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MEMORANDUM

Date:	August 2, 2023	Project #: 263160.004
To:		
From:	Burak Cesme, Laura Zhao, Keir Opie, Ali Razmpa, and Akhilesh Shastri	
Project:	Envision Route 7 Phase IV Mobility Study	
Subject:	VISSIM Existing Conditions Modeling Calibration Memorandum	

INTRODUCTION

The development of the existing conditions model requires a proper calibration effort to closely replicate real-world conditions and accurately reflect field conditions. This technical memorandum describes the calibration efforts for the development of the VISSIM microsimulation model for the Northern Virginia Transit Commission (NVTC) Envision Route 7 Phase IV Mobility Study. The VISSIM calibration process follows the guidance from the Virginia Department of Transportation (VDOT) Traffic Operations and Safety Analysis Manual (TOSAM).[1]

DATA COLLECTION

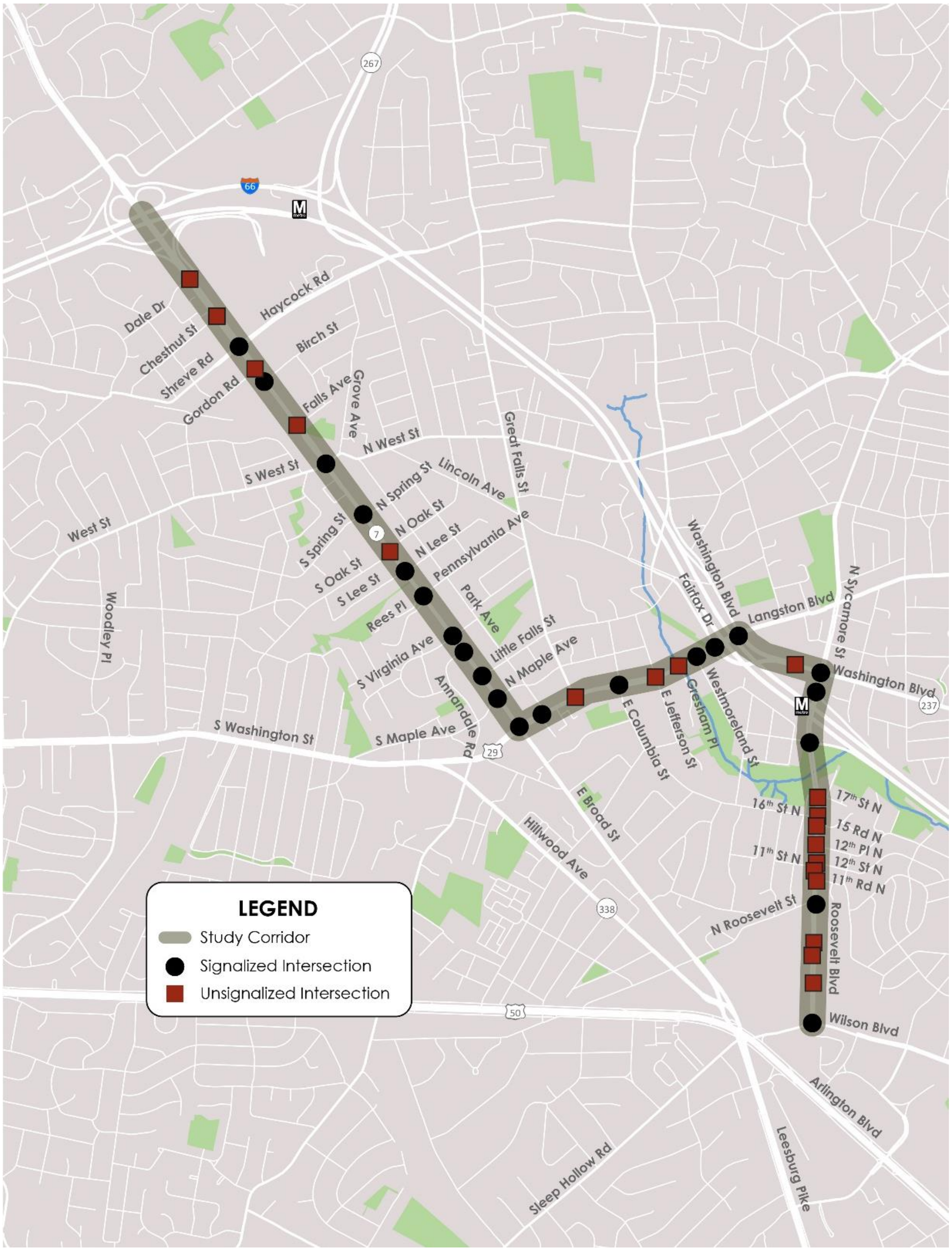
This section summarizes the data collection efforts for the VISSIM model development and model calibration for existing conditions. The study intersections are listed below and displayed in **Figure 1**.

