,346	5,574,348	6,304,735	5,583,058	5,619,505	6,004,922
Per Vehicle											
	Almaden plus 5% Demand	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
Average Speed (mph)	6.1	6.0	6.3	6.0	6.4	5.7	6.3	5.8	6.2	6.2	6.0
Average Delay (s)	310.7	314.8	294.6	317.0	285.4	341.3	293.5	337.7	299.9	303.8	319.4
Average Number of Stops	6.8	6.7	6.7	7.0	6.6	6.6	6.8	7.1	6.6	6.9	7.1
Average Stop Delay (s)	173.9	184.2	160.5	178.9	147.9	205.6	154.4	197.1	167.4	166.6	176.5

Network				
	Almaden plus 10% Demand	Seed 1	Seed 4	Seed 7

Number of Vehicles	14,801	12,832	15,685	15,887
Total Travel Time (h)	9,949,705	8,809,378	10,689,781	10,349,955
Total Distance (mi)	16,142	14,009	17,152	17,266
Total Delay (h)	5,901,180	5,278,483	6,393,010	6,032,048
Per Vehicle				
	Almaden plus 10% Demand	Seed 1	Seed 4	Seed 7
Average Speed (mph)	5.8	5.7	5.8	6.0
Average Delay (s)	326.5	329.5	332.4	317.6
Average Number of Stops	7.1	7.0	7.1	7.1
Average Stop Delay (s)	186.2	188.9	194.3	175.3

APPENDIX D. TRAVEL-TIME

Travel Time Corridors	Existing Baseline (min)	Google Range (min)	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
EB Santa Clara Street	6.9	4 - 12	6.8	6.6	6.6	6.4	7.4	7.1	7.4	7.1	6.7	6.8
WB Santa Clara Street	5.9	2 - 8	6.0	5.6	6.0	6.1	5.9	5.8	5.8	5.6	6.1	5.7
NB Market Street	6.1	3 - 9	4.8	5.8	6.5	5.5	6.0	8.9	5.1	6.2	6.1	5.7
SB Market Street	8.7	4 - 12	9.8	8.5	8.8	8.3	9.2	8.5	8.0	8.3	8.9	8.2
NB 3rd Street	6.2	2 - 7	5.6	5.6	8.0	5.2	6.0	8.9	5.6	5.7	5.4	5.7
SB 4th Street	12.3	3 - 8	12.0	13.3	12.5	11.5	10.5	12.8	11.7	14.6	12.2	13.4
EB San Fernando Street	13.7	5	13.9	14.4	11.8	11.4	12.5	14.8	10.8	21.7	12.2	12.8
WB San Fernando Street	7.1	3 - 6	7.3	7.6	7.3	6.7	7.2	6.3	7.6	7.2	7.0	6.0
NB Almaden	5.0	2 - 6	5.6	5.4	6.3	4.0	4.2	4.0	4.3	6.7	4.5	4.7
SB Almaden	8.7	2 - 8	7.9	8.5	10.4	9.4	8.3	8.5	8.1	7.5	10.0	10.4

Travel Time Corridors	Almaden Conversion (min)	Google Range (min)	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
EB Santa Clara Street	6.6	4 - 12	6.5	6.3	6.3	6.4	6.5	7.1	6.2	7.2	6.4	7.1
WB Santa Clara Street	5.8	2 - 8	5.8	6.1	5.7	5.7	5.9	5.8	5.6	5.6	5.7	5.9

