STARS Route 7 Corridor Improvement Study Draft Traffic Operations Analysis Framework Document

1. Introduction

Route 7 (Harry Byrd Highway) is a busy commuter route with operational and safety issues due to heavy traffic volumes during the peak periods and grades. The study corridor is defined as Route 7 between Route 9 (Charles Town Pike) interchange in Loudoun County and Route 267 (Dulles Greenway) in the Town of Leesburg as shown in **Figure 1**. There were 395 crashes in the corridor during the five years between 2010 and 2014. The goals of the STARS (Strategically Targeted and Affordable Roadway Solutions) Program are to develop comprehensive, innovative transportation improvements to relieve congestion bottlenecks and create projects that improve critical traffic and safety challenges that can be programmed in the VDOT Six-Year Improvement Program. The study corridor is divided into three sub-study areas - western, middle, and eastern areas.

The western area of the project (Sub-Study Area 1) ranges from Route 9 to Roxbury Hall Road near Market Street (Route 7 Business). The morning peak hour traffic volumes on Charles Town Pike from the north through the two existing roundabouts creates operational challenges at the Route 9/Route 7 interchange, especially in the southbound to eastbound direction. Eastbound AM traffic volumes on Route 7, in addition to steep grades on eastbound Route 7, causes safety and operational issues, with traffic from Route 7 queuing into the southernmost roundabout on Route 9.

The middle section (Sub-Study Area 2) at the Market Street interchange has operational and safety issues, especially in the morning peak hour with the acceleration lane onto Route 7. The cloverleaf ramp incorporates a short acceleration lane, which causes queues on eastbound Route 7.

The eastern section (Sub-Study Area 3) consists of the King Street and Dulles Greenway interchanges. The northbound ramp from Dulles Greenway onto westbound Route 7 includes a weaving area that creates operational and safety issues. The operational challenge in the westbound direction results in vehicle queuing onto the Dulles Greenway during the afternoon peak period.

The purpose of this project is to identify short-term and mid-term projects for improvements for safety and operations in the study area. This framework document outlines the scope of work and associated assumptions for the traffic modeling and operational analysis associated with the development of VISSIM and Synchro models that will be used for traffic analysis on this study. The traffic simulation model will be developed and calibrated to represent existing conditions and to satisfy the model calibration measures and targets in the VDOT *Traffic Operations and Safety Analysis Manual (TOSAM)*. The VISSIM traffic simulation model will be used to analyze improvements recommended by the Study Work Group (SWG).

This framework document defines modeling methodology and assumptions required to balance peak period traffic volumes; create the origin-destination (O-D) trip table for sub-study areas; conduct future traffic forecasts; and develop and calibrate an existing VISSIM traffic simulation model for the defined sub-study areas.

Other traffic analysis software will be used in this study and their specific application will be described. This document also introduces the methodology for future traffic volume forecasts in the study area. Traffic and safety analysis measures of effectiveness (MOEs) are documented herein.

1.1. Study Area Limits

The project study area and three sub-study areas are shown in **Figure 2**. The project study area encompasses a 5-mile section of Route 7 (Harry Byrd Highway) between Route 9 (Charles Town Pike) and Route 267 (Dulles Greenway). The following 4 interchanges and 4 ramps on Route 7 are included in the study area:

- Route 9 – southbound Route 9 to eastbound Route 7 ramp
- West Market Street – eastbound Route 7 to eastbound West Market Street ramp and westbound West Market Street to eastbound Route 7 ramp
- South King Street / US 15 – westbound Route 7 to northbound South King Street ramp
- Route 267 (Dulles Greenway) – northbound Route 267 to westbound Route 7 ramp

The study area also includes the following 10 adjacent intersections:

1. Route 9 at Route 662 (Clarkes Gap Road)
2. Route 9 at westbound Route 7 ramps
3. Route 9 at eastbound Route 7 ramps/Route 7 Business (East Colonial Highway)
4. Route 7 Business at Catoctin Circle/Fairview Street
5. US 15 Business (South King Street) at Davis Avenue
6. US 15 (South King Street) at westbound Route 7 ramps
7. US 15 (South King Street) at eastbound Route 7 ramps
8. US 15 (South King Street) at Evergreen Mills Road/Governors Drive
9. Route 7 crossover at White Gate Place
10. Route 7 crossover at Leeland Orchard Road/Roxbury Road

As previously mentioned, to meet the project goals for analyzing safety and operational issues with the most appropriate traffic and safety analysis tools, the study area was divided to three sub-study areas, as illustrated in **Figure 2**, for traffic simulation modeling in VISSIM and operational analysis in Synchro and HCS. No overflow conditions between sub-study areas exist so the three areas can be independently analyzed.

- Sub-Study Area 1: the western area between Route 9 and White Gate Place will be analyzed using VISSIM.
- Sub-Study Area 2: the middle area at the Market Street/Route 7 interchange area will be analyzed using Synchro (for intersections on Market Street) and HCS (for limited access movements on Route 7).
- Sub-Study Area 3: the eastern area between US 15 and Route 267 will be analyzed using VISSIM.