- 1- Dale Drive/Leesburg Pike (VA 7) - unsignalized
- 2 - Chestnut Street/Leesburg Pike (VA 7) - unsignalized
- 3 - Haycock Road /Leesburg Pike (VA 7) - signalized
- 4 - Gordon Road/Leesburg Pike (VA 7) - unsignalized
- 5 - Birch Street /Broad Street (VA 7) - signalized
- 6 - Falls Avenue/Broad Street (VA 7) - unsignalized
- 7 - West Street/Broad Street (VA 7) - signalized
- 8 - Spring Street/Broad Street (VA 7)- signalized
- 9 - Oak Street/Broad Street (VA 7) - unsignalized

[1] http://www.virginiadot.org/business/resources/TOSAM.pdf

- 10 - Lee Street/Broad Street (VA 7) - signalized
- 11 - Rees Place/Pennsylvania Avenue/Broad Street (VA 7) - signalized
- 12 - Virginia Avenue/Broad Street (VA 7) - signalized
- 13 - Annandale Road/Broad Street (VA 7) - signalized
- 14 - Little Falls Street/Broad Street (VA 7) - signalized
- 15 - Maple Avenue/Broad Street (VA 7) - signalized
- 16 - Washington Street (US 29)/Broad Street (VA 7) - signalized
- 17 - Washington Street (US 29)/Park Avenue - signalized
- 18 - Washington Street (US 29)/Great Falls Street - unsignalized
- 19 - Washington Street (US 29)/Columbia Street - signalized
- 20 - Washington Street (US 29)/Jefferson Street - unsignalized
- 21 - Washington Street (US 29)/Gresham Place - unsignalized
- 22 - Langston Boulevard (US 29)/Westmoreland Street - signalized
- 23 - Langston Boulevard (US 29)/Fairfax Drive (VA 237) - signalized
- 24 - Langston Boulevard (US 29)/Washington Boulevard (VA 237) - signalized
- 25 - Washington Boulevard (VA 237)/EFC Metro Parking - unsignalized
- 26 - Washington Boulevard (VA 237)/Sycamore Street - signalized
- 27 - Sycamore Street/I-66 WB off-ramp/Bus Bay Entrance EFC Metro - signalized
- 28 - Sycamore Street/19th Street/I-66 on-ramp - signalized
- 29 - Sycamore Street/Roosevelt Street/17th Street - unsignalized
- 30 - Roosevelt Street/16th Street - unsignalized
- 31 - Roosevelt Street/15th Road - unsignalized
- 32 - Roosevelt Street/12th Place - unsignalized
- 33 - Roosevelt Street/12th Street - unsignalized
- 34 - Roosevelt Street/11th Street - unsignalized
- 35 - Roosevelt Street/ Roosevelt Boulevard - signalized
- 36 - Roosevelt Boulevard/Oakwood Apartments Access 1 - unsignalized
- 37 - Roosevelt Boulevard/Roosevelt Towers Access 1 - unsignalized
- 38 - Roosevelt Boulevard/Oakwood Apartments Access 2 - unsignalized
- 39 - Roosevelt Boulevard/Wilson Boulevard – signalized

Figure 1: Study Corridor and Intersections



Traffic Volume Data

The initial data collection plan for this project was to collect turning movement counts (TMCs) at the study intersections and tube counts at a few select locations in late 2021/early 2022. Following the COVID-19 shutdown and the resulting economic slowdown in the past two years, the team was concerned how and if travel demand would recover in the study corridor. To understand the recent travel demand and traffic patterns in the study area, the project team compared StreetLight[2] data in November 2019, November 2020, and September 2021. Table 1 shows the volume comparisons at three key study intersections.