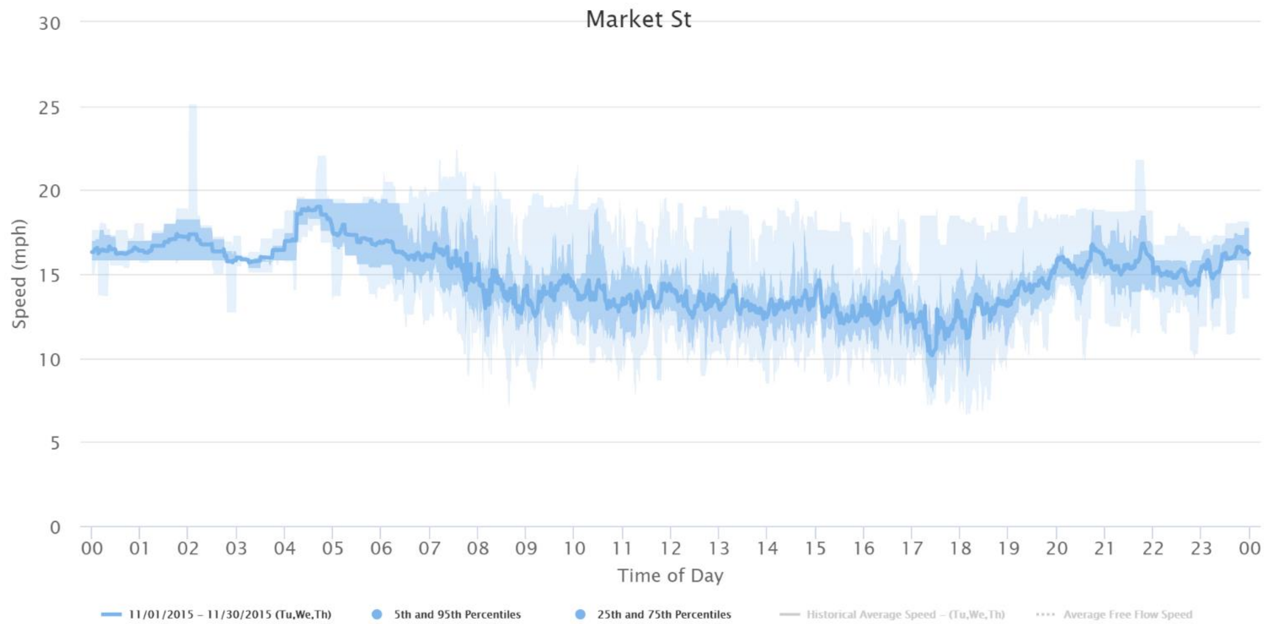
NB Market Street	6.1	3 - 9	6.2	5.5	5.4	6.4	5.4	5.3	9.2	5.1	5.8	6.6
SB Market Street	8.5	4 - 12	8.3	9.7	8.3	8.7	8.2	8.7	8.5	7.8	8.1	9.1
NB 3rd Street	6.1	2 - 7	6.2	5.8	5.3	6.3	5.5	5.9	7.9	5.8	5.9	6.9
SB 4th Street	12.2	3 - 8	12.1	11.7	11.8	12.8	11.2	11.3	13.1	12.3	12.8	12.2
EB San Fernando Street	13.4	5	13.5	12.8	15.0	12.6	11.3	13.9	15.3	14.2	13.1	13.2
WB San Fernando Street	7.1	3 - 6	7.1	7.2	7.5	7.6	6.6	7.3	6.5	7.4	7.0	7.2
NB Almaden	4.7	2 – 6	4.4	6.0	4.2	4.5	4.0	4.1	3.9	4.9	4.8	5.5
SB Almaden	9.3	2 - 8	9.5	8.3	8.1	10.2	9.6	8.1	8.5	10.2	10.2	9.7