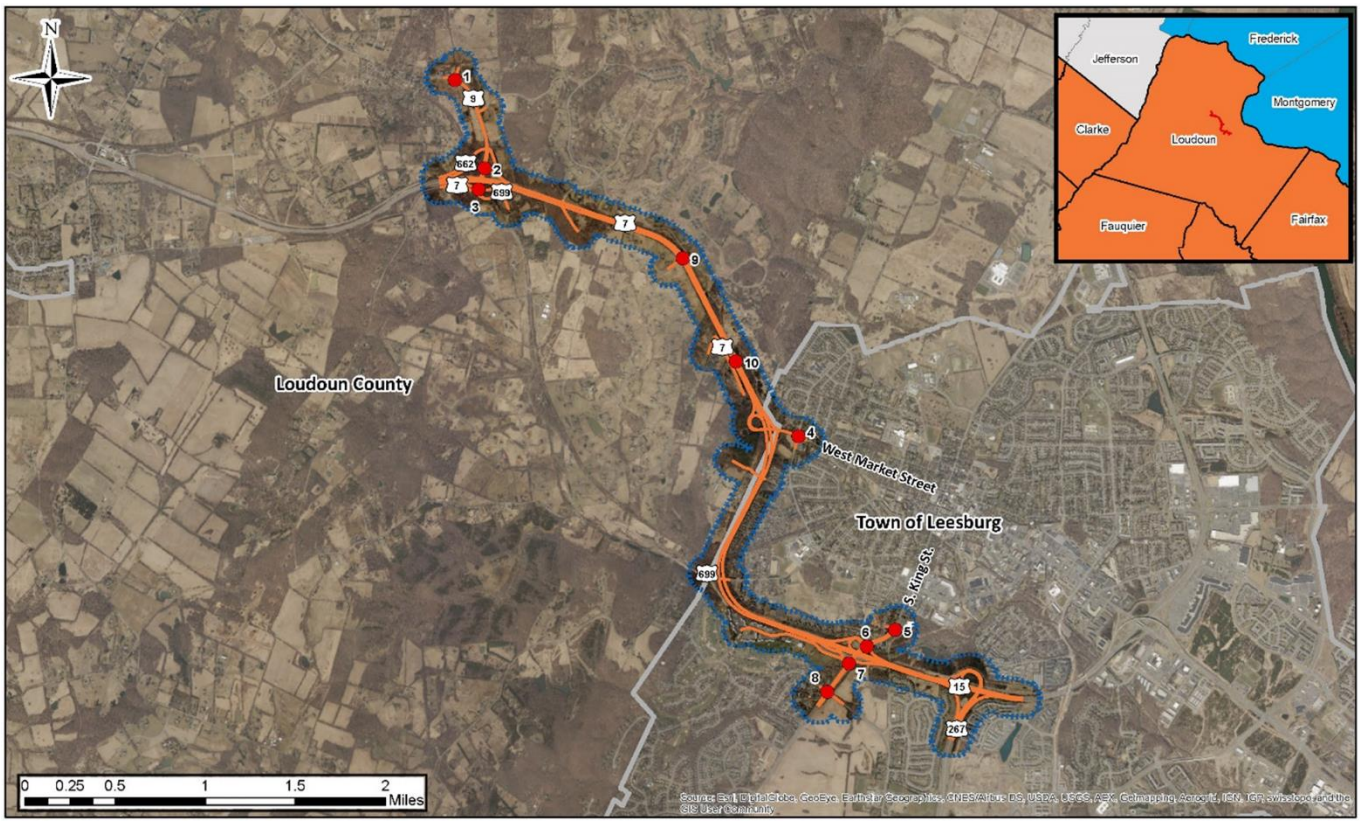
1.2. Purpose and Need of the Study

The determination of the purpose and need for the study is critical to the success of the project, since it sets the stage for the selection of measures of effectiveness, which in turn, drives the selection of the most appropriate traffic and safety analysis tools for the study. Macroscopically, the purpose and need of this study is to improve safety and reduce congestion within the study area. In more detail, the purpose and need of this study is fourfold:

- reduce congestion on eastbound Route 7 to the east of the Route 9 (Charles Town Pike) interchange specifically in the morning peak hour

- improve safety and traffic operations at the two roundabouts at the Route 7/Route 9 interchange specifically in the morning peak hour
- improve traffic operations at the Market Street interchange specifically in the morning peak hour
- improve traffic operations between the Route 267 (Dulles Greenway) and the South King Street interchange specifically in the afternoon peak hour

Figure 1. Study Area



2. Project Scope & Milestones Summary

2.1. Milestone Schedule

- Framework Scoping Document Concurrence – Technical Review Team meeting required
- Field data collection
- Traffic volume balancing review – Technical Review Team meeting required
- Origin-Destination (O-D) trip table estimation
- Development of VISSIM traffic simulation models:
  - 2016 existing conditions AM and PM peak periods (2)
  - Interim improvements AM and PM peak periods (2)
  - 2025 design year build out AM and PM peak periods (2)
- Submittal of draft model calibration technical memorandum
- Preliminary calibration review – Technical Review Team meeting required
- Submittal of draft traffic report
- Review of existing conditions – Technical Review Team meeting required

