Appendix G

Methods and Assumptions for Traffic Analysis and Calibration Memo

TECHNICAL MEMORANDUM

Dulles Interchange at I-495 Capital Beltway Interchange Justification Report – Methods and Assumptions

PREPARED FOR: VDOT

PREPARED BY: VAMegaprojects

DATE: April 17, 2009

This memorandum sets the framework for the transportation analysis for the development and evaluation of functional plans and the Interchange Justification Report. It identifies the analysis years, the limits of the study, travel demand forecasting and modeling methodologies, safety analysis methods, and operational parameters and methods.

I. Scenario Years

- Existing Year - 2005
- Opening Year - 2015
- Design Year - 2030

II. Study Area Limits

The study area is defined as I-495 between Georgetown Pike interchange and Route 123 interchange, Dulles Toll Road and Dulles Airport Access Road between Spring Hill Road interchange and Route 123 interchange and the corresponding ramp termini intersections.

- **I-495 (Capital Beltway)** from south of Route 123 interchange to north of Route 193 interchange.
- **Route 267 Dulles Toll Road Freeway** from west of the main toll plaza at Spring Hill Road interchange to east of Route 123 interchange;
- **Dulles Airport Access Road** from west of the main toll plaza at Spring Hill Road interchange to east of Route 123 interchange;
- **Spring Hill Road** between Jones Branch Drive and Lewinsville Road;
- **Route 123** between Tysons Boulevard and Lewinsville Road;
- **Route 193** between Helga Place and Balls Hill Road;

III. Traffic Forecasting / Demand Modeling Methodology

Travel forecasts for AM / PM peak periods and ADT design year conditions in the Interchange Justification Report (IJR) analysis will be extracted from the previous IJR and other NEPA Re-evaluation studies. All the volumes will be manually re-adjusted for the proposed Build Conditions.

IV. Safety Analysis Methods

For the safety analysis, historic crash rates will be based on three-years of crash data and will be extracted from the Capital Beltway IJR and other NEPA Studies performed for the corridor. The Study would assume a 3-year crash history with 2005 being the existing year. It would include all the major freeway segments and ramps within study area.

Standard Federal Highway Administration crash reduction/counter measure factors will be used to develop future crash estimates for 2030 Build. Crash estimates for 2030 No-build will be derived based on existing crash data, in conjunction with traffic volume projections. The safety analysis study area will encompass the project footprint, as well as the freeway segments extending to the next adjacent set of on-off ramps. However, a full evaluation of adjacent interchanges will not be incorporated as part of the safety analysis for this project.

V. Operational Analysis Methods/Parameters

The analysis for the IJR will build on the traffic and transportation analysis work that has already been done in the Capital Beltway IJR. Tables 1 and 2 present a list of the freeway and arterial / intersection assumptions and analysis parameters.

General Parameters

- Existing conditions analysis results will be presented from the previous analysis work that was performed for the recent IJR.
- In general, the threshold of engineering and operational acceptability for the operational analysis will be based on 2030 Build Measures of Effectiveness (MOE's) that are no worse than 2030 No-Build conditions.
- No Build Conditions (2015 & 2030) assumes improvements associated with the I-495 Beltway HOT lanes project in Virginia. 2030 improvements assume additional ramps at Jones Branch and Dulles interchanges as shown in the I-495 Beltway HOT Lanes IJR.
- Build Conditions
  - (2015) – Assumes No-Build configuration as a base condition, plus the Dulles Airport Access Road (DAAR) ramp improvements identified in the Preferred Plan:
    - Direct flyover ramp serving EB DAAR to SB I-495 GP Lanes
    - Direct flyover ramp serving EB DAAR to NB I-495 GP Lanes
    - Direct flyover ramp serving SB I-495 GP Lanes to WB DAAR
  - (2030) – Assumes Build 2015 Build configuration, plus modification of Jones Branch Drive Connector.
- VISSIM output analysis performed within the study area limits only, utilizing network created for previous IJR. Update VISSIM networks for identified coding errors and modify simulation run parameters (e.g. number of repetitions, data collection time, etc.) based on FHWA guidance.
- Upstream and downstream impacts and adjacent intersections evaluated using HCS & VISSIM.

