

# **AC Transit East Bay Bus Rapid Transit Project – Alameda and Contra Costa Counties, California**

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## **Abstract**

The Alameda-Contra Costa Transit District's (AC Transit) East Bay Bus Rapid Transit Project envisions providing frequent, high-level, high-speed bus service along an approximately 17-mile long alignment from Downtown Berkeley and the University of California at the northern end, through Downtown Oakland, to Downtown San Leandro and the Bay Fair Bay Area Rapid Transit (BART) station at the southern end. The service would operate largely on Telegraph Avenue in Berkeley and northern Oakland, on International Boulevard in eastern Oakland, and on East 14th Street in San Leandro.

AC Transit is currently preparing an Environmental Impact Statement and Environmental Impact Report (EIS/EIR) for this project. This paper would present 1) transit service results, 2) the methodology used to develop traffic volume forecasts for Alameda-Contra Costa Transit District's proposed East Bay Bus Rapid Transit (BRT) Project, and 3) the methodology used to evaluate traffic operations of various BRT routes and stations.

VISSIM Microsimulation software was used to perform the traffic operations analysis for the more complex portions of this project. This paper would present some lessons learned from implementing VISSIM for the BRT project. This paper would serve as a reference for transportation professionals seeking guidance on the evaluation of BRT traffic operations or comparisons of various Bus Rapid Transit Systems.

**Key Words:** Bus Rapid Transit, Microsimulation Calibration and Validation

## **Introduction**

The East Bay BRT Project envisions providing frequent, high-level, high-speed bus service along an approximately 17-mile long alignment from Downtown Berkeley and the University of California at the northern end, through Downtown Oakland, to Downtown San Leandro and Bay Fair Bay Area Rapid Transit (BART) station at the southern end. The service would operate largely on Telegraph Avenue in Berkeley and northern Oakland, on International Boulevard in eastern Oakland, and on East 14th Street in San Leandro.

The East Bay BRT Project includes several features to enhance transit service:

- Dedicated bus lanes for most of its 17-mile alignment;
- Transit priority signal (TSP) treatments and coordination throughout the alignment;
- Frequent BRT service averaging five minutes or less between BRT buses during peak travel periods;
- Wider station spacing for BRT service (approximately one-third to one-half mile between stations);
- Light-rail-like stations, including shelters, boarding platforms, benches, security features, fare machines, real-time bus arrival information, and other amenities;
- Prepaid ticketing and proof-of-payment fare verification; and
- Low-floor, multidoor, level-boarding, and low-emission BRT buses.

The purpose of the East Bay BRT Project is to address several transportation needs in the corridor:

- Better accommodate high levels of existing bus ridership by offering higher frequency, faster, and more reliable service with improved security, cleanliness, and comfort;
- Improve transit access to job and activity centers by providing faster, safer, and more convenient service to major employment, educational, and entertainment hubs in the cities of Berkeley, Oakland, and San Leandro;
- Support transit-oriented residential and commercial development along the corridor by providing better access to local and regional jobs, services, education, and entertainment;
- Better serve low-income and transit-dependent populations by offering improved transit service and facilities along the corridor; and
- Reduce corridor automobile use by providing a viable and competitive transit alternative.