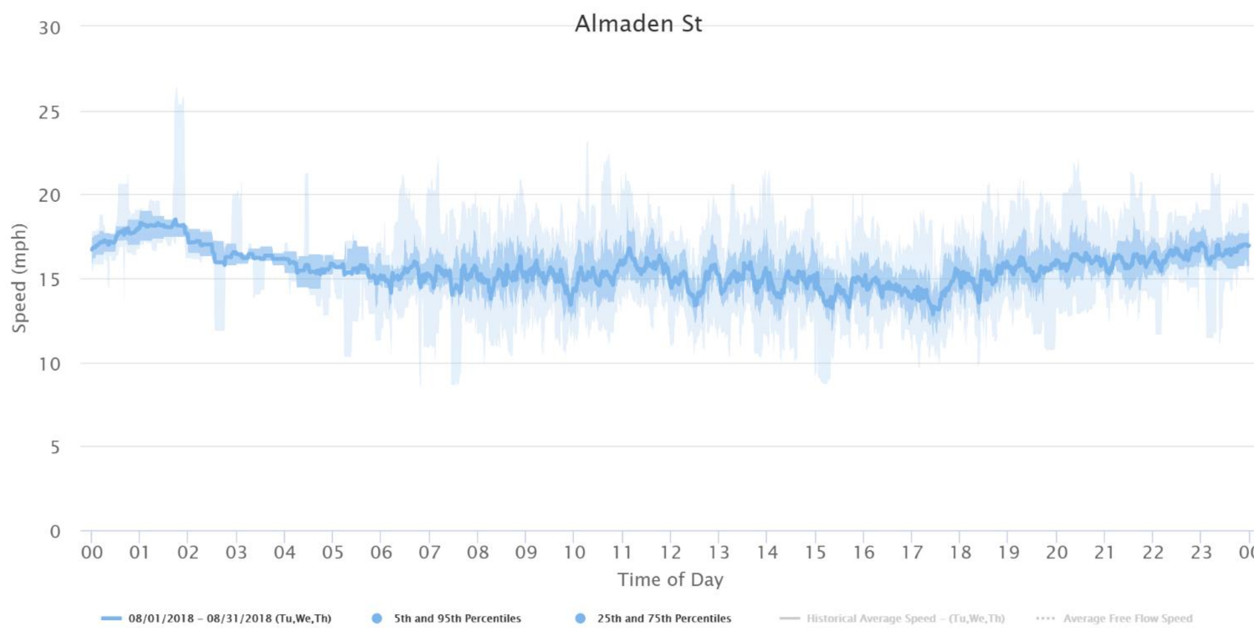
Travel Time Corridors	Almaden Conversion plus 5% Demand (min)	Google Range (min)	Seed 1	Seed 4	Seed 7	Seed 10	Seed 13	Seed 16	Seed 19	Seed 22	Seed 25	Seed 28
EB Santa Clara Street	7.4	4 - 12	6.5	7.0	6.9	6.5	8.2	7.8	6.9	7.9	6.9	9.4
WB Santa Clara Street	5.8	2 - 8	5.9	6.1	5.5	6.1	5.7	5.7	5.5	5.7	5.6	6.2
NB Market Street	6.5	3 - 9	4.7	4.8	6.6	5.7	5.9	7.7	7.3	7.9	5.8	8.3
SB Market Street	8.7	4 - 12	10.3	8.5	9.2	8.2	8.5	8.7	8.3	7.8	8.3	9.7
NB 3rd Street	6.9	2 - 7	7.2	5.5	6.9	5.5	7.0	5.8	11.1	6.0	7.7	5.8
SB 4th Street	13.1	3 - 8	13.1	13.7	14.1	11.4	13.3	11.6	13.9	13.0	13.0	13.7
EB San Fernando Street	14.5	5	12.7	14.9	13.9	12.5	16.1	12.4	17.1	14.9	14.0	16.0

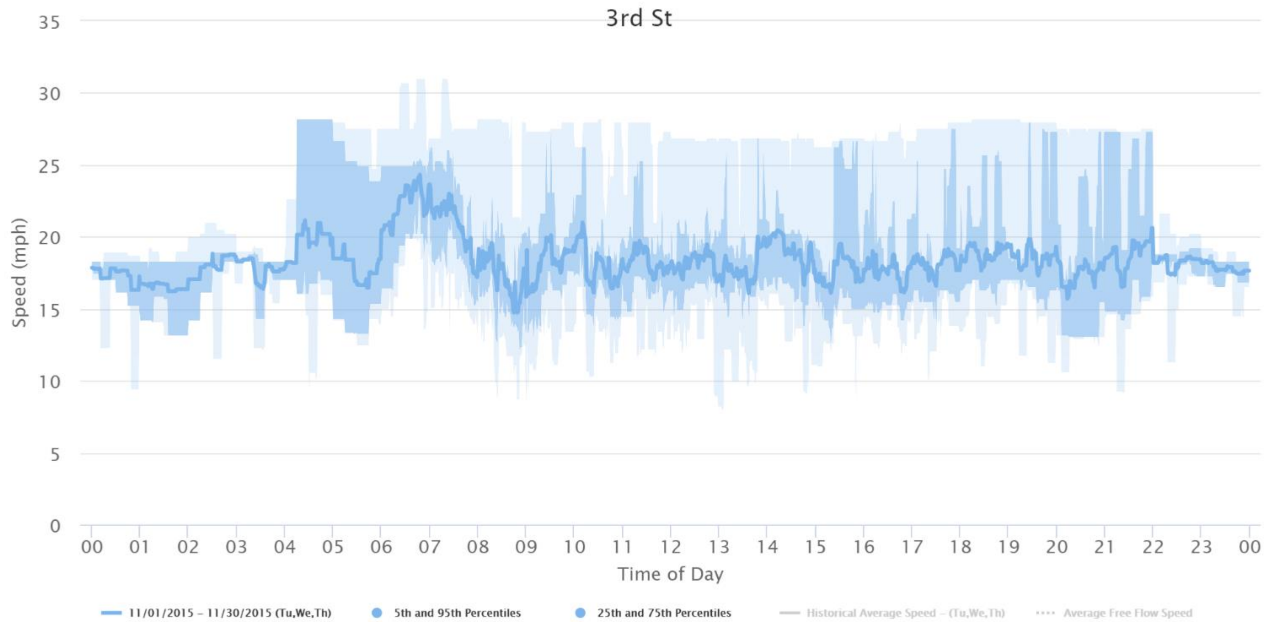
WB San Fernando Street	7.0	3 - 6	6.9	7.1	6.5	6.9	6.8	7.5	6.8	7.3	7.7	6.7
NB Almaden	4.6	2 – 6	4.1	4.6	4.0	4.2	5.2	4.2	5.0	4.2	6.5	4.3
SB Almaden	9.4	2 - 8	8.5	8.4	10.2	9.1	10.2	9.0	8.6	11.6	10.5	8.4