Freeway Parameters

Refer to Table 1 for the list of all freeway parameters/inputs that will be assumed on this project. All of the freeway analysis will be performed using Highway Capacity Software Plus (HCS+) Version 5.21. Within the immediate project footprint only, VISSIM 4.3 will be used to supplement HCS for determination of Level of Service (LOS) and other Measures of Effectiveness (MOE's) due to system impacts. It is assumed that these parameters will be consistently used across analysis scenarios.

TABLE 1

Freeway Operations Parameters / Assumptions by Scenario

	Scenarios			
Freeway Operations Parameters	**2015 No-Build**	**2015 Build**	**2030 No-Build**	**2030 Build**
Peak Hour Volumes	Capital Beltway IJR			
Peak Hour Factor	.90 (Capital Beltway IJR)	.93	.90 (Capital Beltway IJR)	.93
Terrain / Grades	Capital Beltway IJR	Capital Beltway IJR / Functional Plans	Capital Beltway IJR	Capital Beltway IJR / Functional Plans
Percent Heavy Vehicles	Capital Beltway IJR			
Driver Population Adjustment	1.0	1.0	1.0	1.0
Base Free-flow Speed	55	55	55	55
Lane Width	Capital Beltway IJR	From functional plans, otherwise 12 feet	Capital Beltway IJR	From functional plans, otherwise 12 feet
Right-shoulder Lateral Clearance	Capital Beltway IJR	From Functional Plans	Capital Beltway IJR	From Functional Plans
Interchange Density (per mile)	0.5 (Capital Beltway IJR)	0.5	0.5 (Capital Beltway IJR)	0.5
Ramp Free-flow Speeds (mph)	Diamond ramp: 35 Loop ramp: 25 Directional ramp: 35	Diamond ramp: 35 Loop ramp: 25 Directional ramp: 35	Diamond ramp: 35 Loop ramp: 25 Directional ramp: 35	Diamond ramp: 35 Loop ramp: 25 Directional ramp: 35
Simulation – Seeding Time	0-3600 sec			
Simulation – Recording Time	3600-7200 sec			
Simulation – Number of Repetitions	8			
Simulation – MOEs	Speeds, Density, LOS, Volume (throughput serviced), Travel Times for identified Ramp Movements.			
LOS Criteria	LOS E for freeways & ramps in urban areas	LOS E or not worse than No-Build	LOS E for freeways & ramps in urban areas	LOS E or not worse than No-Build

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Arterial Intersection Parameters

Refer to Table 2 for the list of all arterial intersection parameters/inputs that will be assumed on this project. All the intersection analysis will be perform using VISSIM 4.3. It is assumed that these parameters will not change between scenarios, unless otherwise specified.

TABLE 2

Arterial – Intersection Operations Parameters / Assumptions by Scenario

	Scenarios			
Arterial - Intersection Operations Parameters	**2015 No Build**	**2015 Build**	**2030 No-Build**	**2030 Build**
Peak Hour Volumes	Capital Beltway IJR			
Conflicting Peds / Bikes per Hour	None Assumed			
Percent Heavy Vehicles	Capital Beltway IJR			
Lane Width	Capital Beltway IJR	From functional plans, otherwise 12 feet	Capital Beltway IJR	From functional plans, otherwise 12 feet
Signal Phasing and Coordination	Capital Beltway IJR			
Signal Timing – Cycle Length	≤180 seconds			
Signal Timing – Minimum Green	Capital Beltway IJR			
Signal Timing – Yellow + All-red	Capital Beltway IJR			
Right Turn on Red	Allowed			
Simulation – Seeding Time	0-3600 sec			
Simulation – Recording Time	3600-7200 sec			
Simulation – Number of Repetitions	8			
Simulation – MOEs	Speeds, Density, LOS, Volume (throughput serviced)			
Intersection LOS Criteria (average control delay) per HCM 2000	LOS E, V/C critical < 1.0	LOS E, or no worse than No-Build	LOS E, V/C critical < 1.0	LOS E, or no worse than No-Build