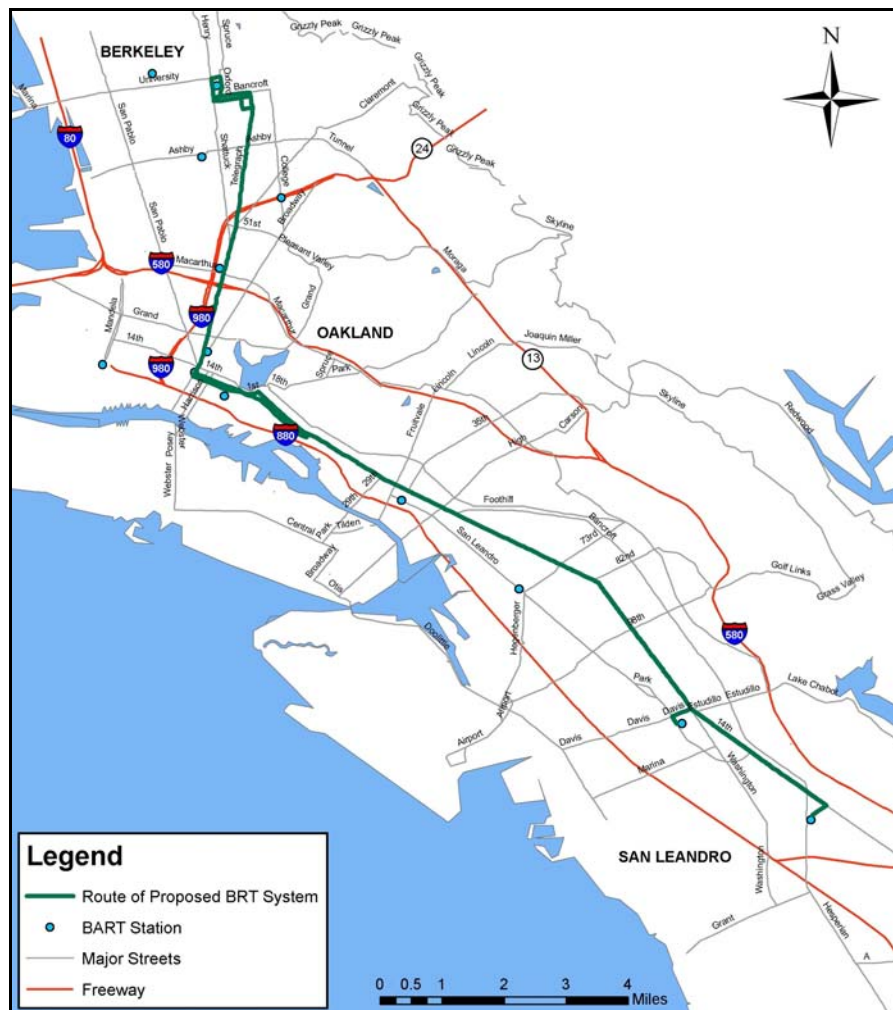
There are several important components of this project. The authors would like to focus on: (1) Transit service and transit patronage, (2) Travel demand forecasting methodology, (3) Traffic analysis procedures, (4) Traffic analysis tools, (5) Calibration and validation of VISSIM microsimulation model, and (6) Lessons learned and conclusions of VISSIM microsimulation application.

## Existing Transit Service

Two primary transit operators currently provide services along and in the vicinity of the alignment of the proposed BRT project. AC Transit currently provides bus services and BART provides heavy-rail services.

AC Transit buses operating along the proposed BRT alignment currently experience 23,910 boardings on an average weekday. Systemwide, AC Transit currently board 206,300 riders on an average weekday, including boardings on its Transbay services (commute bus services over the San Francisco Bay Bridge to and from Downtown San Francisco).

BART provides heavy-rail service on routes paralleling the BRT alignment. In contrast to AC Transit's bus services, BART's service operates at a higher speed, average 35 mph, with fairly wide station spacing (approximately 2 miles between stations). As a result, BART's patronage is heavily weighted toward regional trips (e.g., to and from other counties such as San Francisco and Contra Costa) rather than on trips along the proposed BRT alignment. BART boards 304,900 riders on an average weekday systemwide.



**Exhibit 1: Proposed East Bay BRT Project**

## Travel Demand Forecasting Methodology

The overall purpose of the forecasting process is to develop and compare several measures with the East Bay BRT Project in place (i.e. Build conditions) versus without the project (i.e. No-Build conditions) in the year 2025. These measures include:

- Change in total transit trips;
- Change in AC Transit systemwide boardings;
- Change in BART boardings;
- Change in boardings for all AC Transit bus routes operating along the proposed BRT alignment (“alignment boardings”) and
- Change in roadway volumes.

In most cases, the methodology employed to forecast these measures used a combination of results from the Alameda County Congestion Management Agency’s (ACCMA’s) Alameda County Travel Demand Model (Alameda Model) with some post-model adjustments.

### *Alameda Model and Refinements*

The May 2003 version of the Alameda Model was used as the starting point for developing forecasts of transit and automobile trips, transit boardings, and roadway link volumes for year 2025 No-Build and Build/BRT conditions. The Alameda Model is a full four-step travel demand model that provides state-of-practice capabilities for forecasting the extent to which travelers will shift between travel modes (i.e. mode choice) and which transit routes and roadways travelers choose to use (i.e. trip assignment). The model uses land use data and a simplified representation of the highway and transit systems in Alameda County to derive estimates of transit volumes and roadway traffic volumes for the AM peak hour, PM peak hour and entire day.