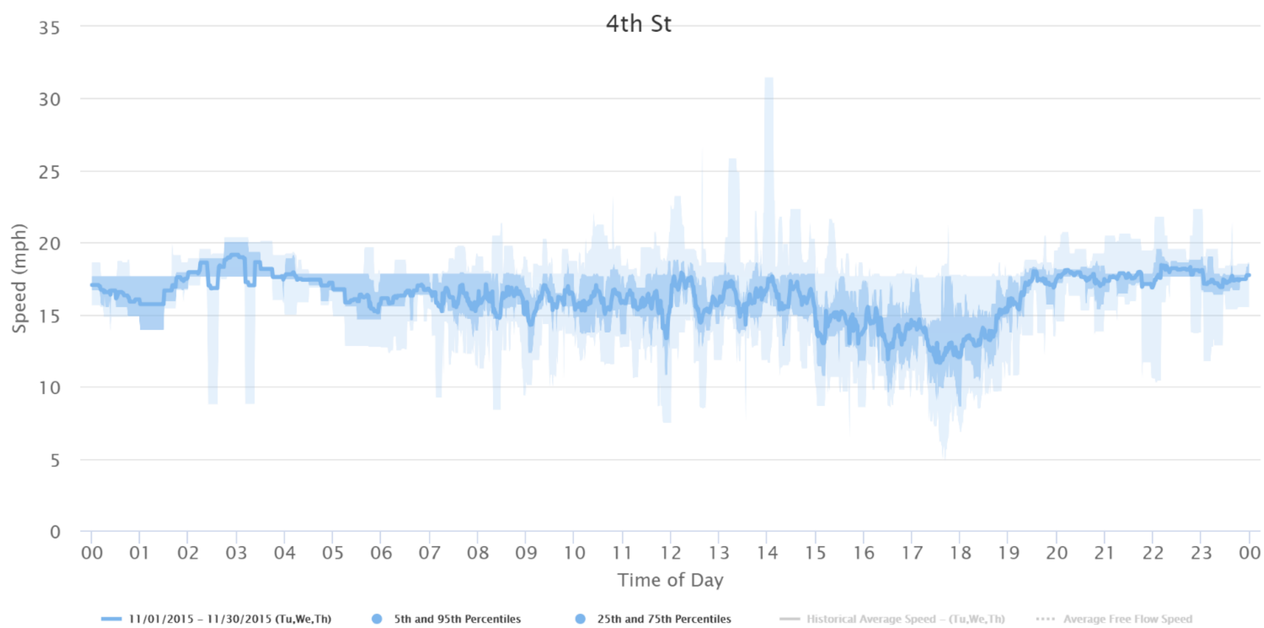
Travel Time Corridors	**Almaden Conversion plus 10% Demand (min)**	**Google Range (min)**	**Seed 1**	**Seed 4**	**Seed 7**
EB Santa Clara Street	7.6	4 - 12	7.1	7.5	8.2
WB Santa Clara Street	6.1	2 - 8	6.0	6.3	5.9
NB Market Street	5.7	3 - 9	5.8	5.4	5.8
SB Market Street	8.7	4 - 12	8.6	9.2	8.3
NB 3rd Street	6.1	2 - 7	6.3	6.4	5.7
SB 4th Street	13.5	3 - 8	13.7	13.6	13.1
EB San Fernando Street	16.5	5	18.5	14.0	16.9
WB San Fernando Street	7.2	3 - 6	6.7	7.4	7.5
NB Almaden	4.5	2 - 6	4.3	4.6	4.8
SB Almaden	9.4	2 - 8	9.4	8.9	9.8

