APPENDIX B – SIMULATION MODEL TECHNICAL MEMO

Stantec

Memo

To:	Scott Thomson Jay Balaji	From:	Graham Winchester
	KYTC Division of Planning		Stantec
File:	US 127 Russell Springs Improvement Study	Date:	December 11, 2020

Reference: Existing Simulation Model Calibration Technical Memo

INTRODUCTION

As part of the US 127 Russell Springs Improvement Study, Stantec was tasked with analyzing existing and projected future peak hour traffic conditions. The study area, shown in **Figure 1**, includes US 127 between the Jamestown Bypass (US 127X) and Lakeway Drive (KY 80) in Russell Springs. Based on a survey of available traffic count data in the study area, the AM peak was determined to be 6:45 AM – 7:45 AM and the PM peak was determined to be 2:30 – 3:30 PM. In March 2020, COVID-19 caused the shutdown of businesses and schools across the state, including in Russell County. As a result, traffic patterns were significantly changed and collecting turning movement counts in the field was not a viable option. Instead, turning movement estimates were developed using available traffic data.

The existing conditions analysis revealed that much of the congestion during the peak hours is concentrated into peak 15-minute periods due to the morning start and afternoon dismissal of Russell County Middle School and Russell County High School. Although Stantec had a 2017 Synchro model covering the northern portion of the study area, it was decided that a more robust software was necessary. A traffic simulation model depicting existing peak hour conditions was instead developed using Caliper's TransModeler (version 5) simulation package. TransModeler allows for a more detailed analysis with multiple matrices of varying time domains within the peak hour, which was necessary to evaluate the short-term impacts related to buses and students traveling to and from the schools.

MODEL DEVELOPMENT

Once the network was created, the roadway names and classifications were added to the link layer based on KYTC's HIS data. Signal timing plans were then added to the six signalized intersections for the AM and PM peak periods. Turning movement files were created based on the turning movement estimates for the following intersections:

- US 127 at KY 80
- US 127 at Kroger/Steve Dr. Connector
- US 127 at KY 619
- US 127 at WB Cumberland Parkway ramps
- US 127 at EB Cumberland Parkway ramps
- US 127 at Voils Road
- US 127 at KY 430
- US 127 at KY 3280
- US 127 at Fruit of the Loom Drive
- US 127 at US 127X

