Simulating Street-Running LRT Terminus Station Options in Dense Urban Environments

- Shaumik Pal, Rajat Parashar and Michael Meyer

Abstract

The Exposition Corridor transit project is a light rail project connecting Downtown Los Angeles to Downtown Santa Monica. Most of the rail line within the City of Santa Monica will operate at-grade along surface streets. As part of the design build process, Exposition Construction Authority and the City of Santa Monica worked extensively to evaluate different alignment alternatives for the terminus station at Colorado Avenue and 4th Street.

This paper summarizes the comprehensive analysis completed by the project team, using VISSIM micro simulation software as the primary tool, both for analysis and visualization. The analysis study area included 26 intersections in the City of Santa Monica. Extensive model calibration and validation was done for the existing conditions to accurately project the future operations with a street-running light rail.

The alternative analysis concluded with identification of necessary improvements to mitigate the impacts. The improvements considered for further study included: transit signal priority, signal improvements, turn restrictions, addition of turn lanes, restriping lanes and street closures.

Introduction and Background

The Exposition Light Rail Transit (LRT) Project is a 15.2 mile light rail line extending from Downtown Los Angeles to Downtown Santa Monica. Phase 1 of the project is from Downtown Los Angeles to Culver City. Phase 2 will extend the project to Santa Monica. The design and construction of the light rail line is overseen by the Exposition Metro Line Construction Authority.

The environmental analysis for Phase 2 was completed in early 2010. It includes eight new stations. There will be three stations in Santa Monica, at 26th Street/Olympic Boulevard, at 17th Street/Colorado Avenue, and at 4th Street/Colorado Avenue.

Due to many factors, the City of Santa Monica wanted to evaluate options regarding multimodal operations at 4th Street/Colorado Avenue and the adjacent intersections. These factors included: heavy pedestrian activity, on-street parking and multimodal nature of Downtown Santa Monica.

This paper summarizes the comprehensive analysis conducted to assess the traffic operations feasibility of a design of a proposed new Light Rail Transit (LRT) station location in the City of Santa Monica near the intersection of Colorado Avenue and 4th Street. Corridor level and intersection level operations analyses were performed using the VISSIM microsimulation software. Extensive model calibration and validation was done for the existing conditions to accurately project the future operations with a street-running light rail. The analysis study area included 26 intersections in the City of Santa Monica. The study area included all signalized intersections in the area bounded by Ocean Boulevard to the west, Santa Monica Boulevard to the north, Lincoln Boulevard to the east and Olympic Boulevard to the south, including the two westbound off ramps at 5th and 4th Streets.