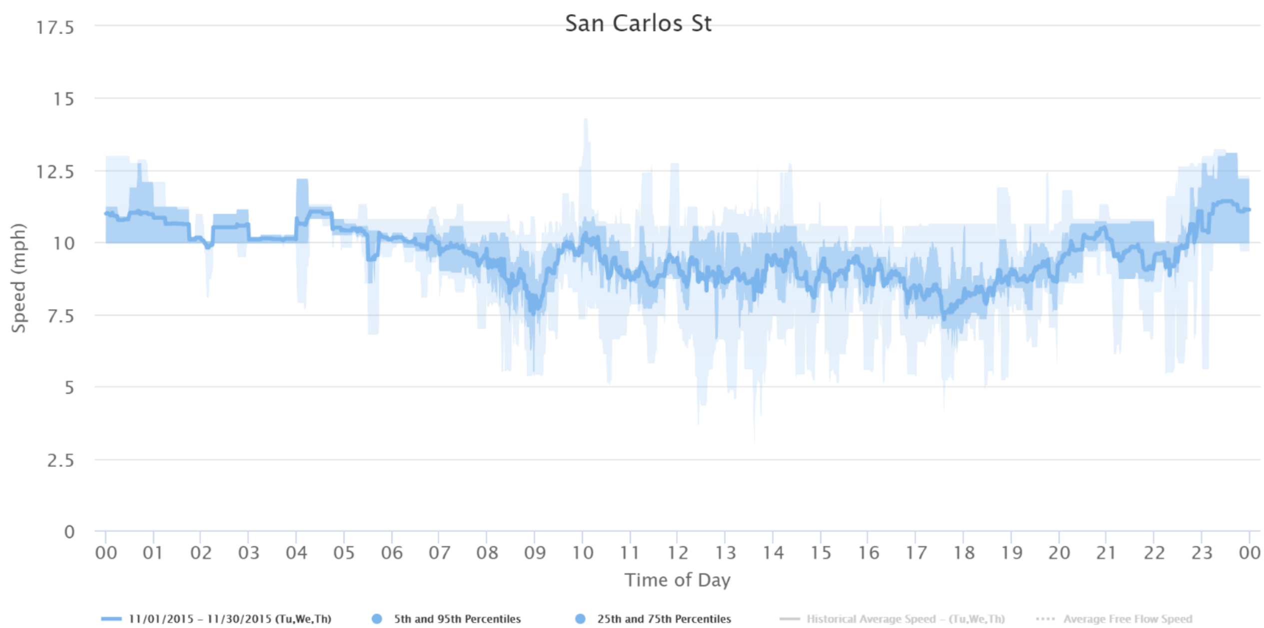
APPENDIX E. SPEED DATA

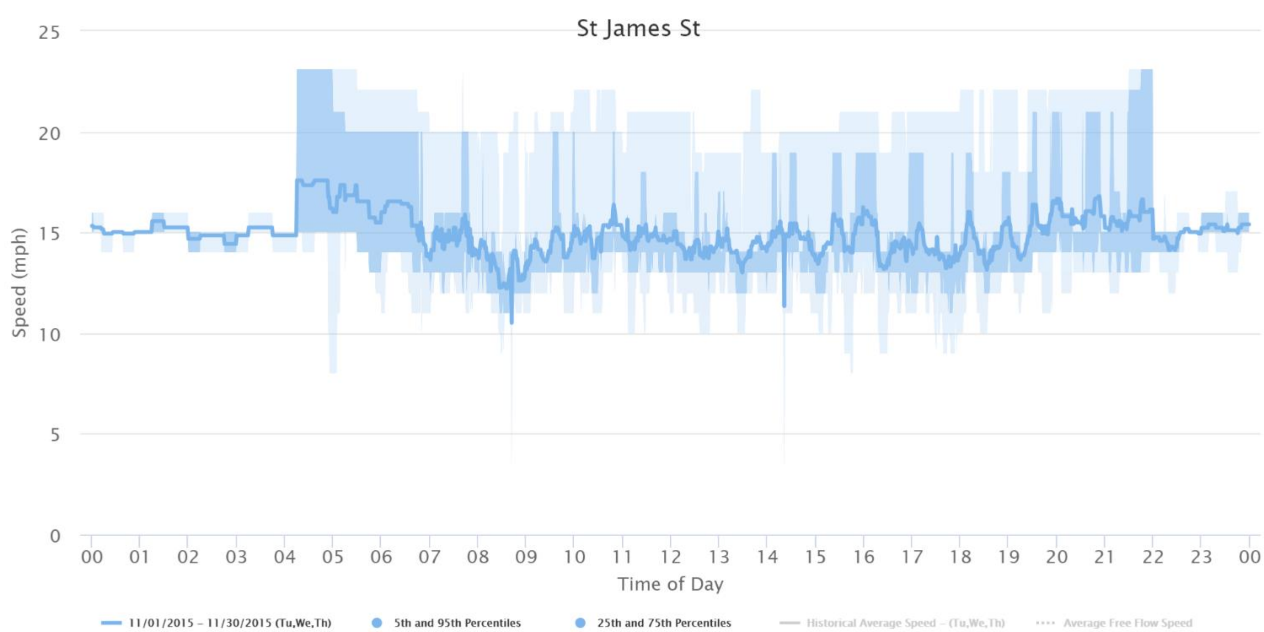


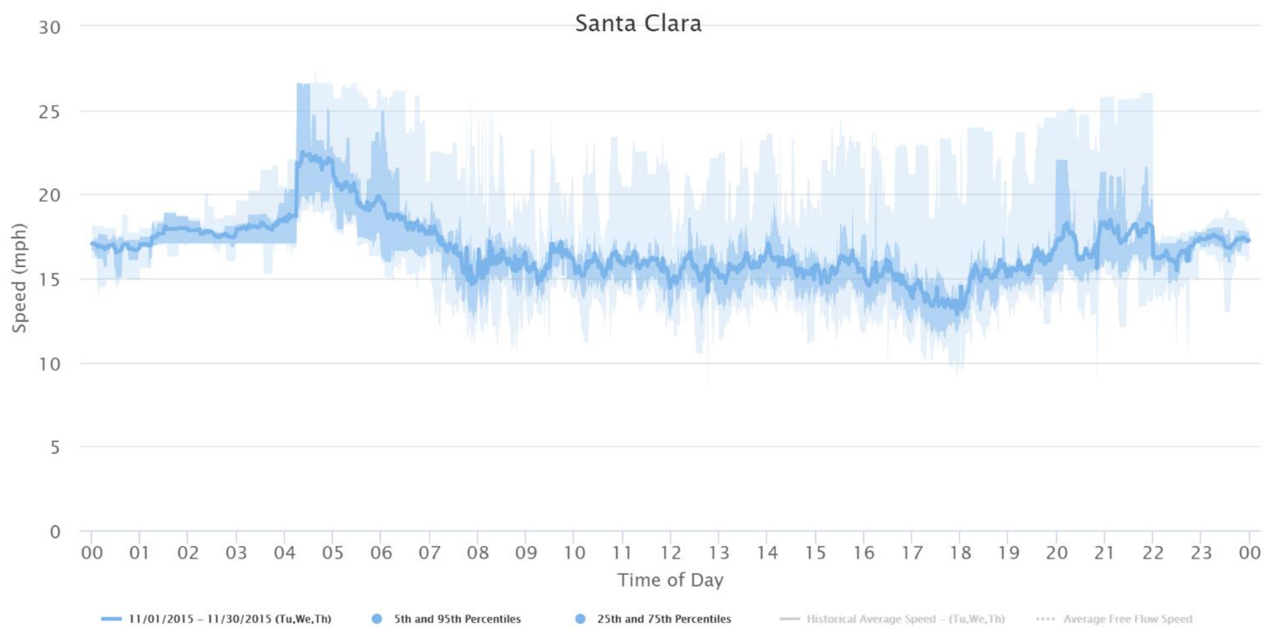



3rd St
Speed (mph)
35
30
25
20
15
10
5
0
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
Time of Day
11/01/2015 - 11/30/2015 (Tu,We,Th)
5th and 95th Percentiles
25th and 75th Percentiles
Historical Average Speed - (Tu,We,Th)
Average Free Flow Speed