List of Intersections that will be evaluated:

- Georgetown Pike & I-495 SB Off Ramp
- Georgetown Pike & I-495 NB Off Ramp
- Georgetown Pike & Balls Hill Road

- Spring Hill Road & Westbound Dulles Toll Road On & Off Ramp
- Spring Hill Road & Eastbound Dulles Toll Road On & Off Ramp
- Spring Hill Road & Jones Branch Drive
- Chain Bridge and Tysons Blvd.
- Dolly Madison Blvd. & Capitol One Drive/Old Meadow Road
- Dolly Madison Blvd. & Scotts Crossing/Colshire Drive
- Dolly Madison Blvd. & Anderson Road
- Dolly Madison Blvd. & Lewinsville Road/Great Falls Street
- Tysons Blvd. & Galleria Drive
- West Park Connector & Hot Lane On & Off Ramps (Build Condition)

VI. Interchange Justification Report Review Process and Approval

Review occurs in three levels-

- Certified Traffic Data – VDOT NOVA District Planning;
- Draft IJR – VDOT Central Office, FHWA Virginia Division;
- Final IJR – VDOT Central Office, FHWA Virginia Division, FHWA Headquarters.

Deliverables

- Draft IJR (20 copies on 11 x 17 sheet size)
- Final IJR (40 hard copies on 11 x 17, 10 electronic copies)
- VISSIM Simulation & Analysis Files (10 electronic copies)

TECHNICAL MEMORANDUM

Dulles Interchange at I-495 Capital Beltway Interchange Justification Report – VISSIM Models Calibration

PREPARED FOR: FHWA

PREPARED BY: VAMegaprojects

DATE: September 30, 2009

For the analyses conducted for the Dulles Interchange Justification Report, VISSIM micro-simulation models were used to analyze the traffic conditions in the study area roadways as a complete system. The VISSIM models of existing and No Build AM and PM peak hours used as base models for this study were developed originally for the I-495 HOT lanes project. Although the base models extended from Georgetown Pike to south of Braddock Road to the south, they were used to analyze traffic operations within the study area of this project only. It was assumed that these VISSIM models were sufficiently calibrated during the I-495 HOT lanes IJR project development and were used as base models from which the Build AM and PM peak hour models were developed. This memorandum details the calibration efforts that were carried out during the I-495 HOT lanes IJR project development, the model refinements made to the base models and the more rigorous approach used in the simulation parameters adopted for this analyses.

BASE MODELS:

The following is a description from the I-495 HOT lanes IJR of the efforts that were carried out for the calibration of the base models:

Balanced existing volumes developed for the I-495 HOT lanes IJR existing conditions (2005) were used as the inputs to the VISSIM models. Since the Beltway (I-495) operates at constrained conditions during the AM and PM peak hours, the free flow speeds at the roadway network termini were reduced to approximately 10 miles per hour to help replicate existing conditions. These speed reductions aid in replicating the stop-and-go traffic conditions that occur regularly beyond the edges of the roadway network used in the VISSIM micro-simulation models. Modification of free flow speeds at the edge of the network to help replicate downstream and upstream congestion is an acceptable technique commonly used in calibration of micro-simulation models. The speed reductions were applied at the following locations:

- Beltway (I-495) north of Georgetown Pike
- Chain Bridge (Route 123) north of the Dulles Toll Road (Route 267)
- Chain Bridge (Route 123) west of Tysons Boulevard
- Dulles Toll Road at the first toll plaza
- Leesburg Pike (Route 7) east of Lisle Avenue
- Leesburg Pike (Route 7) west of Tysons Ring Road
- Leesburg Pike (Route 7) south of I-66
- Arlington Boulevard (Route 50) east and west of I-495