VISSIM Model Calibration

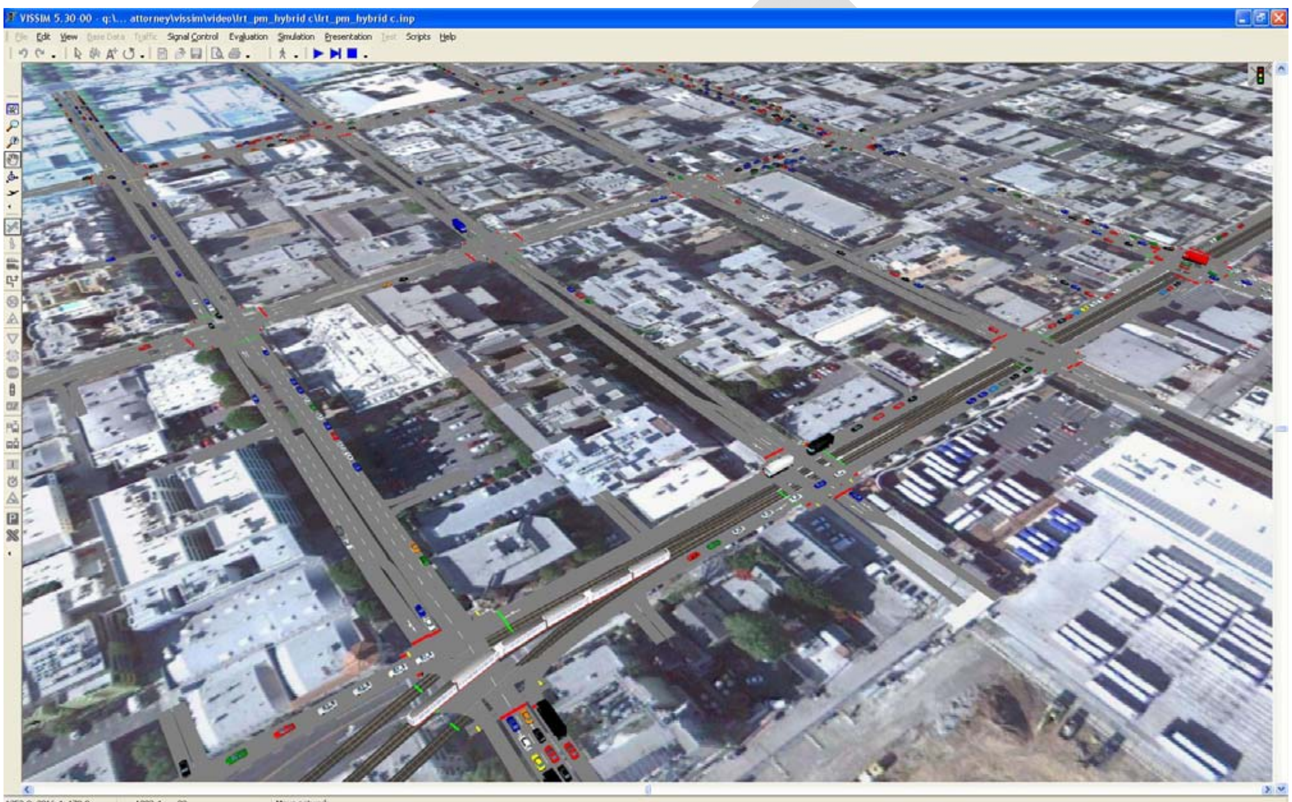
Before using microsimulation traffic models to evaluate the impact of potential projects and improvements on future scenarios, it is important to first develop a simulation network that accurately represents traffic operations under existing conditions. In order to achieve this, the existing conditions model must be calibrated and validated against data collected in the field. VISSIM has a set of user-adjustable parameters that allow for calibration of the model to better match specific local conditions. These parameter adjustments are necessary because no micro-simulation model can include all of the possible factors that might affect capacity and traffic operations including unique local driver behavior. The calibration process accounts for the impact of these “unmodeled” site-specific factors through the adjustment of the calibration parameters.

Therefore, model calibration involves the selection of a few parameters for calibration and the repeated operation of the model to identify the best values for those parameters.

The VISSIM model was developed using VISSIM build 5.30-00, and was calibrated for existing year conditions. The model includes roadway geometrics (including profile grades), traffic signal parameters, speed limits, bus routes, on-street parking, vehicle volume, pedestrian volume, and driver behavior characteristics.

Figure 1 presents a snapshot of the network in VISSIM. The existing network includes all the signalized intersections in the downtown Santa Monica. Links and connectors were coded to match the geometric design and configuration.

Figure 1: Santa Monica Downtown VISSIM network



Volumes: traffic and pedestrian volumes were provided by the City of Santa Monica. Bus route data was obtained from the Big Blue bus and Metro websites. Static vehicle routes were used within the model. The vehicle routing was based on the turning movement volumes and through traffic volumes.

Driver behavior: is associated to each roadway link by its behavior type. For the existing model, only one behavior type was used: Urban. Main operational calibration parameters for driving behavior in VISSIM are car following behavior, necessary lane changing behavior, and lane changing distances.

Car following behavior: For 'urban' link type, Wiedemann 74 model were used. There are three parameters in this model: average standstill distance, additive part of safety distance, and the multiplicative part of safety distance. The average standstill distance has been kept same as default. The other two parameters were changed to achieve desired safety distance.