Over 700 Traffic Analysis Zones (TAZs) are used in the model to represent Alameda County. The model categorizes travel into five trip purposes: home-based work, home-based school/university, home-based shop/other, home-based social/recreational, and non-home-based.

For home-based work trips, the Alameda Model uses a nested logit mode choice model structure. The highest nest includes drive alone, 2-person High Occupancy Vehicle (HOV), 3+ person HOV, and transit. The transit nest includes five transit modes; walk to local bus, walk to express bus, walk to BART, park-and-ride, and kiss-and-ride. The express bus mode is used primarily to represent AC Transit’s Transbay commute buses. The park-and-ride and kiss-and-ride modes are primarily used in conjunction with BART, though there are some opportunities to connect with AC Transit and BART express buses.

For trips other than home-based work, the Alameda Model uses a simple logit mode choice model structure consisting of two modes: auto and transit.

The Alameda Model was used to forecast year 2025 transit and traffic volumes with and without the proposed BRT project. These transit and traffic volumes were then compared to estimates of

year 2000 volumes from the model to determine the growth factors for each transit and roadway link.

Land use data provide existing and projected future population and employment information by TAZ and are a key input to the Alameda Model. The May 2003 Alameda Model uses the Association of Bay Area Governments' (ABAG's) *Projections 2002* land use data. Several adjustments were made to the land use data to better reflect existing conditions and projected future growth in the East Bay BRT corridor. These adjustments were generally shifts of population and employment between adjacent TAZs. All adjustments to land use data were made with the approval of the city in question and are consistent with the citywide and countywide totals for population and employment.

#### *Patronage for Future No-Build Conditions*

Transit patronage is expected to be greater under future No-Build conditions (year 2025). This is primarily because of population and employment growth in the corridor, but also due to other near-term transit improvements AC Transit is making along the proposed BRT alignment. AC Transit boardings along the BRT alignment increase 17 percent over existing conditions to 28,050 per average weekday, or a bit less than 1 percent per year between 2003 and 2025. AC Transit systemwide boardings increase 26 percent to 259,800, or a bit more than 1 percent per year. BART systemwide boardings increase 31 percent to 400,000.

### **Traffic Analysis Procedures**

#### *Initial Intersection Identification Process*

Analysis intersections were identified through a structured process that included an initial screening analysis using the Alameda County travel demand model, followed by supplementary processes to identify additional intersections that were potentially subject to adverse impacts.

