Technical Memorandum

To: Paul Agnello, FAMPO

From: Michael Baker International

Date: March 16, 2018

Re: I-95 Corridor Evaluation Phase 2: Travel Forecasting Methodology

Background

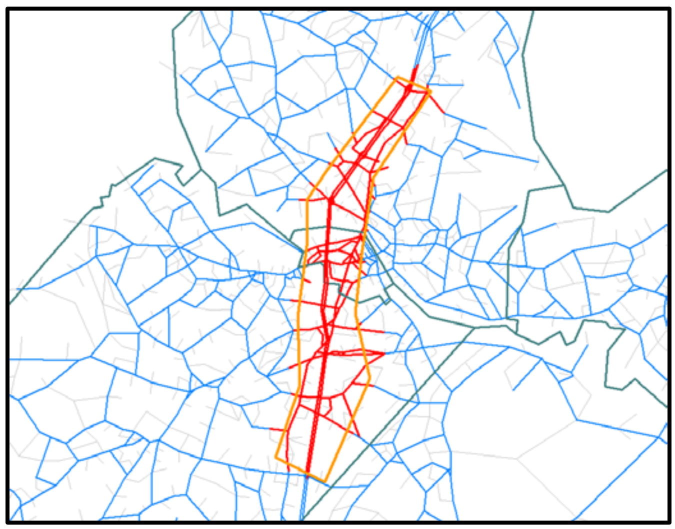
The evaluation of alternatives in this study relied upon macroscopic travel forecasts as well as microscopic operational analysis (covered at the end of this memorandum). The travel forecasts were predicted by the Version 3.1 Travel Forecasting Model adopted for long-range transportation planning in the George Washington Regional Commission (GWRC) area. This model consists of three primary steps: trip generation, trip distribution, and trip assignment. Trip generation determines the amount of travel activity by persons at various locations, or activity centers, in the region based on population and household data from the Census as well as employment data from the Virginia Employment Commission (VEC). Based on the level of travel activity and roadway travel time between the activity centers, the trip distribution step determines the pattern and number of person trips moving between the activity centers. Roadway travel times are dependent on regional roadway locations/connections and characteristics such as lanes, facility type, speed, and traffic capacity for existing and planned transportation projects. Data describing external travel to the region, based the Fredericksburg Region 1999 Origin-Destination Survey and Census worker flows also provide guidance in the trip distribution step.

A next step estimates vehicle trips traveling between activity centers based on the person trip estimates generated in the trip distribution step and auto occupancy factors developed from VRE survey data and published standards[1]. The trip assignment step then assigns the vehicle trips to various combinations of roadways or routes that connect the activity centers, with the objective of minimizing travel time and delay due to traffic congestion. This last step results in the estimation of vehicle traffic volumes on all roadways contained in the travel model. A comparison with observed vehicle volumes derived from traffic counts provides a means to determine the accuracy or performance of the travel model estimates.

[1] "NCHRP 365: Travel Estimation Techniques for Urban Planning", Transportation Research Board, National Research Council, 1998.

The version 3.1 model was developed for FAMPO in early 2017 and includes the most recent zonal socioeconomic data and traffic analysis zone (TAZ) structure developed for the 2045 Long-Range Transportation Plan (LRTP). The base year for the version 3.1 model is 2015. The details of the updates for the version 3.1 model and corresponding regional validation results are available in the memorandum to FAMPO from Cambridge Systematics, *FAMPO Travel Demand Model Version 3.1 Update*, February 24, 2017. This current model builds on what originally was a basic 3-step model, developed in the 1990s, with HOT Lanes and some capabilities to account for the VRE service in the I-95 corridor. Subsequent updates occurred in 2005 with the Version 2 model, and then in 2006-2007 by VDOT staff and The Corradino Group to add I-95 HOT lanes south to Garrisonville to facilitate conformity analysis.

Figure 1: I-95 Phase 2 Validation Study Area



This current travel model analysis consisted of three primary components which included reviewing the performance of the model in the study area, adjusting the model for better performance in the study area, and application of the model for the development and comparison of the study alternatives.