- Little River Turnpike (Route 236) east of Heritage Drive
- Braddock Road (Route 620) east of Ravensworth Road
- Braddock Road (Route 620) west of Queensberry Avenue
- I-495 south of Braddock Road
- I-395 north of Beltway (I-495)
- I-395 south of Beltway (I-495)
- I-66 east of Leesburg Pike (Route 7)
- I-66 west of Nutley Street
- Lee Highway (Route 29) east of Shreve Road – Build Conditions Only
- Lee Highway (Route 29) west of Hartland Road – Build Conditions Only

Additional adjustments to the existing models include changes in the distances over which lane changes are made. The lane change distance adjustments were changed at different locations with the goal of calibrating existing queues and travel times within the study area. In addition, in areas where significant lane-change conditions are found, default driving behavior was adjusted in the model to account for more aggressive/cooperative lane-change behavior. Adjustments in the lane change parameters were used to avoid unrealistic gridlock conditions due to some limitations in VISSIM to replicate realistic behavior under very congested/severe weaving conditions. In most cases the same parameters were used for all existing and future scenarios. However, there are cases where a particular congested operation warranted coding more aggressive behavior in one scenario and not in others. It is important to note that changes in behavior will only take place when congested conditions are present. In order to properly replicate existing conditions on the Beltway, and calibrate adequately the existing travel speeds and congestion levels, volume adjustments were made after the development of the EMME-2 origin/destination table at selected entry points to the network. The following volume adjustments were made:

- During the AM peak hour 2,000 vehicles were added at the southern entrance to the Beltway (I-495) and all 2,000 vehicles were assigned to traverse the entire segment of northbound Beltway (I-495) from the Springfield interchange to north of Georgetown Pike. Traffic was not reduced at any of the other entry points to offset these additional 2,000 vehicles.
- During the AM peak hour, 1,000 vehicles were added to eastbound I-66 from west of Nutley Street to northbound Beltway (I-495) to exit the network north of Georgetown Pike. Traffic was not reduced at any of the other entry points to offset these additional 1,000 vehicles.
- During the PM peak hour, 2,000 vehicles were added at the northern entrance to the Beltway and all 2,000 vehicles were assigned to traverse the entire segment of southbound Beltway (I-495) from north of Georgetown Pike to the Springfield interchange. Traffic was not reduced at any of the other entry points to offset these additional 2,000 vehicles.

In order to properly model future conditions, the traffic volumes added to the existing conditions models were added to all future year scenarios.

Additionally, small volume differences exist between the post-processed volume forecasts (shown in Figures 11, 12, 13 and 14) and the VISSIM input volumes throughout the network due to the variability associated with the re-generation of O-D tables with the post-processed traffic volumes. EMME/2 matrix manipulation tools were used to re-generate O-D pairs based on the original trip tables (from TP+) and the post-processed input volumes. The iterative process was assumed adequate when volumes were within +-15% of the adjusted (postprocessed) volumes.

The development of the VISSIM models included an extensive quality assurance/quality control process. All network inputs entered by a modeler were checked by another modeler. All routes and signal settings were checked by a modeler different from the one who entered the inputs into the VISSIM models. Close coordination was maintained throughout the modeling effort to incorporate adequate geometric improvements into the VISSIM models. A log of modifications was maintained to communicate to all modelers the correct set of inputs and assumptions to be used with the VISSIM models for this project.

Each model was run for one hour, with a one hour initialization period (for a total of 120 minutes of micro-simulation modeling). The travel times, density, volumes and delays evaluated for each traffic condition: AM peak hour and PM peak hour, were computed from the average of four model runs. The use of the average travel times for the entire peak hour was considered adequate because the Beltway corridor has a high, consistent volume during the entire peak hour. VISSIM models for existing traffic conditions were calibrated to match the observed Beltway (I-495) and I-66 speeds as well as observed queues throughout the study area. Speeds and queues were selected for calibration because these two widely accepted measures of system performance provide information that indicates whether or not the micro-simulation model reflects adequately observed field traffic conditions. As shown in Tables - 1 through 4 below, the calibrated VISSIM models for existing conditions replicate adequately existing speeds and travel times within the study area.