Reference: US 127 Russell Springs Improvement Study

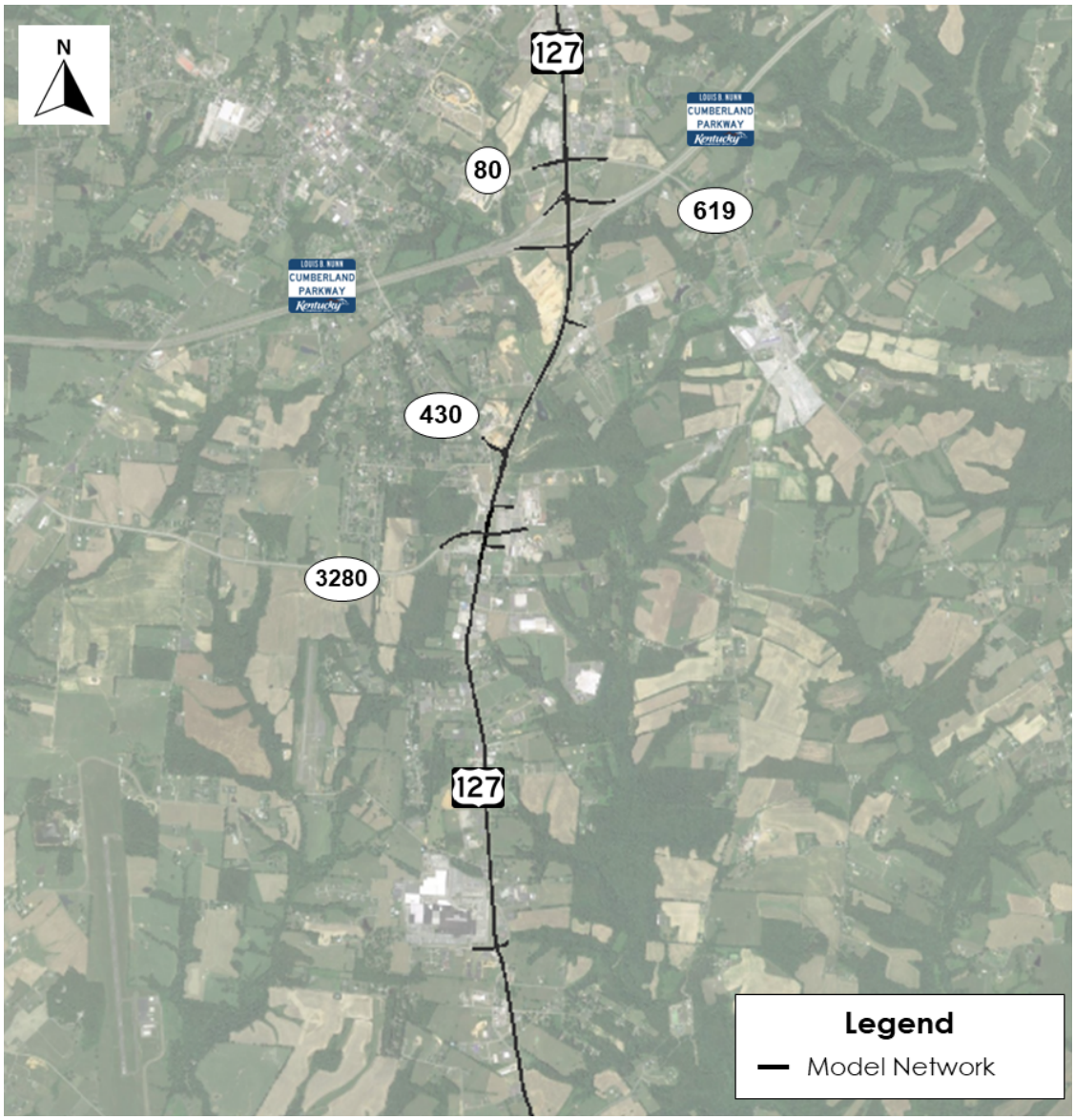

Figure 1: US 127 Study Area

Model Trip Tables

Trip tables for the AM and PM peak hours were developed using a 23 x 23 matrix with rows and columns representing each of the external nodes in the network. The turning movement estimates were used as inputs for TransModeler's origin-destination matrix estimation procedure to develop trip tables for the AM and PM peak hours. 2017 turning movement counts, which were collected in 15-minute intervals, were analyzed to develop the time distribution curve of traffic in the trip tables.

Table 1 and **Table 2** present the time distribution of traffic for the AM and PM peaks.

Reference: US 127 Russell Springs Improvement Study

Table 1: Time Distribution for AM Peak

Time	% of Total
6:45	23.3%
7:00	27.7%
7:15	26.6%
7:30	22.4%

Table 2: Time Distribution for PM Peak

Time	% of Total
2:30	24.3%
2:45	24.9%
3:00	27.2%
3:15	23.5%

School Traffic

To accurately reflect the morning drop-off and afternoon dismissal of the Russell County Schools, separate matrices were developed for school traffic. Both schools begin in the morning at 7:30 AM and release in the afternoon at 2:30 PM.

The matrix for the AM drop-off period, 7:10 AM – 7:25 AM, was developed using KYTC counts and Streetlight origin-destination data. The number of buses traveling to the schools in the morning was decided to be the same as the number of buses leaving the schools in the afternoon, as determined by drone footage of afternoon dismissal. Since buses arrive to the school in a similar manner as other vehicles, only one matrix was used for the AM drop-off period.

The matrices for the PM dismissal, 2:30 PM – 2:45 PM, were developed using KYTC counts, Streetlight data, and drone footage. Since the drone footage showed the buses exiting the school first, a separate matrix was developed for buses to release between 2:30 PM and 2:32 PM.

Additionally, TransModeler's 'Incident/Work Zone Tool' was used to create a school zone on US 127 near Russell County Middle and High Schools. Speeds were lowered to 25 miles per hour (MPH) during the 15-minute AM drop-off period and the 15-minute PM dismissal.

Vehicle Class Parameters

The model's vehicle fleet mix was updated to reflect the Kentucky distribution, which tend to have a higher percentage of pickups and SUVs. **Figure 2** presents a comparison of vehicle fleet mixes for the US 127 simulation model, Caliper (TransModeler) defaults, and Kentucky averages, as provided by KYTC. The vehicle fleet mix for this project is as follows:

- Car Low MPR (High performance passenger cars) – 5.0%
- Car Mid MPR (Middle performance passenger cars) – 19.0%
- Car High MPR (Low performance passenger cars) – 14.0%
- Pickup/SUV – 54.0%
- Multi-Unit Truck – 1%
- Single-Unit Truck – 3%
- Bus – 3.0%
- Motorcycle – 1.0%