The StreetLight analysis revealed that the traffic volumes were substantially lower in 2021 compared to 2019. Additionally, TMCs were collected at two select intersections (Broad Street at West Street and Broad Street at Washington Street intersections) in April 2022 and these counts, compared to the 2019 data, also indicated large reductions in intersection volumes. These two intersections were selected because they are critical signalized intersections along the corridor with heavy cross street traffic and included 2019 TMC data to allow for comparison. As a result, alternative approaches were developed to estimate intersection volumes for VISSIM model development.

Table 1 Vehicle Volume Comparison

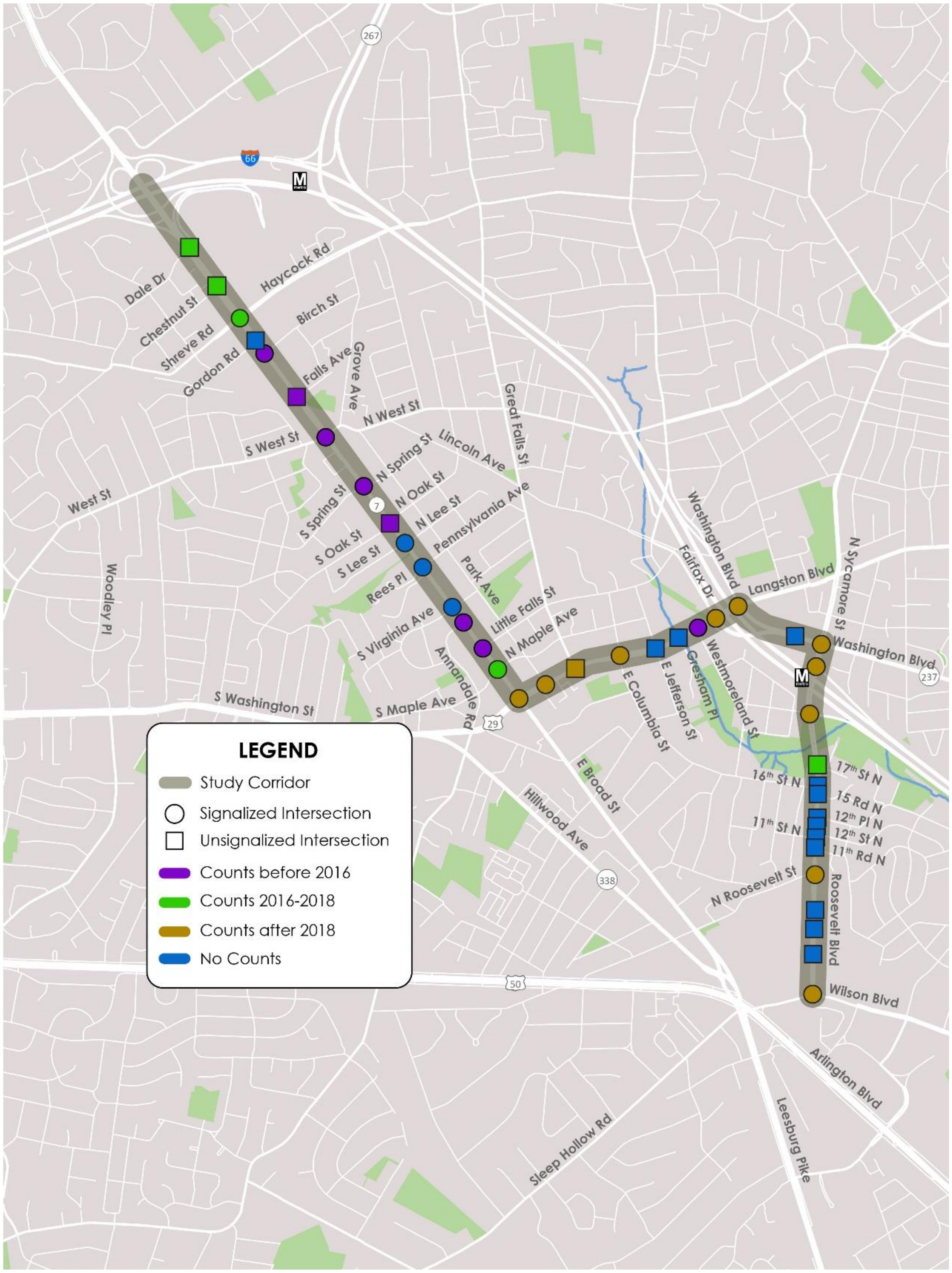
AM Peak (7 AM – 9 AM)			
Intersection	**StreetLight % Change in TEV (2021 vs. 2019)**	**StreetLight % Change in TEV (2020 vs. 2019)**	**Field Counts % Change in TEV (2022 vs. 2019/2013)**
Route 7 and Washington St	-24%	-34%	-22%[1]
Route 7 and Haycock Rd	-44%	-48%	N/A
Route 7 and West St	-43%	-45%	-39%[2]
PM Peak (4 PM – 6 PM)			
Intersection	**StreetLight % Change in TEV (2021 vs. 2019)**	**StreetLight % Change in TEV (2020 vs. 2019)**	**Field Counts % Change in TEV (2022 vs. 2019/2013)**
Route 7 and Washington St	-12%	-16%	-10%[1]
Route 7 and Haycock Rd	-6%	-21%	N/A
Route 7 and West St	-16%	-20%	-15%[2]

