Stantec

DRAFT

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Reference: CVG Simulation Draft Calibration Memorandum

As a part of the CVG Circulation Study, Stantec developed a traffic simulation model depicting existing peak hour conditions using Caliper's TransModeler (version 5) simulation package. The study area, as shown in **Figure 1**, is bound by I-75 to the east, I-275 to the north, KY 237 (North Bend Rd.) to the west, and KY 18 (Burlington Pike) to the south. Based on an analysis of traffic count data in the study area, the aggregate AM peak was determined to be 7:15 – 8:15 AM and the PM peak was determined to be 4:30 – 5:30 PM.

Model Development

The Kentucky Statewide Model (KYSTM) was used as the initial source for the simulation model network and was converted into a simulation network through TransModeler. Aerial imagery and field notes were used to enhance and refine the network to include additional roadways and all appropriate roadway attributes such as turn lanes and median widths, and operational controls, such as traffic signals and speed limits. Roadway names and classifications were added to the link layer based on KYTC's HIS data. Signal timing plans provided by KYTC were programed for the 59 signalized intersections for the AM and PM peak periods. Turning movement files were created for AM Autos, PM Autos, AM Trucks, and PM Trucks. Turning movement counts were taken from the following sources:

- CVG Master Plan from 2017
- Cummins Consulting Services counts from 2017
- QK4 counts from 2016
- Abbie Jones counts from 2018

These turning movement counts were then aggregated by link to populate the following fields:

- AB_AM_TMC_Autos
- AB_AM_TMC_Trucks
- AB_PM_TMC_Autos
- AB_PM_TMC_Trucks
- BA_AM_TMC_Autos
- BA_AM_TMC_Trucks
- BA_PM_TMC_Autos
- BA_PM_TMC_Trucks

Directional traffic counts from existing KYTC count stations and the Eastern Bypass Study were used to populate links for the following fields:

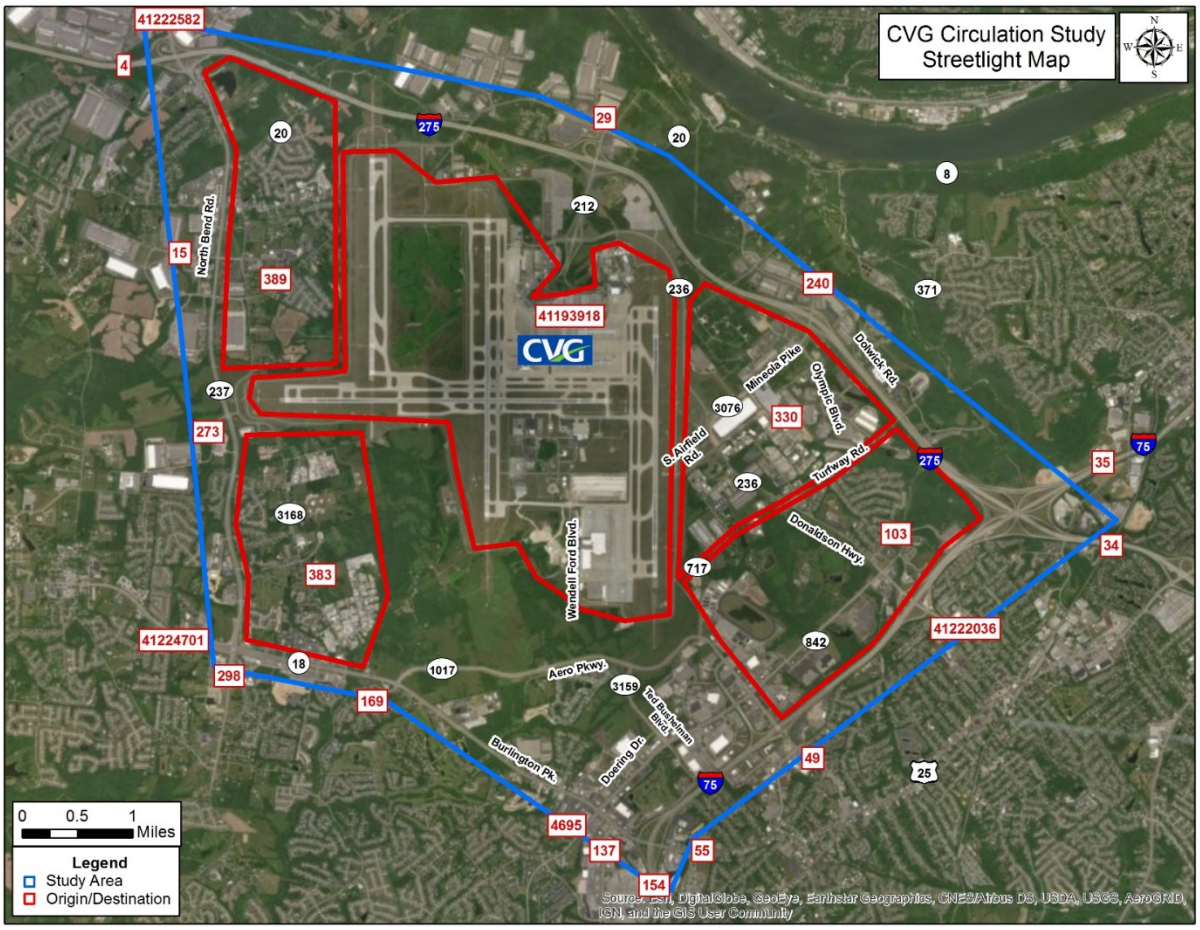
- AB_AM_LC_Autos
- AB_AM_LC_Trucks
- AB_PM_LC_Autos
- AB_PM_LC_Trucks
- BA_AM_LC_Autos
- BA_AM_LC_Trucks
- BA_PM_LC_Autos
- BA_PM_LC_Trucks