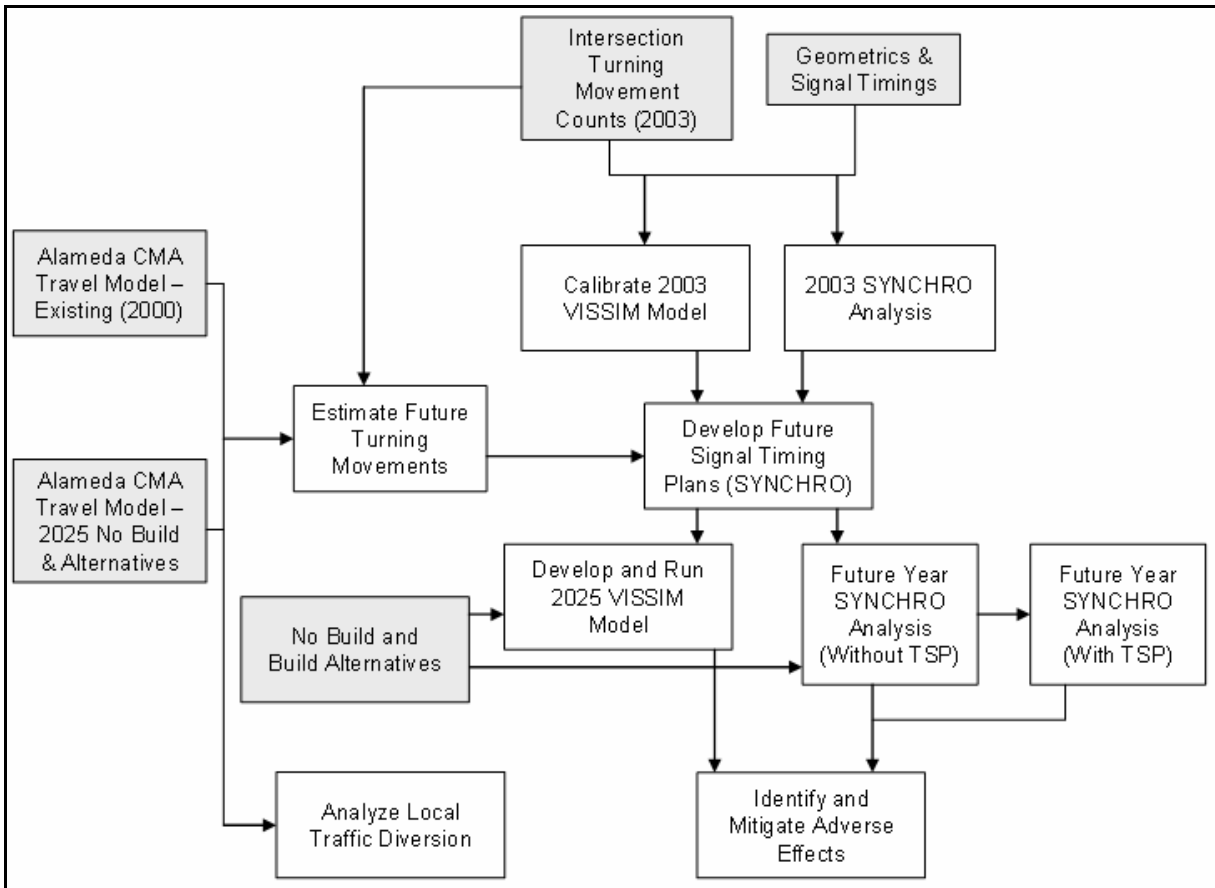
The screening analysis was conducted on 48 roadway segments and was consistent with the Alameda County Congestion Management Agency's (CMA) procedures for roadway analysis. This analysis used PM peak-hour travel model data to identify roadway segments where the link-level volume-to-capacity (V/C) ratio for the build scenario would degrade below thresholds established by the Alameda County CMA. Key intersections in the vicinity of the identified roadway segments were added to an initial list of intersections for detailed analysis in the PM peak-hour.

*Alameda County CMA Travel Demand Model*

As noted in prior sections, the Alameda County CMA travel demand model provides estimates of roadway volumes throughout the study area for many potential analysis years. The demand model uses population and employment estimates, and a simplified representation of the highway and transit systems to derive estimates of roadway traffic and transit volumes for the AM peak hour, PM peak hour, and entire day. The travel demand model was used to forecast years 2010 and 2025 volumes with and without the proposed project. These volumes were then compared to estimated year 2000 volumes from the travel demand model to determine the volume change on each roadway and transit link.

*Macroscopic Intersection Analysis*

The methodology used for the traffic analysis for this study is based on the process presented in Chapter 16 of the Highway Capacity Manual (HCM). The primary output of this method is the Level of Service (LOS). The input information required to conduct an operational analysis for signalized intersections are detailed and varied. This information falls into three main categories: 1) geometric; 2) traffic and signalization; and 3) forms the basis for selecting computational values and procedures for the steps that follow, namely the Lane Grouping, Demand Flow Rate, Saturation Flow Rate, Capacity and Volume/Capacity, and the Performance Measures.



**Exhibit 2: Traffic Analysis Process**

Control delay and LOS for most study intersections were calculated using Synchro analysis software (Version 5.0). Synchro is a complete software package for modeling and optimizing traffic signal timings, and Version 5.0 implements the methodologies of the 2000 HCM for signalized and unsignalized intersections. Synchro requires data on road characteristics (geometric), traffic counts, and signal timing for each analysis intersection. In general, Synchro's default parameters were used, except for locations where specific field data were available (e.g., pedestrian counts, truck percentages, double parking); or adjustments to saturation flow rates were needed to match LOS results reported in other studies.

Synchro can analyze an intersection as an individual isolated location or as part of subnetwork of interrelated intersections. Both isolated and network applications of Synchro were employed for this traffic analysis. The decision to analyze each intersection as isolated or networked was based on distance to adjacent analyzed intersections, presence of other major signalized intersections between analyzed intersections, stability of traffic volumes, and presence or absence of signal interconnections.

### *Microsimulation*

Microsimulation is frequently used for analysis of complex intersections, particularly when significant interaction between signalized intersections is observed or expected. Examples of such complexity and interaction include:

- Intersections that are closely spaced;
- Coordinated signal phases and timing with a high degree of vehicle platooning;
- Queues that extend to or through an upstream intersection;
- High levels of on-street parking and pedestrian activity; and
- Periodic lane blockages related to bus stops, double-parking, and/or delivery activity.