TEV: Total Entering Vehicles; N/A: Not Available.
1 Field count from 2019
2 Field count from 2013

For the intersection volume development, the project team coordinated with the City of Falls Church and Arlington County to obtain any recent peak hour TMCs at the study intersections. Counts from previous studies had been conducted between 2013 and 2019. **Figure 2** shows the traffic counts availability at study intersections as well as the dates the data were collected.

[2] StreetLight data uses anonymized location records from smart phones and navigation devices in connected cars and trucks to show travel patterns and order of magnitude travel demand.

Figure 2: Traffic Counts Availability at Study Intersections



Historic data was utilized to estimate intersection volumes at the study intersections. Given the effect of the pandemic, the project team assumed 2019 as the "existing" conditions (i.e., existing base year conditions). As can be observed, TMCs are available at most of the signalized intersections in the study area. Note that historic TMCs were from 6 AM to 9 AM for the AM peak period and from 3 PM to 7 PM for the PM peak period. Using the peak period TMCs, peak hours were then selected for the study area, which indicated 7:30 AM to 8:30 AM for the AM peak and 4:30 PM to 5:30 PM for the PM peak. Counts at intersections along Route 7 were mostly collected between 2016 and 2018 with some counts from 2013. Available counts at intersections along Washington Street and Roosevelt Street are relatively more recent and were collected in 2018 and 2019.

For the volume development, 2018 and 2019 TMCs were used as the basis since data was recently collected and could accurately capture 2019 conditions. For intersections in which data was collected in 2013 and that are adjacent to the 2018/2019 intersections without major intersection or major driveway in between, the volumes were adjusted to match the 2018 and 2019 volumes through volume balancing. For volume balancing, the 2018/2019 volumes were held steady and adjacent intersection volumes with 2013 data were adjusted proportionally based on their original (i.e., 2013) volumes. For intersections that do not have any volume data (typically unsignalized intersections), link volumes were first developed based on the input and output volumes. Then, the link volumes were supplemented by the Streetlight data from 2019 before the pandemic to obtain turn proportions and estimate turning movement volumes. Finally, volume balancing was performed throughout the network.

Travel Time Data

In addition to traffic volumes, travel time data on critical segments within the study area were needed for VISSIM calibration. Similar to the volume data, the initial plan for the speed data collection was to use the floating car technique and supplement that with the travel time data extracted from the Regional Integrated Transportation Information System (RITIS) platform. However, due to the COVID-19 impacts on traffic, travel time was collected on select segments only using the INRIX XD[3] probe data from the RITIS platform.