Necessary Lane changing behavior: A necessary lane change is defined in VISSIM as lane change that is necessary for a vehicle to reach its final destination in the network. Driver aggressiveness is controlled by changing necessary lane change parameters. Change in this parameter is made to make drivers more aggressive than default. This reflects the driver characteristics observed in the field.

The objective of model calibration is to obtain the best match possible between model performance estimates and the field measurements of performance. However, there are diminishing returns where large investments in effort yield small improvements in accuracy at a certain point in the calibration process. The Federal Highway Administration (FHWA) has set calibration procedures and standards for highway microsimulation models. FHWA calibration targets were applied as follows:

<u>Hourly Flows, Model Versus Observed</u>

- Individual Link Flows
    - Within 100 vehicles/hour (v/h), for Flows < 700 v/h
    - Within 15%, for 700 v/h < Flow < 2,700 v/h
    - Within 400 v/h, for Flow > 2,700 v/h
- Sum of All Link Flows
    - Within 5% of the sum of all link counts
- GEH Statistic < 5 for Individual Link Flows > 85% of cases
- GEH Statistic for Sum of All Link Flows GEH < 4 for sum of all link

<u>Travel Times, Model Versus Observed</u>

- Travel Times, Network within 15%

<u>Visual Audits</u>

Bottlenecks

- Visually Acceptable Queues – To analyst's satisfaction

<u>VISSIM Model Run Procedure:</u> The model is set to run for 4,500 simulation seconds. This allows for a 15-minute "warm-up" period (0 to 900 seconds) where congestion can develop, and then a 60-minute period (900 to 4,500 seconds) when the analysis statistics are collected. The simulation resolution is set at 10 time steps per simulation second. In order to increase the confidence level of the data obtained from the simulation runs, a total of 20 simulation runs, each with a different random seed, were performed for PM peak hour, and the average of these runs was used in the calibration.

<u>Results:</u> **Table 1** summarizes the results for calibration criteria of traffic flow. **Table 1** shows that all calibration targets based on volumes were achieved.

Table 1: Existing Validation Results (Criteria - Volume)

Criteria – Volume	Targets (FHWA Criteria)	Results	
		AM Peak Hour	PM Peak Hour
Individual Vehicle Flows			
Within 100 veh/h, for flow < 700 veh/h	> 85% of cases	100%	100%
Within 15 % for 700 veh/h < flow < 2700 veh/h	> 85% of cases	100%	100%
Within 400 veh/h, for flow> 2700/h	> 85% of cases	-N.A.-	-N.A.-
Sum of all Links	Within 5%	1.1%	1.0%
GEH Statistic < 5 for Individual Link Flows	> 85% of cases	98%	98%
GEH Statistics for sum of all link flows	Less than 4	1.71	1.55

Travel time data was collected along seven travel paths, in both directions. Travel time corridors are shown in **Figure 2**. Travel time runs were conducted along the major study area corridors: Lincoln Avenue, 5th Street, 4th Street, Ocean Avenue, Broadway Street and Santa Monica Boulevard. In total, 14 travel time runs were compared.

Table 2 summarizes the results for calibration criteria of travel time. **Table 2** shows that 92% of the travel time corridors met the calibration criteria. 13 of the 14 travel time run matched FHWA calibration criteria in both am and pm peak hour.