4th St
Speed (mph)
35
30
25
20
15
10
5
0
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
Time of Day
11/01/2015 - 11/30/2015 (Tu,We,Th)
5th and 95th Percentiles
25th and 75th Percentiles
Historical Average Speed - (Tu,We,Th)
Average Free Flow Speed


San Carlos St
17.5
15
12.5
10
7.5
5
2.5
0
Speed (mph)
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
Time of Day
11/01/2015 - 11/30/2015 (Tu,We,Th)
5th and 95th Percentiles
25th and 75th Percentiles
Historical Average Speed - (Tu,We,Th)
Average Free Flow Speed


St James St
25
20
15
10
5
0
Speed (mph)
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
Time of Day
11/01/2015 - 11/30/2015 (Tu,We,Th)
5th and 95th Percentiles
25th and 75th Percentiles
Historical Average Speed - (Tu,We,Th)
Average Free Flow Speed


Santa Clara
Speed (mph)
30
25
20
15
10
5
0
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00
Time of Day
11/01/2015 - 11/30/2015 (Tu,We,Th)
5th and 95th Percentiles
25th and 75th Percentiles
Historical Average Speed - (Tu,We,Th)
Average Free Flow Speed

APPENDIX F. PEAK HOUR TRAFFIC COUNTS

Node	Intersection	Period	Peak Hour	Northbound			Eastbound			Southbound			Westbound			Count Date
				L	T	R	L	T	R	L	T	R	L	T	R	
3249	ALMADEN /PARK	PM	5:00-6:00	162	352	107	90	582	380	101	1160	66	266	334	36	10/18/16
3061	ALMADEN /SAN CARLOS	PM	5:00-6:00	107	198	22	48	351	253	65	920	108	0	187	32	10/18/16
3251	ALMADEN/SAN FERNANDO	PM	4:45-5:45	36	175	63	25	184	224	110	1179	14	168	45	47	10/25/16
3252	ALMADEN/SANTA CLARA (E)	PM	5:00-6:00	21	275	123	27	107	162	101	499	10	256	148	46	5/5/15
3253	ALMADEN/SANTA CLARA (W)	PM	5:00-6:00	0	0	0	0	143	173	85	404	56	95	128	0	5/5/15
3244	ALMADEN/WOZ	PM	5:00-6:00	81	131	186	0	207	52	35	246	32	134	363	0	5/12/15
4087	BALBACH/MARKET	PM	5:00-6:00	26	103	37	81	321	78	0	0	0	0	206	24	12/6/16
3077	BIRD/SAN CARLOS	PM	5:00-6:00	6	119	34	11	68	5	17	28	34	12	107	67	10/14/14
3513	FIRST /SANTA CLARA	PM	5:00-6:00	72	120	72	65	793	0	0	0	0	0	540	38	3/4/14
3506	FIRST/REED	PM	4:30-5:30	68	198	16	210	598	64	174	333	187	11	412	32	5/12/15
3510	FIRST/SAN CARLOS	PM		0	0	0	0	0	159	0	1252	149	0	0	0	5/12/15
3511	FIRST/SAN FERNANDO	PM	5:00-6:00	0	0	0	0	613	212	96	730	97	163	414	0	5/25/17

Node	Intersection	Period	Peak Hour	Northbound			Eastbound			Southbound			Westbound			Count Date
				L	T	R	L	T	R	L	T	R	L	T	R	
3512	FIRST/SAN SALVADOR	PM	4:50-5:50	0	0	0	0	705	175	151	805	114	155	430	0	2/25/14
3537	FOURTH /REED	PM	4:15-5:15	34	88	29	51	653	60	121	550	47	55	346	30	2/18/16
3538	FOURTH /SAN CARLOS	PM	5:00-6:00	0	0	0	155	78	384	106	903	0	0	0	0	5/19/15
3540	FOURTH /SAN SALVADOR	PM	4:30-5:30	108	365	0	0	0	0	0	492	5	430	286	158	5/19/15
3545	FOURTH /WILLIAM	PM	4:30-5:30	131	281	43	71	565	88	184	861	166	0	0	0	2/27/18
3539	FOURTH/SAN FERNANDO	PM	5:00-6:00	84	325	64	9	163	276	4	303	24	20	115	10	9/12/17
3541	FOURTH/SANTA CLARA	PM	5:00-6:00	0	0	0	0	222	139	49	564	107	72	122	0	11/3/16
3107	MARKET /SAN CARLOS	PM	5:00-6:00	80	489	255	67	223	0	0	0	0	0	226	85	2/25/14
3669	MARKET /SAN SALVADOR	PM	5:00-6:00	36	412	31	55	107	0	0	0	0	0	172	136	5/12/15
3667	MARKET/SAN FERNANDO	PM	4:45-5:45	0	0	0	0	714	139	55	267	74	106	494	0	3/4/14
3670	MARKET/SANTA CLARA	PM	4:45-5:45	0	250	344	257	263	218	408	610	0	0	0	0	3/17/16
3671	MARKET/ST JAMES	PM	5:00-6:00	29	225	69	7	279	192	10	123	6	27	111	13	11/9/16