Several software packages provide microsimulation capabilities. Based on features of the proposed projects, a microsimulation software package was needed that could address, at a minimum, the following items:

- On-street fixed guideway transit service, either center or side running;
- Signal prioritization/pre-emption for BRT;
- Modifications to existing signal plans (i.e., signal coordination and pre-emption);
- BRT stops within simulation area;
- Heavy pedestrian traffic at intersections; and
- Conversion of travel lanes or parking in bus-only lanes.

Based on these needs, VISSIM was selected as the microsimulation software. VISSIM is a microscopic, time step, and behavior-based multipurpose traffic simulation program that can be used to analyze multimodal traffic flows that are subject to constraints. It is capable of modeling various roadway functional classifications, including complex signalized and unsignalized intersections, roundabouts, exclusive lanes, traffic interchanges, etc. VISSIM models were developed to analyze the areas within the BRT corridor experiencing some or all of the complexities described above.

## **Calibration and Validation of VISSIM Model**

This section presents the methodology and results of calibration and validation for the VISSIM models. Each microsimulation run was started 15 minutes prior to the peak period, allowing for each network to reach equilibrium prior to beginning the formal analysis period. Each simulation model was run 20 times, and the average of vehicle turning movement volumes at each intersection was calculated. These volumes were compared to the observed field counts to ensure the calibration criteria for volumes were satisfied.

### *Calibration Acceptance Criteria*

Calibration involves modifying the models internal parameters so that the model accurately represents observed conditions. The following criteria were used for acceptance of the calibrated microsimulation networks:

- (1) A visual verification of the model to ensure that a) all roadway and transit network characteristics were coded appropriately, and b) the model appeared to be accurately replicating general travel flows and congestion hot spots that were observed during field reviews in each simulation area.
- (2) The modeled peak-hour volumes for all intersections within each simulation area must be within 15 percent of observed volumes for observed flows greater than 150 vehicles per hour. These targets must be satisfied for 80 percent of the intersection movements in each simulation area.
- (3) The modeled peak-hour volumes for all intersections within each simulation area fall within 30 percent of observed volumes for flows less than or equal to 150 vehicles per hour. These targets must be satisfied for 80 percent of the intersection movements in each simulation area.
- (4) All model parameters (e.g., saturation flow rates, gap acceptance rates, etc.) must fall within the bounds of good professional practice and be reasonable for the general travel conditions in each simulation area.

### *Validation Acceptance Criteria*

After calibration of each simulation area was achieved, the individual models were rerun and validated against observed travel times and intersection levels of service. The following criteria were adopted to validate the predictive capability of each model:

- (1) The modeled block-to-block travel times were compared with the travel times observed in the field. Statistical two-sample t-tests were conducted to compare the difference between the means for the modeled and observed travel times. Corresponding to a confidence interval of 95 percent, a p-value greater than or equal to 0.1 (corresponding to a two-tailed confidence interval of 95 percent) was considered acceptable for validation purposes.
- (2) LOS estimates from the VISSIM model were compared to the LOS values documented in reports prepared for other recent studies.

Main Street	Cross Street	Approach	Approach Movement	VISSIM Counts	Field Counts	Percent Difference	Calibration Criteria
Shattuck	Addison (East)	EB	EBL	29.3	37	-20.81%	Below 150 vph
		EB	EBT	52.9	43	23.02%	Below 150 vph
		NB	NBL	74.35	55	35.18%	Below 150 vph
		NB	NBR	156.35	46	239.89%	Below 150 vph
		NB	NBT	985.1	1,196	-17.63%	Above 150 vph
		WB	WBR	104	105	-0.95%	Below 150 vph
		WB	WBT	72.2	72	0.28%	Below 150 vph
Shattuck	Center (West)	EB	EBR	160.5	165	-2.73%	Above 150 vph
		EB	EBT	100.5	101	-0.50%	Below 150 vph
		SB	SBL	77.3	63	22.70%	Below 150 vph
		SB	SBR	132.35	125	5.88%	Below 150 vph
		SB	SBT	883.4	811	8.93%	Above 150 vph
		WB	WBL	101.6	48	111.67%	Below 150 vph
		WB	WBT	118.7	121	-1.90%	Below 150 vph
Shattuck	Center (East)	EB	EBL	65.4	71	-7.89%	Below 150 vph
		EB	EBT	100.1	93	7.63%	Below 150 vph
		NB	NBL	141.65	71	99.51%	Below 150 vph
		NB	NBR	71.45	93	-23.17%	Below 150 vph
		NB	NBT	1,068.65	1,150	-7.07%	Above 150 vph
		WB	WBR	31.2	76	-58.95%	Below 150 vph
		WB	WBT	30.2	98	-69.18%	Below 150 vph