Figure 2: Travel Time Corridors

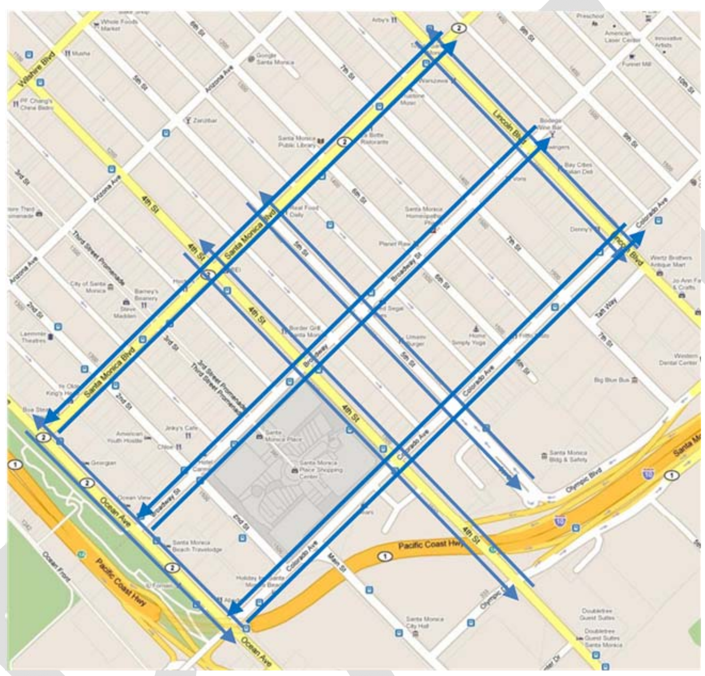


Table 2: Existing Validation Results (Criteria – Travel Time)

Criteria – Travel Time	**Targets (FHWA Criteria)**	**Results**	
		AM Peak Hour	**PM Peak Hour**
Within 15% (or 1 min, if higher)	>85% of cases	93%	93%

As shown in **Table 1** and **Table 2**, the existing conditions model is well calibrated. The model meets the targets set by FHWA both in terms of volume and travel time.

Alternative Analysis

The future VISSIM model was developed for year 2030 with the LRT Project. The input to the future condition VISSIM model included LRT alignment, LRT speeds, roadway geometry, traffic volume, pedestrian volume, signal timing plan, bus routes and on-street parking. Total of 10 different alternatives were analyzed including future no build. These alternatives varied in terms of LRT alignment near the station and lane closures in the study area.

Figure 3: Simulating Train Operations

Traffic operation analyses were conducted for the peak hours. Measures of effectiveness such level of service, intersection queue and travel time were obtained from VISSIM model output. These measures of effectiveness were used to compare alternatives and to analyze the impact of the LRT alignment on the traffic operations.

One of the major concerns of this study was intersection at the Colorado Avenue and 5th Street. The proposed Exposition LRT station will be coming on Colorado Avenue between 5th Street and 4th Street. Due to proximity to the station, when LRT will pass through this intersection, the LRT speed will be slower than at other intersection. There were concerns that due to LRT, there will be longer queues at the intersection of Colorado Avenue and 5th Street. The main traffic operation concern at this intersection was the northbound queues at this intersection and the potential spill back onto the I-10 Westbound off ramp.