The travel time data was collected for the mid-week weekday AM peak period (6-9 AM) and PM peak period (4-7 PM) for the month of October 2019 on each detailed link in the XD data. The travel time data on these selected segments were then analyzed to obtain AM and PM peak hour travel times to compare against simulated travel time (see below for the comparison results). For each segment, the total travel time on each weekday peak periods were averaged to represent the typical condition segment travel time. Travel time segments in the VISSIM network were adjusted accordingly to match the INRIX segments for calibration purposes.

[3] INRIX probe data was generated using Global Positioning System (GPS) trajectory data collected from a wide array of commercial vehicle fleets, connected cars, and mobile applications. INRIX provides speed and travel time data at different levels of granularity. INRIX XD data is the type with high granularity. INRIX XD data segments can quickly capture changes in traffic conditions compared to traditional INRIX Traffic Message Channel (TMC) data. At the same time, the XD data may produce a high data volume that require additional storage and higher processing time and power.

Bus Speed Data

While bus speed is not a calibration metric required by TOSAM, it is critical to obtain reasonable bus speeds from the simulation model that can reasonably reflect existing operations. This will allow for conducting a more fair assessment of the BRT operations in the future condition models. Therefore, the project team decided to also include bus speed as part of the calibration process.

Bus speed data was obtained from Washington Metropolitan Area Transit Authority (WMATA) using their *Ridecheck Plus* data for weekdays in October 2019. *RideCheck Plus* provides automated reporting of ridership and location for bus operations and management. This data provides bus running times (i.e., travel times) by timepoint pairs identified by WMATA where each timepoint typically includes several bus stops and intersections.

VISSIM CALIBRATION TARGETS

Table 2 summarizes the project's calibration targets for the quantitative measures as documented in TOSAM. The simulated traffic volume measure compares the traffic volumes at critical links and/or turning movement to the field counts and the developed traffic volumes. The simulated travel time measure compares simulated vehicle travel times to INRIX probe data along specified routes. The simulated queue length measure was not included in this project since it was not possible to collect field queue data due to the COVID-19 impacts. Lastly, as previously discussed, TOSAM does not provide any guidance on bus speed calibration targets. The project team assumed that simulated bus speeds should be within ±5 mph of the observed bus speeds for the calibration target. The threshold of 5 mph was selected based on engineering judgment since TOSAM does not include any threshold for bus speed calibration.

Table 2 Simulated Measures and Calibration Targets per TOSAM

Simulated Measure	Calibration Threshold/Target
Simulated Traffic Volume (vehicles per hour) 85% of the network links and/or turning movement, and a select number of critical links and/or turning movements, as determined by the DTE or his/her designee, shall meet the calibration thresholds.	Within ± 20% for <100 vph Within ± 15% for ≥100 vph to <1000 vph Within ± 10% for ≥1000 vph to <5,000 vph Within ± 500 vph for ≥5,000 vph
Simulated Travel Time (seconds) 85% of the travel time routes and segments, or a select number of critical routes and segments, as determined by the DTE or his/her designee, shall meet the calibration thresholds. Travel time routes should be determined in cooperation with the VDOT project manager based on project needs and goals.	Within ± 30% for average observed travel times on arterials
Simulated Queue Length (feet) A select number of critical locations and/or movements, as determined by the DTE or his/her designee, shall meet the calibration thresholds.	Visually acceptable maximum queue lengths are represented at critical locations

Simulated Bus Speed (mph)[1] A select number of bus routes shall meet the calibration threshold.	Within ±5 mph for average bus speed

[1] Bus speed calibration target is set based on engineering judgment.

CALIBRATION METHODOLOGY

Simulation Run Time

A warm-up period of thirty minutes (1800 seconds) was applied prior to the analysis period to allow for the model to populate with a sufficient number of vehicles to better represent field conditions. The thirty-minute warm-up period was selected to ensure that all vehicles will be able to enter and exit the network when traveling from one end to another during the warm-up duration. The MOEs were not collected during the warm-up period.