After the preliminary evaluation of the 2015 base year model in the study area shown in Figure 1, it was observed that the model over-estimates traffic crossing the Rappahannock River. It is often the case that travel demand models do not adequately portray the perceived impedance to crossing major geographic boundaries such as rivers. To account for this phenomenon, time penalties are applied which reflect additional impedance. For this study, various time penalty values were tested to find the level of additional delay on the river crossings that would improve the validation within the study area. The final adjustments were a 15 second time penalty on the I-95 crossing, a 2 second penalty on the Cambridge Street crossing, and a 5 second penalty on the William Street crossing. Updates to the model process were subsequently implemented in the 2045 model setups.

The tables on the following pages show the differences in the study area validation, based on daily volumes, before and after the implementation of the time penalties on the river crossings. Guidelines for evaluating the validation of the model are based on recommendations from the *Virginia Travel Demand Modeling Policies and Procedures Manual Version 2.0*, June 2014. Note that before the time penalty adjustment, certain roadway groups highlighted in the tables below did not meet guidelines for accuracy. After adjustment, all roadway groups meet guidelines and the overall study area validation improves.

Table 1: RMSE and Volume-Count Ratio by Facility Type - Before Adjustment

Facility Type	Number of Links	Estimated Volume	Observed (AAWDT_2015)	% RMSE	% Deviation	Deviation Guideline
1 – Interstate	6	358,305	345,500	13.8%	3.7%	±7%
2 – Multi-Lane Arterial	28	511,826	459,500	23.0%	11.4%	±10%
3 – Two-Lane Arterial	18	217,296	189,400	24.1%	14.7%	±15%
4 – Collector	10	53,830	51,100	29.5%	5.3%	±25%
5 – Local	14	27,637	24,600	65.7%	12.3%	±25%
Total	76	1,168,894	1,070,100	23.9%	9.2%	±10%

Table 2: RMSE and Volume-Count Ratio by Volume Group - Before Adjustment

Volume Range	Number of Links	Estimated Volume	Observed (AAWDT_2015)	% RMSE	RMSE Guideline	% Deviation
Less than 5,000	20	46,321	40,100	67.8%	100%	15.5%
5,000-9,999	20	168,777	143,000	29.6%	45%	18.0%
10,000-14,999	13	159,816	155,000	23.7%	35%	3.1%
15,000-19,999	9	181,355	147,500	30.4%	30%	23.0%
20,000-29,000	6	149,915	148,000	9.3%	27%	1.3%
30,000-49,000	3	144,128	132,500	15.5%	25%	8.8%
50,000-59,999	2	95,829	107,000	14.8%	20%	-10.4%
Greater than 60,000	3	222,753	197,000	17.0%	19%	13.1%
Total	76	1,168,894	1,070,100	23.9%	40%	9.2%

Table 3: RMSE and Volume-Count Ratio by Facility Type - After Adjustment

Facility Type	Number of Links	Estimated Volume	Observed (AAWDT_2015)	% RMSE	% Deviation	Deviation Guideline
1 – Interstate	6	355,604	345,500	13.5%	2.9%	±7%
2 – Multi-Lane Arterial	28	497,632	459,500	19.1%	8.3%	±10%
3 – Two-Lane Arterial	18	216,227	189,400	24.1%	14.2%	±15%
4 – Collector	10	53,944	51,100	30.3%	5.6%	±25%
5 – Local	14	27,200	24,600	63.4%	10.6%	±25%
Total	76	1,150,607	1,070,100	21.9%	7.5%	±10%