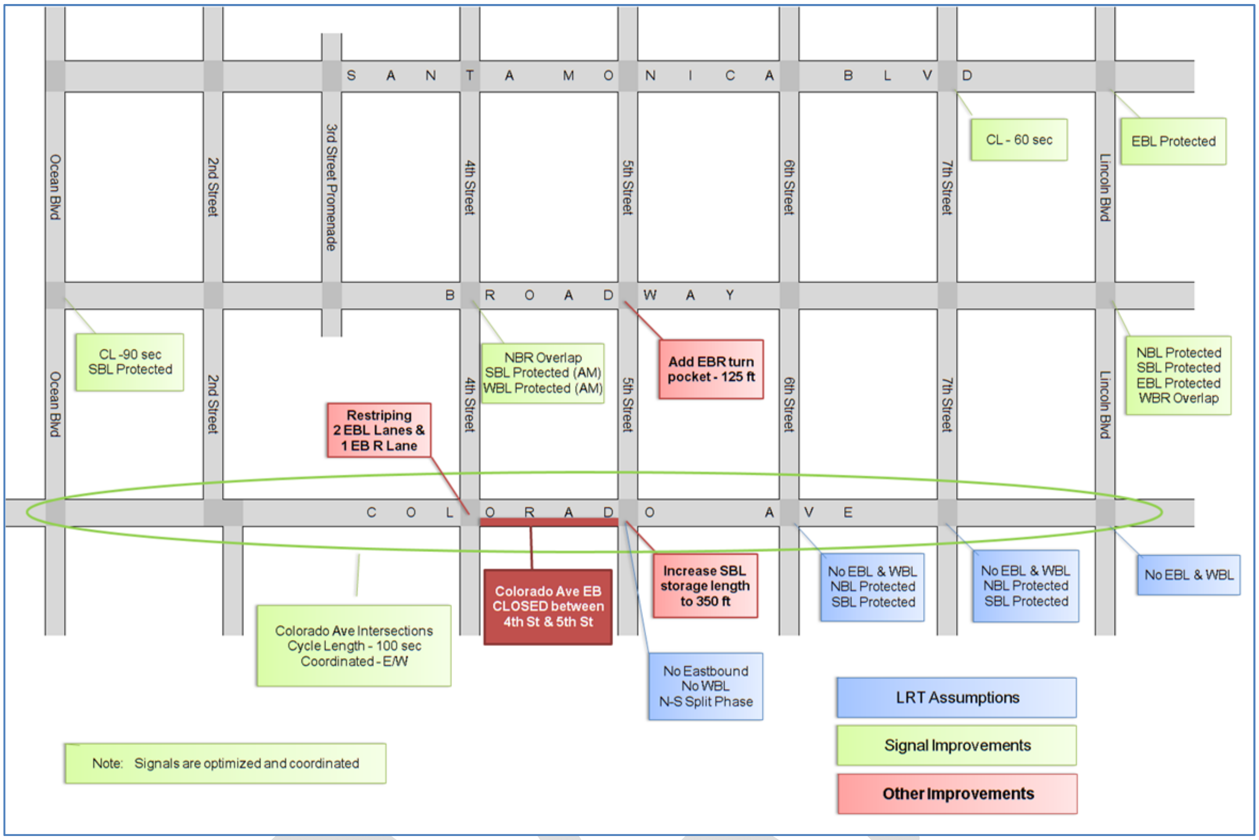
Detailed microsimulation analysis was conducted at the intersection of Colorado Avenue and 5th Street. Along with level of service analysis, detailed queue lengths were analyzed at the northbound direction. The maximum queue length for northbound approach was compared with available storage length.

Mitigation Analysis

Mitigation of project traffic impacts is designed to identify potential future level of service problems, as a result of the project, and to address them before they actually occur. Mitigation measures are developed to offset a project's significant impacts. City’s latest threshold of significance was utilized to determine project significant traffic impacts. **Figure 3** illustrates the range of mitigation measures that were recommended during the alternative analysis of the station alignments. The final mitigations were different from the recommended measures shown in Figure 3.

All mitigation recommendations were developed on a conceptual level, but the recommendations will be in sufficient details to determine their effectiveness and feasibility. Levels of service analyses were conducted for scenarios including these improvements to demonstrate that significant traffic impacts can be mitigated through the implementation of these measures.

Figure 3: Range of Mitigation Measures



Conclusions

The alternative analysis using VISSIM as a tool was extremely beneficial to the City and Expo Authority to discuss and recommend the final alignment alternative. The model calibration process, although very intensive was a key task to be accomplished due to the multimodal nature of the downtown area.

This was another example were extensive coordination proved to be useful in selecting the preferred alignment. In addition, modeling the LRT with automobile traffic proved to be especially challenging in a pedestrian dominated environment.

Author Information

Shaumik Pal is a Senior Transportation Planner at Iteris Inc. He has nine years of experience in the field of transportation planning and engineering. Mr. Pal has served as transportation planner/engineer for preparation of technical traffic analyses for various roadway improvement projects, corridor analyses and circulation studies. He has also served as the project manager for preparation of traffic impact studies for many capital improvement projects in an around Los Angeles, Riverside and San Bernardino County.

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Michael Meyer is a Principal at Iteris Inc. He has managed transportation planning and traffic engineering projects of increasing importance during his 35 years as a transportation consultant. His wide ranging client base includes both the public and private sector and he is frequently a member of multi-disciplinary teams developing integrated land use and transportation plans. .