The simulation run time was conducted for a one-hour peak period during the AM and PM periods, in addition to the thirty-minute warm-up time:

- AM Peak Hour
  - 7:00 – 7:30 AM – Warm-up
  - 7:30 – 8:30 AM – Evaluation Period
- PM Peak Period
  - 4:00 – 4:30 PM – Warm-up
  - 4:30 – 5:30 PM – Evaluation Period

The simulation run time used in the existing conditions models will remain the same in the future condition models. In addition, a simulation resolution of ten is used in the existing condition models and the same value will be used in future analyses.

Sample Size Determination

The simulation model should run multiple times with different random seeds to capture the impact of the stochastic nature of the model on the results and to obtain statistically reliable model outputs. Determining and applying the appropriate number of simulation runs is crucial in developing accurate results. Federal Highway Administration (FHWA) developed a statistical process to guide the selection of the appropriate number of simulation runs. To assist the application of the FHWA approach, the *VDOT Sample Size Determination Tool* is used as suggested in TOSAM to determine the required number of simulation runs in this study.

An initial ten simulation runs were performed with different random seed numbers. After the first ten runs, the selected measure of effectiveness (MOEs) of each run were entered into the calculation engine. Speed was used as the MOE to determine the necessary number of simulation runs. The adequacy of the number of runs was assessed by the tool for AM and PM peak periods as shown in **Figure 3** and **Figure 4**.

Based on the outputs of the sample size determination tool, it requires ten simulation runs for both AM and PM periods, respectively. The same number of simulation runs will be used in future condition models.

Figure 3 Sample Size Calculation for AM Peak Hour

Virginia Department of Transportation

Sample Size Determination Tool, Version 2.0

User Inputs	(pink)
Constants	(green)
Outputs	(blue)

Sample Size (N) = Number of Model Runs
Sample Mean (X_s) = $(1/N)(X_1 + X_2 + X_3 \ldots + X_N)$
Sample Standard Deviation (S_s) = $\sqrt{[(\Sigma(X-X_s)^2)/(N-1)]}$
Sampling Error = $Z(S_s/\sqrt{N})$
Confidence Level = $X_s \pm Z(S_s/\sqrt{N})$
% of Sample Mean (E) = % Tolerance * X_s
Sample Size Needed = $[(Z)^2 * (S_s)^2] / (E)^2$

Model Iterations

Measure of Effectiveness (MOE):	Speed
Confidence Interval:	95%
Tolerance Error:	10%
Number of Model Runs:	10

Run Number	***Speed***
1	14.41048
2	15.05845
3	14.56332
4	14.00284
5	14.41641
6	14.33568
7	14.63566
8	13.95435
9	14.48519
10	13.70557

Sample Size Outputs

N	=	10.0
X_s	=	14.4
S_s	=	0.4
E	=	1.4
Z	=	1.96

Sampling Error	=	0.24		
95% Confidence Interval	=	14.1	to	14.6
Percentage of Mean	=	1.67%		**Good**
Sample Size Needed	=	**10**		

Z is the number of standard deviations away from the mean corresponding to the required confidence level in a normal distribution.

Figure 4: Sample Size Calculation for the PM Peak Hour

VDOT Virginia Department of Transportation

Sample Size Determination Tool, Version 2.0

User Inputs
Constants
Outputs

Sample Size (N) = Number of Model Runs
Sample Mean $(X_s) = (1/N)\,(X_1 + X_2 + X_3 \ldots + X_N)$
Sample Standard Deviation $(S_s) = \sqrt{[(\Sigma(X - X_s)^2)/(N-1)]}$
Sampling Error = $Z\,(S_s/\sqrt{N})$
Confidence Level = $X_s \pm Z\,(S_s/\sqrt{N})$
% of Sample Mean (E) = % Tolerance * X_s
Sample Size Needed = $[(Z)^2 * (S_s)^2] / (E)^2$

Model Iterations

Measure of Effectiveness (MOE):	Speed
Confidence Interval:	95%
Tolerance Error:	10%
Number of Model Runs:	10