Figure 1. CVG Simulation Model Study Area

Origin-Destination Data

Individual auto and truck trip tables for the AM peak and PM peak hours were developed for a 204 x 204 matrix representing each of the external nodes in the network. Vehicle trip data from Streetlight Insight, a data vendor specializing in GPS navigation and Location-based services (LBS) (i.e. wi-fi) point data. Navigation GPS data was used for trucks while LBS data was used for autos. Streetlight data was collected for 17 origin/destination (OD) gateways and five larger area polygons around the airport. Data was collected from April to June 2017 for each Tuesday, Wednesday, and Thursday between 7:00 – 9:00 AM and 4:00 – 6:00 PM. The streetlight zones were matched with corresponding nodes from the simulation model, as shown in **Figure 2**.

Reference: **CVG Simulation Draft Calibration Memorandum**



The raw Streetlight data was processed through pivot tables to produce separate matrices of index values for autos and trucks. The Streetlight index values was entered into the 204 x 204 matrices, remaining empty cells, were filled values of “1” or “0”, depending on the reasonable likelihood of trips between minor external nodes such as driveways. TransModeler’s OD Matrix Estimation tool was used to process the network link counts and turning movement counts with the seed matrix to develop trip tables for AM Autos, AM Trucks, PM Autos, and PM Trucks.

To further improve the trip tables, the time distribution of traffic was updated to a curve with four 15-minute intervals. **Table 1** and **Table 2** present the time distribution of traffic for the AM and PM peaks.

Table 1: Time Distribution for AM Peak

Time	% of Total
7:15	25.0%
7:30	26.7%
7:45	26.2%
8:00	22.1%

Table 2: Time Distribution for PM Peak

Time	% of Total
4:30	24.7%
4:45	23.8%
5:00	25.7%
5:15	25.8%

Vehicle Class Parameters

The vehicle class parameters for the AM and PM autos matrices were updated to values similar to the overall fleet characteristic of urban and suburban Kentucky, as provided by KYTC. Trucks are not included in the vehicle fleet for autos given they are assigned through separate matrices. The vehicle fleet mix for autos is:

- Car Low MPR (High performance passenger cars) – 6.36%
- Car Mid MPR (Middle performance passenger cars) – 40.97%
- Car High MPR (Low performance passenger cars) – 8.46%
- Pickup/SUV – 41.26%
- Bus – 0.15%
- Motorcycle – 2.8%

The truck matrices were split into AM and PM medium sized single-unit (SU) trucks and AM and PM and heavy multi-unit trucks. Based on a survey of vehicle classification data in the study area, multi-unit trucks were found to be more prevalent on I-75 and I-275 than the rest of the study area. **Table 3** presents the percentages of total truck trips were used to create the truck matrices:

Table 3: Single- and Multi-Unit Truck Percentages

Truck Type	% Interstate through trips	% All other trips
Single-Unit	28%	62%
Multi-Unit	72%	38%

Calibration

The criteria used to confirm that the simulation model have been sufficiently calibrated were taken from the FHWA's *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 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 heavy 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. Common corrections included the proper placement of lane connectors and the correct assignment of signal timing plans phases to intersection approaches. Once errors in data and the model geography were satisfactorily resolved, areas where traffic was still inconsistent with expected volumes were reexamined. Where necessary, trip values in the trip tables were adjusted for external nodes for which no count data was available, according to professional judgement. 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% or lower to confirm the model was sufficiently calibrated for assigned volumes. Aggregate assignment-to-count ratios were also compared by volume group, according to the FHWA guidance targets.