Table - 1: AM Peak Hour Model Calibration Results (NORTHBOUND)

Interchange with I-495		Distance (feet)	Model		Field Average		Difference*		
From	To		Travel Time (sec)	Speed (mph)	Travel Time (sec)	Speed (mph)	Travel Time (%)	Speed (mph)	Speed (%)
Braddock Rd	Route 236	9,083	171	36	157	40	9%	-3	-8%
Route 236	Gallows Rd	6,919	140	34	152	31	-8%	3	9%
Gallows Rd	Route 50	4,451	88	35	90	34	-3%	1	3%
Route 50	I-66	7,287	278	18	294	17	-6%	1	6%
I-66	Route 7	9,304	397	16	312	20	27%	-4	-21%
Route 7	Dulles Toll Rd	8,096	313	18	275	20	14%	-2	-12%
Dulles Toll Rd	Georgetown Pike	9,845	266	25	264	25	1%	0	-1%
Entire Corridor		**54,984**	**1652**	**23**	**1544**	**24**	**7%**	**-2**	**-7%**

* (Model – Field)/Field

Table - 2: AM Peak Hour Model Calibration Results (SOUTHBOUND)

Interchange with I-495		Distance (feet)	Model		Field Average		Difference*		
From	To		Travel Time (sec)	Speed (mph)	Travel Time (sec)	Speed (mph)	Travel Time (sec)	Speed (mph)	Speed (%)
Braddock Rd	Route 236	9,842	172	39	165	41	4%	-2	-4%
Route 236	Gallows Rd	8,327	105	54	118	48	-11%	6	12%
Gallows Rd	Route 50	9,423	115	56	108	59	7%	-4	-6%
Route 50	I-66	7,428	89	57	78	65	15%	-8	-13%
I-66	Route 7	4,318	51	58	58	51	-13%	7	14%
Route 7	Dulles Toll Rd	7,085	83	58	90	54	-8%	4	8%
Dulles Toll Rd	Georgetown Pike	8,913	104	59	105	58	-1%	1	1%
Entire Corridor		**55,337**	**719**	**52**	**721**	**52**	**0%**	**0**	**0%**

* (Model – Field)/Field

Table - 3: PM Peak Hour Model Calibration Results (NORTHBOUND)

Interchange with I-495		Distance (feet)	Model		Field Average		Difference*		
From	To		Travel Time (sec)	Speed (mph)	Travel Time (sec)	Speed (mph)	Travel Time (sec)	Speed (mph)	Speed (%)
Braddock Rd	Route 236	9,083	106	58	112	55	-5%	3	5%
Route 236	Gallows Rd	6,919	82	58	77	61	6%	-3	-6%
Gallows Rd	Route 50	4,451	52	58	60	51	-13%	7	14%
Route 50	I-66	7,287	86	58	90	55	-5%	3	5%
I-66	Route 7	9,304	109	58	100	63	9%	-5	-8%
Route 7	Dulles Toll Rd	8,096	100	55	120	46	-16%	9	19%
Dulles Toll Rd	Georgetown Pike	9,845	382	18	342	20	12%	-2	-11%
Entire Corridor		**54,984**	**917**	**41**	**901**	**42**	**2%**	**-1**	**-2%**

* (Model – Field)/Field

Table - 4: PM Peak Hour Model Calibration Results (SOUTHBOUND)