Run Number	*Speed*
1	14.49
2	15.23
3	15.33
4	15.39
5	15.43
6	15.55
7	15.31
8	15.15
9	14.62
10	14.76

Sample Size Outputs

N	=	10.0
X_s	=	15.1
S_s	=	0.4
E	=	1.5
Z	=	1.96

Sampling Error	=	0.23		
95% Confidence Interval	=	14.9	to	15.4
Percentage of Mean	=	1.51%		Good
Sample Size Needed	=	10		

Z is the number of standard deviations away from the mean corresponding to the required confidence level in a normal distribution.

CALIBRATION RESULTS

This section provides a summary of the VISSIM calibration results for the existing condition models.

Simulated Traffic Volumes

Simulated traffic volume is one of the model calibration thresholds identified in the TOSAM. Typically, areas in the network that carry the highest traffic volumes, such as freeway and arterial mainlines, are the primary focus of interest for calibration. Following the guidance provided in TOSAM, simulated volumes at study intersections were extracted from the models and compared to the developed traffic volumes. **Table 3** provides a summary of the number of movements that met the calibration threshold identified in TOSAM. The full comparison of simulated volume versus developed volume along with the percent difference is included in **Appendix A**.

Table 3 Peak Hour Simulated Traffic Volume Calibration Results

Peak Hour	Number of Movements Meeting Threshold	Total Number of Movements	% Meeting Threshold	TOSAM Required % Meeting Threshold	Threshold Met?
AM Peak Hour	324	338	95.9%	85.0%	**Yes**
PM Peak Hour	278	296	93.9%	85.0%	**Yes**

Results indicate that for all the volume groups analyzed, at least 85 percent of the movements meet the volume calibration thresholds identified in TOSAM.

Simulated Travel Time

In addition to the simulated traffic volumes, simulation travel times for selected critical segments were compared to INRIX travel times along with the calibration thresholds that need to be met. **Table 4** and **Table 5** provide a comparison of the simulated travel time and INRIX time during AM and PM peak periods.

Table 4 AM Peak Hour Simulated Travel Time and INRIX Travel Time Comparison for Model Calibration

AM Peak Hour					
Segment	**VISSIM Travel Time (sec)**	**INRIX Travel Time (sec)**	**% Difference**	**Calibration Threshold**	**Threshold Met?**
EB Leesburg Pike/Broad Street (VA 7): Dale Drive – West Street	137.4	130.5	5%	Within ±30%	**Yes**
WB Leesburg Pike/Broad Street (VA 7): West Street – Dale Drive	157.6	137.6	15%	Within ±30%	**Yes**
EB Broad Street (VA 7): **West Street – Washington Street**	212.0	178.2	19%	Within ±30%	**Yes**
WB Broad Street (VA 7): **Washington Street – West Street**	217.4	206.6	5%	Within ±30%	**Yes**
EB Washington Street (US 29): **Broad Street – Washington Boulevard**	127.2	175.8	-28%	Within ±30%	**Yes**
WB Washington Street (US 29): **Washington Boulevard – Broad Street**	158.4	136.4	16%	Within ±30%	**Yes**
EB Washington Boulevard (US 237): **Langston Boulevard – Sycamore Street**	68.4	54.0	27%	Within ±30%	**Yes**
WB Washington Boulevard (US 237): **Sycamore Street – Langston Boulevard**	102.7	125.2	-18%	Within ±30%	**Yes**
EB **Sycamore Street**/Roosevelt Boulevard: Washington Boulevard **– Wilson** Boulevard	195.4	180.2	8%	Within ±30%	**Yes**
WB **Sycamore Street**/Roosevelt Boulevard: **Wilson** Boulevard – Washington Boulevard	202.1	196.2	3%	Within ±30%	**Yes**

Table 5 PM Peak Hour Simulated Travel Time and INRIX Travel Time Comparison for Model Calibration