Node	Intersection	Period	Peak Hour	Northbound			Eastbound			Southbound			Westbound			Count Date
				L	T	R	L	T	R	L	T	R	L	T	R	
3731	PARK/WOZ	PM	5:00-6:00	27	1337	85	44	134	0	0	0	0	0	75	337	9/12/17
3750	REED/SECOND	PM	5:00-6:00	20	36	24	34	695	33	136	153	17	33	374	17	10/20/16
3751	REED/SEVENTH	PM	5:00-6:00	1	202	0	0	0	0	0	904	665	36	291	114	5/19/15
3753	REED/THIRD	PM	5:00-6:00	35	194	0	74	0	330	0	1216	48	0	0	0	10/28/15
3766	SAN CARLOS /THIRD	PM	4:45-5:45	71	112	51	49	159	83	20	28	35	22	132	48	11/9/16
3764	SAN CARLOS/SECOND	PM	5:00-6:00	57	220	25	112	94	166	53	860	105	195	133	60	2/13/13
3763	SAN CARLOS/WOZ	PM	5:00-6:00	70	229	14	103	64	112	31	739	110	181	138	37	2/6/13
3770	SAN FERNANDO/SECOND	PM	5:00-6:00	21	251	146	29	105	139	111	454	22	280	154	55	2/13/13
3773	SAN FERNANDO/THIRD	PM	5:00-6:00	55	269	130	34	101	163	97	443	43	264	152	47	2/5/13
3779	SAN SALVADOR/SECOND	PM	5:00-6:00	0	0	0	0	884	268	30	191	76	0	472	0	3/12/13
4111	SAN SALVADOR/SEVENTH	PM	5:00-6:00	99	314	72	0	0	184	51	1313	88	297	0	117	7/17/13
3781	SAN SALVADOR/THIRD	PM	5:00-6:00	0	0	0	0	268	178	88	978	113	214	180	0	3/19/13

Node	Intersection	Period	Peak Hour	Northbound			Eastbound			Southbound			Westbound			Count Date
				L	T	R	L	T	R	L	T	R	L	T	R	
3785	SANTA CLARA/10TH	PM	5:00-6:00	0	0	0	0	74	47	194	1205	115	158	218	0	3/19/13
3782	SANTA CLARA/SECOND	PM	5:00-6:00	0	0	0	0	115	54	84	1273	55	66	123	0	3/12/13
3786	SANTA CLARA/THIRD	PM	5:00-6:00	3	273	45	7	3	17	67	1009	32	76	9	68	3/20/13
3797	SECOND/WILLIAM	PM	4:45-5:45	0	0	0	0	85	35	90	482	71	63	130	0	10/17/13
3805	SEVENTH/WILLIAM	PM	5:00-6:00	0	0	0	0	106	44	65	492	32	61	62	0	10/17/13
3827	THIRD/WILLIAM	PM	5:00-6:00	27	361	52	25	123	0	0	0	0	0	89	66	3/12/13

APPENDIX G. VEHICLE ROUTES ADJUSTED FOR ALMADEN CONVERSION

Adjusted Routes
1-19
7-36
8-36
13-16
13-28
13-31
13-35
17-35
18-34
22-34
23-34
27-32
35-34
37-34
40-34
50-26
51-34
66-18
66-30
66-7
68-13
70-13
70-15
70-16
70-50
70-51
70-68
70-88
72-12

72-13
72-53
73-15
73-16
73-41
73-42
73-74
73-9
74-24
75-57
76-112
76-19
76-21
76-22
76-62
76-65
77-54
66-5
67-9
70-12
70-14
71-8
71-9
74-20
74-21
74-22
76-18