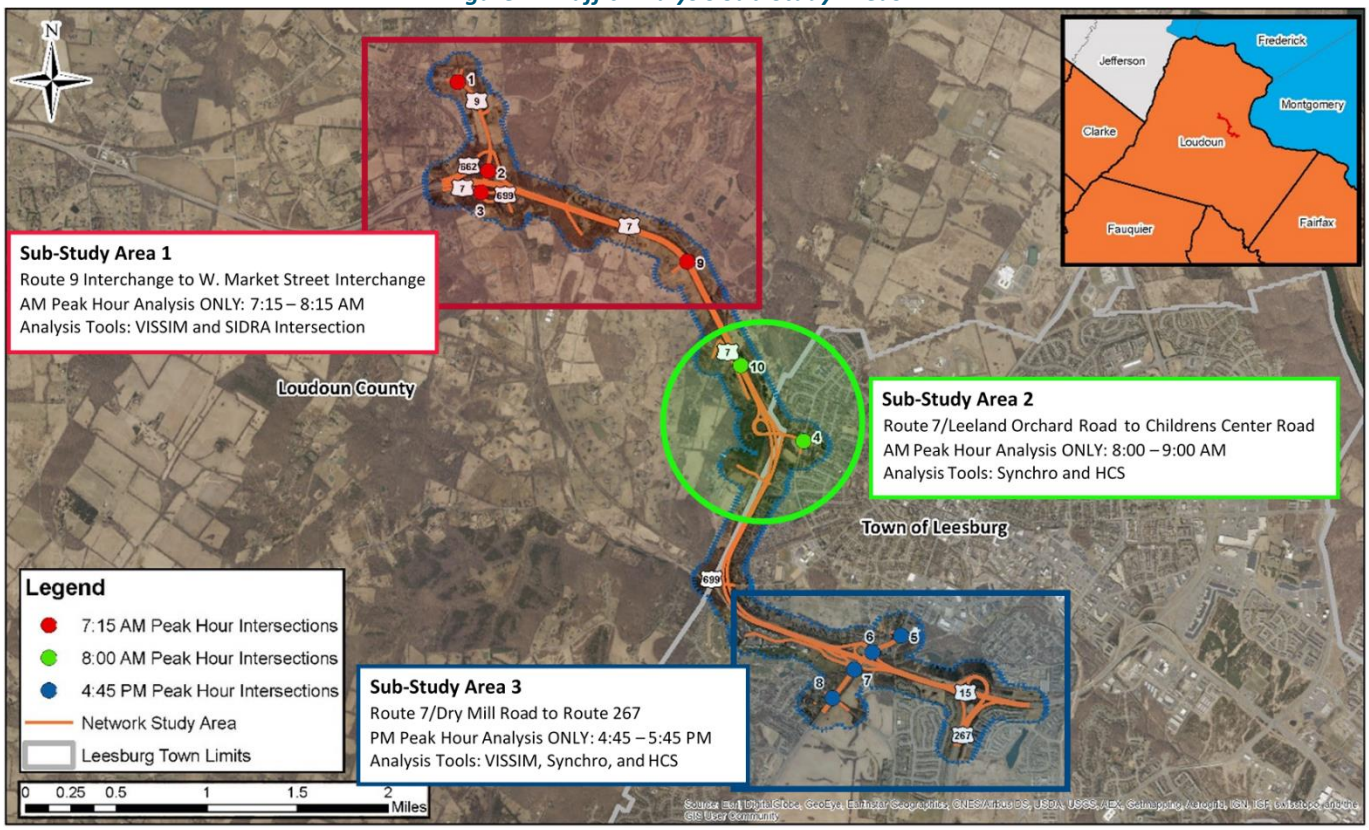
- Comment responses and report revisions
- Submittal of final existing conditions traffic report

2.2. Traffic Volumes

Existing 2016 traffic volumes will be balanced for both peak hours for traffic analysis in the sub-study areas using traffic counts collected at the ramps, intersections, and arterials. To determine the peak periods and peak hours, all of the traffic count data, which consists of turning movement counts (TMCs), 48-hour tube counts on arterials and ramps, and mainline counts, were summed for the entire study area network and compared for every 15-minute increment. The following information provides a brief summary of the peak hours and peak periods in the corridor:

- Sub-Study Area 1: AM peak hour - 7:15 AM to 8:15 AM
- Sub-Study Area 2: AM peak hour - 8:00 AM to 9:00 AM
- Sub-Study Area 3: PM peak hour - 4:45 PM to 5:45 PM
- AM and PM network peak periods: 6:30 AM to 8:30 AM and 4:00 PM to 6:00 PM

Figure 2. Traffic Analysis Sub-Study Areas



2.1. Traffic Analysis Time Period

The traffic analysis time periods to be evaluated are the typical weekday AM and PM peak hours. However, the AM and PM VISSIM models will have a longer simulation period to account for the traffic seeding, peaking, and dissipating from the network. The VISSIM model will be calibrated using existing peak hour traffic conditions. The proposed VISSIM simulation periods are summarized in **Table 1**. Traffic simulation will be performed for 3.5

hours in the AM and PM peak periods – a 30-minute seeding period, two peak period hours, and a one-hour shoulder period.