PM Peak Hour					
Segment	VISSIM Travel Time (sec)	INRIX Travel Time (sec)	% Difference	Calibration Threshold	Threshold Met?
EB Leesburg Pike/Broad Street (VA 7): Dale Drive – West Street	173.3	206.3	-16%	Within ±30%	**Yes**
WB Leesburg Pike/Broad Street (VA 7): West Street – Dale Drive	175.7	233.0	26%	Within ±30%	**Yes**
EB Broad Street (VA 7): **West Street – Washington Street**	196.3	149.6	-16%	Within ±30%	**Yes**
WB Broad Street (VA 7): **Washington Street – West Street**	185.9	83.5	1%	Within ±30%	**Yes**
EB Washington Street (US 29): **Broad Street – Washington Boulevard**	134.7	224.5	-10%	Within ±30%	**Yes**
WB Washington Street (US 29): **Washington Boulevard – Broad Street**	152.4	139.5	-18%	Within ±30%	**Yes**
EB Washington Boulevard (US 237): **Langston Boulevard – Sycamore Street**	76.8	184.7	-8%	Within ±30%	**Yes**
WB Washington Boulevard (US 237): **Sycamore Street – Langston Boulevard**	74.1	186.7	-2%	Within ±30%	**Yes**
EB **Sycamore Street**/Roosevelt Boulevard: Washington Boulevard **– Wilson** Boulevard	241.4	75.6	8%	Within ±30%	**Yes**
WB **Sycamore Street**/Roosevelt Boulevard: **Wilson** Boulevard **–** Washington Boulevard	214.3	184.1	16%	Within ±30%	**Yes**

Results show that the simulated travel times for all segments are within the 30% range of observed average travel times during the AM and PM peak hours, meeting the calibration target. Therefore, the travel time calibration is deemed acceptable.

Simulated Bus Speeds

Although TOSAM does not require calibration of bus speeds, the project team compared the simulated bus speed to the speed data obtained from WMATA to reasonably simulate bus operations. Simulated travel speeds for Route 28A within the study area were compared to field bus speeds. Instead of comparing travel times, speed data was used since the bus speed timepoint pairs obtained from WMATA do not exactly match with the simulation boundaries, which prevents conducting a fair comparison of travel times. **Table 6** and **Table 7** provide a comparison of the simulated bus speeds and field speeds along with the calibration thresholds that need to be met.

Table 6 AM Peak Hour Simulated Transit Speed and AVL Travel Speed Comparison for Model Calibration

Route	Direction	From	To	VISSIM Speed (mph)	AVL Speed (mph)	Difference	Calibration Threshold	Threshold Met?
28A	EB	West Fall Church STA	Broad St. & Washington St.	11.6	11.8	0.2	Within ±5 mph	**Yes**
28A	WB	Broad St. & Washington St.	West Fall Church STA	10.0	13.8	3.8	Within ±5 mph	**Yes**

Table 7 PM Peak Hour Simulated Transit Speed and AVL Travel Speed Comparison for Model Calibration

Route	Direction	From	To	VISSIM Speed (mph)	AVL Speed (mph)	Difference	Calibration Threshold	Threshold Met?
28A	EB	West Fall Church STA	Broad St. & Washington St.	10.3	7.9	2.4	Within ±5 mph	**Yes**
28A	WB	Broad St. & Washington St.	West Fall Church STA	9.9	14.4	-4.5	Within ±5 mph	**Yes**

Results show that the simulated bus speeds for the selected segments are within the ±5 mph range of observed bus speeds during AM and PM peak hours, meeting the calibration target. Therefore, the simulated travel speed calibration is deemed acceptable.

CONCLUSIONS

This technical memorandum describes the calibration efforts followed for the development of VISSIM microsimulation model for the Envision Route 7 Phase IV Mobility Study. Based on the quantitative comparisons of simulated traffic volumes, vehicle travel times, and bus speeds, it is concluded that the existing conditions calibration results meet the calibration targets presented in **Table 2**. The adjustments made in the existing conditions AM and PM VISSIM models for calibration (e.g., changes in driving behavior, lane changing, and gap acceptance) will also be carried over to future condition models.

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APPENDIX A: SIMULATED TRAFFIC VOLUMES COMPARISON