To compare truck volumes, in the simulation model, TransModeler's vehicle-to-roadside communication (VRC) sensors were added to the network to collect truck volumes. Given the limited truck count locations, VRC's were placed only on the interstates and major arterials, with separate counts taken for each direction.

Table 4 presents the calibration statistics for both autos and trucks for both AM and PM models.

Table 4. Volume Calibration Statistics

Total Volume to Count:	AM Peak Hour		PM Peak Hour	
	All Traffic	Trucks	All Traffic	Trucks
Target: within 5% of count				
sum of assignment	327,416	4,198	332,426	3,602
sum of counts	322,327	3,831	343,650	3,546
Sum assign/counts (within 5%)	1.6%	9.6%	3.3%	1.6%
Links with <700 vehicle count	330		192	
Link assignments within 100 vehicles of count	282		165	
Target: within 85% of links	85%		86%	
Links between 700 and 2700 count	132		160	
Link assignment within 20% of count	119		128	
Target: within 85% of links	90%		80%	
Links >2700 vehicle count	19		17	
link assignments within 400 vehicles of count	18		15	
Target: within 85% of links	95%		88%	
Percent Root Mean Square Error	18.8%	19.2%	17.6%	23.2%
Target: <20 Acceptable; <15 Desirable				

Average vehicle speeds are reported for each network link segment for both the AB and BA directions. The model speeds were compared to actual recorded speeds in the study area. Locations with the highest speed differentials were looked at first. The first step in calibrating the speeds was to ensure that the default road classification speed limit and actual speed limit were the same. Several roadways had posted speed limits that did not match up with the default road classification speed limit, causing a large discrepancy between the model speed and actual speed. These speed limits were corrected. Other locations with high speed

differentials were corrected in the process above, adding or subtracting trips to the trip tables in an iterative manner. **Table 5** presents the comparison of speed. In both the AM and PM peak hours, 17 out of the 22 locations recorded were within ten percent of the observed speed.

Table 5. Model Speed Comparisons

Link	Direction	Name	AM Peak Hour				PM Peak Hour			
			Model Speed	Observed Speed	Delta	Delta Pct.	Model Speed	Observed Speed	Delta	Delta Pct.
202396	NE	I-75	62	54	8	15%	62	53	9	18%
202393	NE	I-75	63	60	3	4%	64	59	4	7%
411951933	N	I-75	62	63	0	0%	63	64	1	-1%
223984	SW	I-75	62	66	-4	-6%	61	60	0	1%
202417	SW	I-75	61	68	-6	-9%	61	66	5	-8%
202416	S	I-75	63	66	-3	-5%	62	64	2	-3%
202345	SE	I-275	64	66	-2	-4%	60	57	2	4%
202349	E	I-275	63	65	-2	-3%	63	63	0	0%
202352	E	I-275	64	64	0	0%	63	68	4	-7%
202330	W	I-275	57	63	-6	-9%	64	65	1	-2%
223914	NW	I-275	63	68	-4	-6%	62	66	4	-5%
202334	W	I-275	65	66	-1	-1%	64	67	2	-4%
411951881	W	I-275	63	67	-3	-5%	64	67	4	-6%
411948491	S	North Bend Rd	45	53	-8	-15%	29	44	15	-34%
411948491	N	North Bend Rd	32	48	-16	-33%	44	46	2	-4%
411944304	S	North Bend Rd	42	46	-4	-9%	47	39	8	21%
411944304	N	North Bend Rd	44	48	-4	-8%	22	35	13	-38%
411952004	SW	Houston Rd	41	34	7	19%	37	27	10	37%
411952070	W	Aero Pkwy	45	49	-4	-8%	44	44	0	-1%
411952070	E	Aero Pkwy	42	50	-8	-16%	40	43	3	-7%
411952141	S	Donaldson Hwy	49	47	2	5%	49	49	0	0%
411952141	NW	Donaldson Hwy	46	47	0	-1%	47	49	2	-4%