Table 1. Proposed VISSIM Simulation Periods

Proposed Simulation Periods				
	Seeding Period	**Peak Period**	**Shoulder Period**	***Sub-Study Area Peak Hour***
AM	6:00 to 6:30	6:30 to 8:30	8:30 to 9:30	7:15 to 8:15
PM	3:30 to 4:00	4:00 to 6:00	6:00 to 7:00	4:45 to 5:45

2.2. Analysis Scenarios

Kimley-Horn, in collaboration with the SWG, will develop up to two potential improvement alternatives for each interchange using countermeasures to address operational, geometric, and safety deficiencies identified by the SWG. An initial list of potential interim improvements, supported by supplemental "hand" sketches, will be developed by the study team. This initial list of potential interim improvements will not be analyzed quantitatively. The number of potential improvements will be reduced through the screening process to two alternatives for use in the Build analysis using VISSIM and Synchro for each sub-study area.

Potential improvements will be qualitatively screened given their aptitude to mitigate existing operational and safety issues while staying within existing geometric and right-of-way constraints and meeting the purpose and need of the project. If necessary, operational analyses will be conducted with Synchro and/or Highway Capacity Software (HCS) to supplement the screening process. VISSIM analysis results will not be used during the improvement screening process. The interim year for the future analysis is 2025. In addition to the Build scenarios, a 2025 No-Build scenario will be analyzed.

2.3. O-D Trip Table Development Methodology

To capture the existing traffic weaving patterns on Route 7 between Route 267 and US 15, StreetLight traffic origin-designation (O-D) data will be used to assist with the development of traffic routings. The development of the final O-D trip table will be performed in VISUM for Sub-Study Area 3 during the PM peak hour. VISUM is a planning software that will be used to scale and fine-tune the initial O-D trip matrix based on Streetlight traffic O-D data to approximately match the mainline and ramp traffic counts. This O-D estimation process in VISUM is also referred to as TFlowFuzzy.

3. Methodology and Key Assumptions for Traffic Analysis

3.1. Traffic Analysis Tools

The traffic operations analysis for the alternatives will be accomplished using a combination of Synchro, HCS, SIDRA Intersection, VISUM, and VISSIM. All inputs and analysis methodologies are consistent with the VDOT *TOSAM*. According to the *TOSAM*, the VDOT Project Manager will need to approve the use of VISUM on this project, since VISUM is not a tool that is included in the *TOSAM*. Other than VISUM, the selection of the traffic analysis tools complies with the *TOSAM*. Measures of Effectiveness (MOEs) for each tool are detailed in **Section 3.5** of this document.

VISSIM 7 will be used to analyze traffic in Sub-Study Areas 1 and 3. **Figure 2** shows the study area that will be analyzed in VISSIM and Synchro. VISUM 14 will be used to develop O-D trip tables for Sub-Study Area 3 during

PM peak period. Traffic simulation model development will be consistent with the guidance and requirements in the *TOSAM*. A list of additional model input assumptions is provided in **Appendix A**.

Synchro Professional (Version 9.0) will be used to optimize signal timings at study area intersections and for the traffic analysis at the intersections in Sub-Study Area 2. Once timings at each signalized intersection are optimized, they will be analyzed using 2000 HCM methodologies included within Synchro.

HCS 2010 will be used to analyze Route 7 mainline and ramp traffic operations at the Market Street/Route 7 interchange.

SIDRA Intersection 6 will be used to analyze the two existing roundabouts at the Route 9/Route 7 interchange as well as at any other proposed roundabouts within the study area.