Interchange with I-495		Distance (feet)	Model		Field Average		Difference*		
From	To		Travel Time (sec)	Speed (mph)	Travel Time (sec)	Speed (mph)	Travel Time (sec)	Speed (mph)	Speed (%)
Braddock Rd	Route 236	9,842	301	22	356	19	-15%	3	18%
Route 236	Gallows Rd	8,327	627	9	508	11	23%	-2	-19%
Gallows Rd	Route 50	9,423	440	15	388	17	14%	-2	-12%
Route 50	I-66	7,428	332	15	326	16	2%	0	-2%
I-66	Route 7	4,318	136	22	126	23	8%	-2	-8%
Route 7	Dulles Toll Rd	7,085	113	43	106	46	7%	-3	-6%
Dulles Toll Rd	Georgetown Pike	8,913	105	58	108	56	-3%	2	3%
Entire Corridor		**55,337**	**2053**	**18**	**1917**	**20**	**7%**	**-1**	**-7%**

* (Model – Field)/Field

UPDATES TO BASE MODELS:
Since the VISSIM base models were developed for a much larger study area the analysis team closely examined the operating conditions of the models within the study area for this effort. This exercise ensured that the calibration steps conducted for the larger network as described above, also addressed sufficiently the operations of the facilities under this study. In adapting the previous HOT lane VISSIM model for use here, a number of model refinements were carried out as described below.

The following network modifications were made to the base models:

- As shown in Figure-1, the lane arrangements under the original configuration at the exit ramp from westbound Dulles Toll Road to Spring Hill Road were resulting in no vehicles using the right most lane. This does not conform to what was observed in the field. Also, the original configuration shows the middle lane as E-ZPass (electronic toll collection) only lane and the right most lane as exact change lane on the ramp. The analysis team went into the field at this location and based on the observations, modified the lane configuration as shown in Figure-2 below. To match the field conditions the right most lane was coded as E-ZPass lane and the middle lane was coded as exact change lane. These changes brought the operating conditions at this location to match the observed field conditions. This improvement also reduced some of the spillback from this ramp onto the westbound Dulles Toll Road movement. These changes impact the outputs of the simulation, although they do not affect the system wide operations significantly thus not requiring calibrating the entire models.
- Other modifications made to the network files included matching of link number IDs and link lengths between the AM & PM files to ensure consistency in the outputs. These changes were mostly cosmetic with no significant impact to the outputs of the simulations thus not requiring calibrating models.