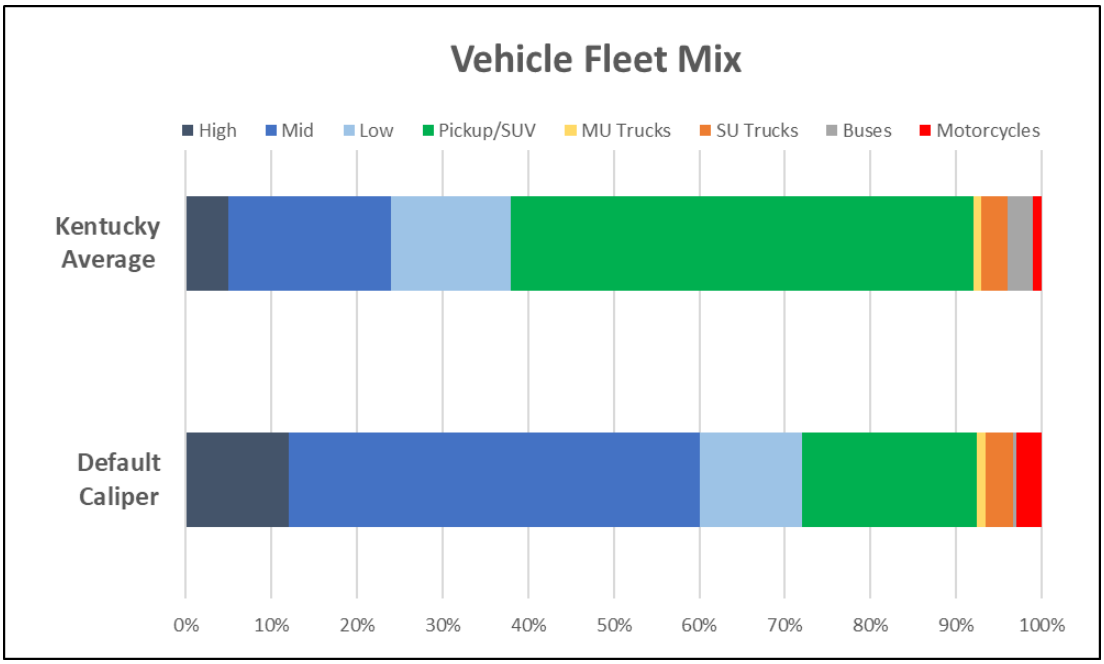

Figure 2: Lone Oak Road Vehicle Fleet Mix

Stopped Gaps

When a vehicle comes to a stop, the spacing between vehicles can have a significant impact on queue length and capacity. Stopped gaps in Kentucky average 9.47 feet in urban areas and 11.7 feet in rural areas. Caliper's default parameters do not differentiate between urban and rural areas, instead differentiating between stopping behind a non-heavy vehicle and stopping behind a heavy vehicle. The default Caliper values are shown in **Table 3** below. To better reflect conditions in an urban Kentucky study area, the mean stopped gap with a non-heavy vehicle in front was raised to 9.3 feet.

Table 3: Gaps Between Stopped Vehicles

Scenario	Default Mean (ft)	Updated Mean (ft)	St. Dev (ft)
Non-heavy vehicle in front	8.0	9.3	4.0
Heavy vehicle in front	12.0	12.0	4.0

Run Yellow Threshold

At signalized intersections, the run yellow threshold determines whether a vehicle will enter the intersection during a yellow traffic signal indication. If the expected travel time is less than the threshold, the vehicle will proceed through the intersection. Otherwise, it will decelerate and

stop at the stop bar. The Caliper default run yellow threshold is 1.5 seconds. This value was reduced to 1.0 seconds to better reflect driving behavior in Kentucky.

Calibration Statistics

The criteria used to confirm that the simulation model has been sufficiently calibrated were taken from the Federal Highway Administration's (FHWA) *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software, July 2004 (FHWA Publication No. FHWA-HRT-04-040)*. The specific criteria, which were originally developed by the Wisconsin Department of Transportation, are found in Table 4 on page 64 of that document. The criteria consist of three general metrics: 1) visual audits, 2) traffic flow, and 3) travel speeds. Traffic flow and travel speeds are quantifiable based on observed data and the model output while the guidance says that visual audits are to be conducted to the "analyst's satisfaction."

Visual audits were performed throughout the calibration process. At the beginning of the process, areas with congestion were specifically targeted to ensure that these areas reflected existing traffic conditions.

Intersections were checked to ensure that the turning movement and link-based counts were accurate. Once errors in data and the model geography were resolved, areas where the traffic was inconsistent with expected volumes were reexamined. In rare cases where necessary for low volume external nodes, minor adjustments were made to trip tables to reflect professional judgement of expected minimal traffic levels from those locations. An iterative process of incremental adjustments made in isolation was used to ensure the overall balance of the model was maintained.

To compare traffic flows, link-based trip volumes for the five runs were averaged and compiled for each direction of each link and compared to actual traffic counts on the segments. Several statistical measures were used to measure model assignment volumes to matched observed counts. The most important of these measures is percent root-mean-square error (RMSE) with a target threshold of 20 percent or lower to confirm the model was sufficiently calibrated for assigned volumes. **Table 4** presents the calibration statistics for both the AM and PM models.

Reference: US 127 Russell Springs Improvement Study

Table 4: Volume Calibration Statistics

Total Volume to Count:	AM Peak	PM Peak
Target: within 5% of count		
Sum of assignment	22,181	26,149
Sum of counts	21,759	25,636
Sum assign/counts (within 5%)	1.94%	2.00%
Links Assignments		
Link assignments within 100 vehicles of count	70	70
Target: within 85% of links	100%	100%
Percent Root Mean Square Error		
Target: < 20.00%	4.15%	9.26%

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