3.2. VISSIM Model Calibration Methodology and Criteria

The VISSIM models will be calibrated using guidance and direction provided in the TOSAM. Traffic volumes, speed, and travel time will be used as calibration measures for freeway segments. Traffic volume and queue length will be used as calibration measures at intersections. Calibration thresholds for each measure are summarized in Table 2.Table 2Table 2. Calibration Items and Targets

Simulated Measure	Calibration Threshold
Simulated Traffic Volume (vehicles per hour) For mainline and interchange ramps, difference targets must be met for a minimum of 85% of mainline segments and ramps. At intersections, difference targets must be met for a minimum of 85% by movements for the study intersections.	Within ± 20% for <100 vph Within ± 15% for ≥100 vph to <300 vph Within ± 10% for ≥300 vph to <1,000 vph Within ± 5% for ≥1,000 vph
Simulated Average Speed (miles per hour) Difference targets must be met for a minimum of 85% of mainline segments.	Within ± 7 mph of average observed speeds on freeways
Simulated Travel Time (seconds) Difference targets must be met for the defined travel time segments along Route 7 mainline.	Within ± 20% for average observed travel times on freeways
Simulated Queue Length (feet) Difference targets must be met for the critical locations consisting of ramps and intersection approaches.	Within ± 20% (arterials) or ± 35% (freeways) of observed maximum queue length Capturing queues that have the potential of impacting: • spillover into through movements (from the turn lane), • spillover to an adjacent intersection, • the mainline in the case of a signal at the end of a ramp terminal, or • creating significantly long side street queues.

1. **Traffic Volume:** Simulated throughput calibrated using data collected during the AM and PM peak hours. Freeway traffic volumes will be calibrated for mainline, diverge, merge, weave, and ramp

segments. Intersection traffic volumes will be calibrated by turning movement volumes at the study intersections.

2. **Speed:** Simulated speed calibrated using data collected during the AM and PM peak hours. Field speed data from the travel time runs will be used to quantitatively calibrate speed results. Speed heat maps with location on the y-axis and time on the x-axis for the peak period will be used as a supplement to the quantitative comparison. INRIX speed data provided by VDOT will be used to supplement the field data. Bottleneck locations identified in field observations will be verified using the speed heat map.
3. **Travel Time:** Simulated travel time calibrated using data collected during the AM and PM peak hours. The proposed travel time segments are identified in **Table 3**.

Table 3. Proposed Travel Time Segments

	AM Corridor Segment	PM Corridor Segment
Route 7	Eastbound: Off-ramp to Route 9 to White Gate Place	Eastbound and Westbound: Sycolin Road bridge to King Street (via east-facing ramps)
	Westbound: White Gate Place to on-ramp from Route 9	Eastbound and Westbound: Battlefield Parkway bridge on Dulles Greenway to Route 7 on-ramp from King Street

4. **Queue Length:** Simulated queue length calibrated using data collected during the AM and PM peak hours. Due to the variability in queue length, the queue length calibration effort will be focused on critical locations where extensive queuing issues consistently exist. The field data used to calibrate the model will be reviewed and approved by the SWG. The following 7 locations are considered the critical list of locations:

   Ramps

   a. Eastbound Route 7 on-ramp from Route 9 (AM peak)
   b. Westbound Route 7 off-ramp to northbound US 15 (PM peak)
   c. Northbound Dulles Greenway (Route 267) off-ramp to westbound Route 7 (PM peak)

   Intersection approaches

   a. Southbound Route 9 at Clarks Gap Road (AM peak)
   b. Southbound Route 9 at Route 7 westbound ramps intersection (AM peak)
   c. Southbound Route 9 at Route 7 eastbound ramps intersection (AM peak)
   d. Eastbound Business 7 at Route 9 (AM peak)

   Other intersections and ramps that do not experience significant queue issues will not be calibrated using queue length but will be calibrated using traffic volume.

The VISSIM model calibration procedures and results will be summarized in the Existing Conditions Traffic Report submitted to VDOT. The report will document modifications that were made to the traffic simulation model to meet the calibration targets and the calibration results. If any target(s) are not satisfied and the traffic simulation model can still be considered reasonably calibrated, written justification will be provided and a mutually-agreeable resolution will be determined.

3.3. Simulation Seeding Time and Number of Runs

VISSIM simulation seeding time will be determined using the average travel time for a vehicle to traverse the corridor in the peak travel direction during the peak hours.