**Exhibit 3: A Section of Detailed Volume Calibration Data in Downtown Berkeley Area**

Observed Volumes above 150 vph			Observed Volumes Below 150 vph		
Error Range	Number	Percent of Total	Error Range	Number	Percent of Total
Over 15%	4	17.4%	Over 30%	7	11.9%
Within 15%	19	82.6%	Within 30%	52	88.1%
Total	23	100.0%	Total	59	100.0%

**Exhibit 4: Volume Calibration Summary for Downtown Berkeley Simulation Area**

## **Lessons Learned and Conclusions of VISSIM Microsimulation Application**

### *Priority Rules (Conflict Movements between Vehicles, Pedestrians, and Bicycles)*

VISSIM is trajectory based software, which means that all vehicles will travel on links/lanes of the network. When there are conflict movements, such as crossings at intersections, VISSIM uses a feature known as “priority rules” to designate right of way for conflicting movements at intersections, with minimum headway (distance), minimum gap time, and minimum speed the main conditions imposed at conflict points. It is very time-consuming to manually code each priority rule in the model. In this project, there are several intersections with more than 20 conflict movements (BRT lanes, pedestrian crosswalks, vehicle through/turn lanes, etc.) Priority rules do not only effect the animations (when animations were shown to the public or clients), but also contribute significant travel delay at the intersections with the most conflict movements.

### *VISSIM Simulated Delay vs. HCM Level of Service Thresholds*

Many government agencies require HCM Level of Service as a critical measure of effectiveness (MOE) for most traffic operational studies. However, when the project involves a complex multimodal transportation system (such as bus, transit, bicycle, pedestrian, rail, etc.), HCM Level of Service no longer effectively represents the effectiveness of the entire system. VISSIM cannot produce levels of services directly from the model. Thus, for this project, the VISSIM simulated delay was compared with the thresholds of HCM Level of Service to derive the value of level of service at each study intersection.

HCM Level of Service Thresholds were based on the specific calculations/formulations from the Highway Capacity Manual. However, the delay in VISSIM was derived from detailed interactions between each individual vehicle throughout the entire simulation time period, including all network components. It is debatable if VISSIM simulated delay could be applied to HCM’s Level of Service Thresholds to obtain the value of level of service.

### *On-Street Parking*

Since VISSIM does not directly account for reduction in lane capacity due to parking activity, a reduced saturation flow rate was used in some locations. There is significant double parking observed in the study areas due to street vendors, delivery trucks, and garbage collection trucks. Double-parked vehicles occupy the parking lane and a part of the through lane; thus reducing the effective capacity of the through lane.

### *Reduced Speed Areas*

Reduced speed areas were coded in at all left turns and right turns in order to reflect the friction caused by random pedestrian movement at crosswalks. Reduced speed areas were also introduced to model the effect of reduced lane width due to on-street parking, illegal double parking, and other field observations. For instance, a reduced speed distribution of 9.3 to 12.4 mph was adopted for all turning movements along Shattuck Avenue in Downtown Berkeley.

### *Delay Calculation of Over Saturated Networks*

When the travel demand exceeds the capacity of the roadway system, certain vehicles would not be generated by the VISSIM model due to the spilled back queue blocking the entry links. In other words, vehicles could not be totally generated at the end of the simulation time periods. It is recommended that the systemwide network delay should include the delay generated by the exceeded travel demand as if these vehicles were entering the network.

For this specific study, several dummy entry loops were created to fully capture the exceeded travel demand. Thus, the systemwide travel delay was compared with different scenarios (different designs of BRT terminals, etc.) on the same basis (with 100% travel demand).

### *Report Output*

VISSIM generates various outputs in text formats. Several Microsoft Excel Macros and Visual Basic Applications were created for this project to effectively aggregate results/MOEs. Thus, it is highly recommended that upfront programming efforts be taken into consideration.

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