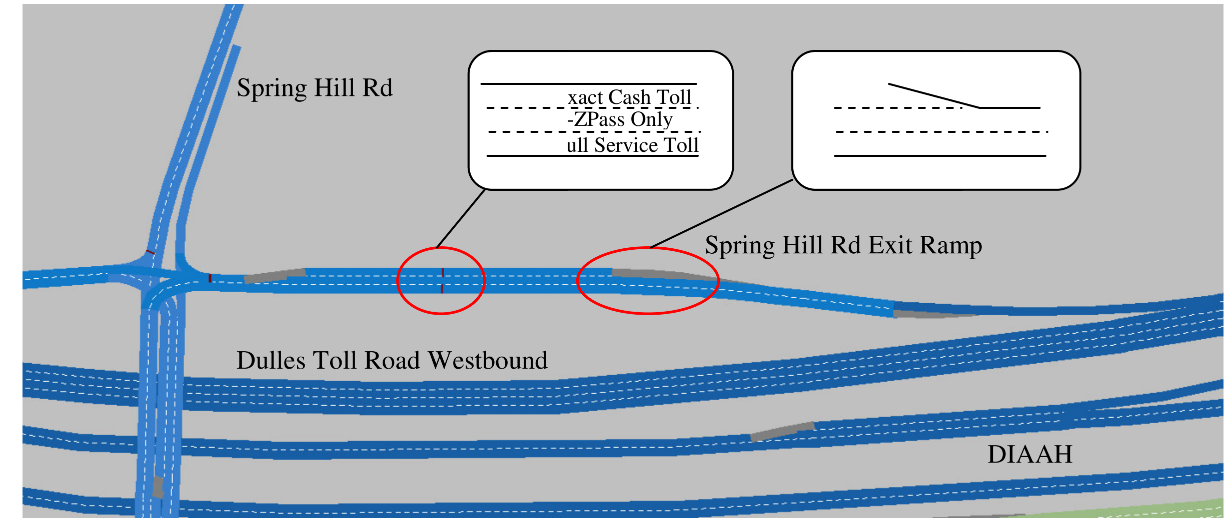

Figure 1: Original Lane Configuration

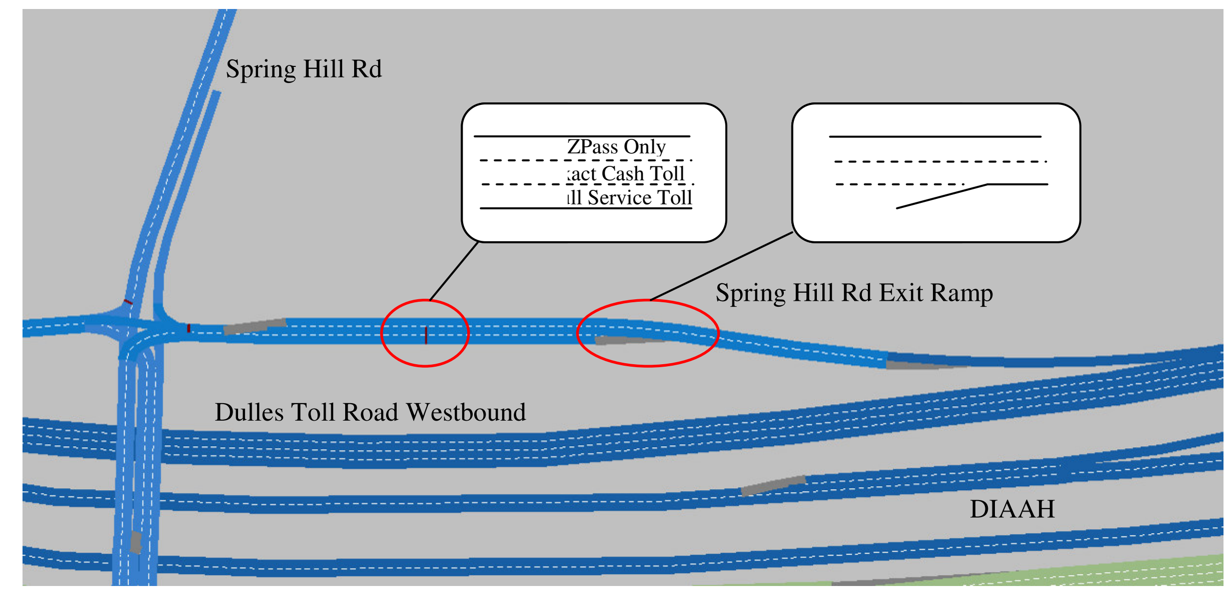

Figure 2: Modified Lane Configuration

Although the above changes would affect the output of the simulation, they do not require calibrating the models again. Hence no special calibration exercise was undertaken for this effort.

In addition, in coordination with the FHWA Resource Center traffic operations experts different, more rigorous approaches were adapted in the set-up and modeling effort to assure best modeling practices were used. VISSIM models were run for two hours, which include one hour of initialization period followed by one hour of data collection (for a total of 120 minutes of micro-simulation modeling). To account for the stochastic nature of the simulation a total of 8 simulation runs were carried out to evaluate the travel times, density, volumes and delays for each traffic condition. The data collection time and number of runs made for this IJR are different than the approach used for the I-495 HOT lanes IJR and because of this reason the results of VISSIM analysis would differ between the two analyses. The use of the average travel times for the entire peak hour was considered adequate because the Beltway corridor has a high, consistent volume during the entire peak hour. The net result of these changes is that VISSIM outputs will not be directly comparable to those in the previously approved IJR and reviewers are cautioned against direct comparison of results reported here.

It should also be noted that the results reported in this IJR are an average of multiple runs from a stochastic simulation, with each run generating different results based on the random seed number. This means that the results will not always be derivative of the inputs and are subjective to the randomness of the simulation. These variances in results are an acceptable practice.