Results from an average of multiple traffic simulation runs will be reported and used during the calibration process. The traffic simulation sample size determination guidance provided in the *TOSAM* will be used along with the Sample Size Determination Tool. Corridor travel times in the southbound direction during the AM peak period and in the northbound direction during PM peak period, along with the peak hour traffic throughput for the critical ramps and intersection approaches identified for queue calibration purposes, will be used to determine the number of simulation runs.

3.4. Quality Control and Assurance

The development of VISSIM models includes an extensive quality assurance and quality control process. All network base geometry, inputs, routes, and signal settings will be checked by a modeler not associated with the initial coding and entry of information into the model. A log of modifications made during model development and calibration processes will be maintained to communicate changes to all modelers and ensure consistency in methodology and assumptions across the various traffic simulation models.

3.5. Measures of Effectiveness

The following measures of effectiveness (MOE) will be used for the operational analysis of the roadway network under existing conditions.

Freeway/Ramps Performance Measures

The freeway performance measures from VISSIM are listed below and will be reported for each hour of the AM and PM peak periods.

- Average speed (mph)
- Average density (vehicle/mile/lane)
- Average traffic volume (vehicles per hour)
- Average travel time (minutes) for designated segments
- Average and maximum queue length (feet) for all freeway ramps

The freeway performance measures from HCS are listed below and will be reported for the AM peak hour in the Market Street/Route 7 interchange area (Sub-Study Area 2).

- Average speed (mph)
- Average density (vehicle/mile/lane)
- Traffic volume (vehicles per hour)

Speed, density, and traffic volume will be reported for mainline freeway, weave, ramp junction (diverge and merge), and ramp segments. The outputs from VISSIM models will be summarized in the freeway output schematic using the *TOSAM* freeway output macro. VISSIM-based graphics of freeway link speeds and/or densities will also provide a visual representation of corridor operational characteristics.

Intersection Performance Measures

The intersection performance measures from VISSIM are listed below and will be reported for each hour of the AM and PM peak periods.

- Average control delay (second/vehicle) by movement and approach
- Average and maximum queue length (feet) by movement
- Average travel time (minutes) along arterial segment (Route 9 during AM peak period)

The intersection performance measures from Synchro are listed below and will be reported for the AM peak hour in the Market Street/Route 7 interchange area (Sub-Study Area 2).

- Average control delay (second/vehicle) by movement and approach
- 95th percentile queue length (feet) by movement

The roundabout performance measures from SIDRA Intersection are listed below and will be reported for the peak hour.

- Average control delay (second/vehicle) by movement and approach
- 95th percentile queue length (feet) by movement

4. Future Traffic Volume Forecast

In coordination with the SWG, Kimley-Horn will use turning movement count data collected during the AM and PM peak hours; VDOT existing and historic traffic count data; information from approved traffic studies; and volume projections from the latest available Loudoun County travel demand model to develop forecasts for the No-Build and Build years. The estimated growth rate will be based on an extrapolation from base year (2010) Loudoun County model projections and 2030 Loudoun County model projections.

Kimley-Horn will coordinate with the SWG to review and approve the proposed growth rate prior to developing future traffic volumes. The process to develop future forecast volumes for No-Build and Build alternatives involves applying the approved growth rate(s) to the existing balanced traffic volumes and conducting traffic volume adjustments and balancing them to generate intersection turning movement traffic volumes and ramp traffic volumes. It is understood that the Loudoun County model does not have a 2025 horizon year scenario available for use on this study. As a result, the 2030 model will be used to assist with the traffic growth rate estimation. It is anticipated that the traffic growth rates extrapolated using the 2030 model reasonably reflect anticipated growth in the study area. Traffic volumes will be developed for 2025.

5. Safety Issues

Kimley-Horn will review and document crash histories in the Route 7 corridor within the study area for the most recent five-year period (2010 - 2014). Using the VDOT crash database, pertinent data fields will be synthesized into a tabular format for analysis.

Kimley-Horn will summarize segment-wide crash data in tabular format for up to ten factors such as weather conditions, lighting conditions, type of collision, severity of crash, and other pertinent crash factors as necessary to aid in identifying crash patterns. Kimley-Horn will develop a graphic using GIS to illustrate the location, crash type, and crash severity within each segment area. Kimley-Horn will compare corridor crash rates to available jurisdictional and statewide average crash rates on comparable roadways, to be provided by VDOT Central Office.

No crash analysis will be conducted at the at-grade intersections. The crash analyses will be focused on the freeway.

6. Report Deliverables

The following documents related to the traffic analysis will be produced as deliverables during the course of this project:

- **Draft Traffic Operations Analysis Framework Document:** Technical memorandum outlining the methods and assumptions for traffic simulation model calibration. This document will serve as a basis for number of runs, calibration measures, criteria, and targets to meet the project goals within a reasonable amount of effort. The document will be submitted to the Technical Review Team for review prior to a Technical Review Team meeting to discuss assumptions for traffic simulation model calibration.
- **Draft Existing Conditions Technical Memorandum:** Documentation and graphical representation of traffic operations and safety under existing conditions, model calibration results, and existing conditions traffic operations. The draft report will be submitted to the SWG for review and comment.
- **Draft No-Build Conditions Technical Memorandum:** Documentation and graphical representation of No-Build traffic operations with a resolution of comments received from the SWG on the Draft Existing Conditions Technical Memorandum.
- **Draft Build Conditions Technical Memorandum:** Documentation and graphical representation of Build traffic operations with a resolution of comments received from the SWG on the No-Build Conditions Technical Memorandum.
- **Draft Project Report:** Documentation of traffic and safety results for the existing, no-build, and build conditions, incorporating the operations and safety results from the recommended alternatives. The draft report will be submitted to the SWG for review and comment.
- **Final Project Report**

Accepted and agreed upon by VDOT:

VDOT (Northern Virginia District):	**VDOT (Central Office):**
_____	_____
Signature	Signature
_____	_____
Printed Name	Printed Name
_____	_____
Title	Title
_____	_____
Date	Date

Appendix A

Software Tool Input Assumptions

Table 4. VISSIM Input Assumptions

VISSIM Assumptions			
Category	**Input**	**Assumption**	**Modification/Notes**
Modeling Approach	Volume Intervals	15-minute intervals for duration of simulation period	VDOT TOSAM
	Arrival Distribution	Exact traffic volumes	VDOT TOSAM
	Vehicle Fleet	Use North American vehicle fleet provided by VDOT	VDOT TOSAM
Volume	Peak Hour Factors	Accounted for when volumes are coded in 15 minute intervals	VDOT TOSAM
	Heave Vehicle Percentage	Based on existing counts	VDOT TOSAM
Speed	Mainline	85th percentile speed	VDOT TOSAM
	Ramps	Warning speed + 10 mph	VDOT TOSAM
	Arterials	Posted speed + 7 mph	VDOT TOSAM
Geometry	Number of Lanes (Route 7)	2 EB/2 WB *3 WB w/o Market Street	Per project description
	Acceleration/Deceleration Lengths	Merge and diverge lengths consistent with HCM freeway segment definition	All measurements will be collected from aerial imagery in GIS
	Vehicle Reaction Points	Default (or will be adjusted to calibrate)	Kimley-Horn assumption
	Link Lengths	Based on aerial imagery. Turn lanes coded using effective storage length.	VDOT TOSAM
Simulation and Calibration	Signal Controllers	Ring-Barrier Controller (RBC)	VDOT TOSAM
	Signal Timings	Obtained from existing signal timing plans provided by VDOT	VDOT TOSAM
	Seeding Time	30 minutes (or adjust to reach equilibrium)	VDOT TOSAM
	Simulation Runs	10 minimum, 30 maximum	Use TOSAM Sample Size Determination Tool to determine the number of runs