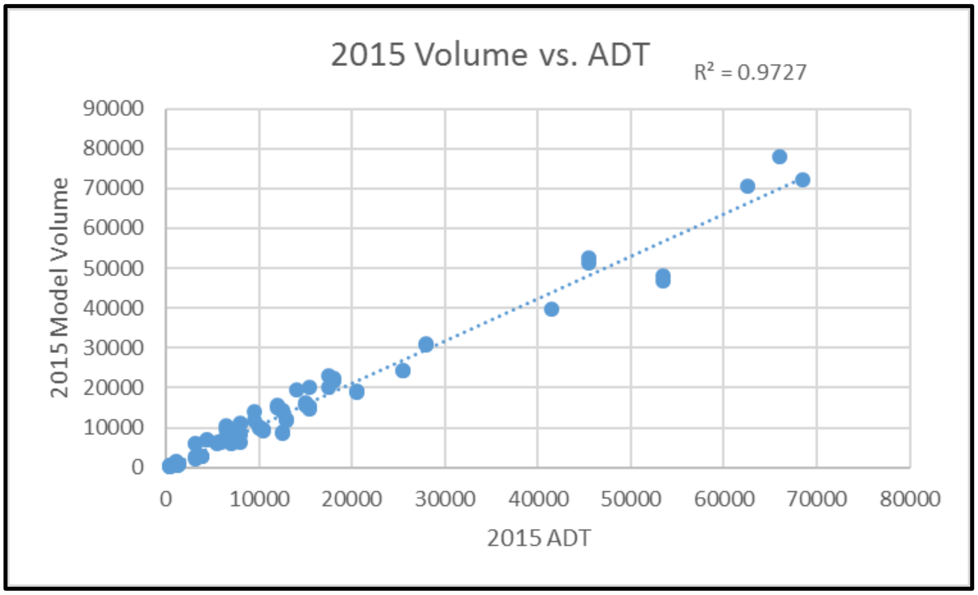
Table 4: RMSE and Volume-Count Ratio by Volume Group - After Adjustment

Volume Range	Number of Links	Estimated Volume	Observed (AAWDT_2015)	% RMSE	RMSE Guideline	% Deviation
Less than 5,000	20	45,684	40,100	65.5%	100%	13.9%
5,000-9,999	20	168,183	143,000	29.3%	45%	17.6%
10,000-14,999	13	158,911	155,000	23.4%	35%	2.5%
15,000-19,999	9	169,811	147,500	21.0%	30%	15.1%
20,000-29,999	6	148,482	148,000	9.1%	27%	0.3%
30,000-49,999	3	143,611	132,500	15.0%	25%	8.4%
50,000-59,999	2	95,004	107,000	15.9%	20%	-11.2%
Greater than 60,000	3	220,921	197,000	16.2%	19%	12.1%
Total	76	1,150,607	1,070,100	21.9%	40%	7.5%

An additional measure of model validation in the study area is the square of the correlation coefficient (R), which should be greater than 0.85[2]. **Figure 2** below shows that the adjusted FAMPO model meets this criterion as well.

[2] Model Validation and Reasonableness Checking Manual, Federal Highway Administration, February 1997.

Figure 2: FAMPO Model 2015 Study Area Correlation



Forecast Methodology

The method used to produce traffic volume forecasts for each of these scenarios is based on guidance provided in publications NCHRP 255[3] and NCHRP 765[4]. These publications prescribe a method of using estimated traffic volumes from a travel demand model along with observed traffic counts to derive the traffic forecasts. The first step of the process is to calculate the difference between future year model volumes and existing year model volumes, as well as the ratio between the future and existing model volumes. For each location, the volume difference and ratio are applied to the base year traffic counts. If certain criteria are met, the average of the two methods is used to produce the traffic forecasts. In cases where the difference method would yield a negative number, only the ratio method is applied. In cases where the ratio of model volumes is greater than 3, only the difference method is applied. Final adjustments are made to the forecasts to ensure that volumes are balanced between the interchanges and adjacent intersections, where appropriate.

Peak Hour Volumes

For the I-95 Phase 2 Study, this methodology was applied for the development of AM and PM peak hour forecasts for segments of I-95, the ramps for each interchange, and the intersections adjacent to the

[3] Pedersen, N.J. and Samdahl, D.R., "NCHRP Report 255: Highway Traffic Data for Urbanized Area Project Planning and Design." *National Cooperative Highway Research Program Report*, Washington DC. (1982).
[4] CDM Smith, Horowitz, A., Creasey, T., Pendyala, R., and Chen, M., "NCHRP Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design." *National Cooperative Highway Research Program Report*, Washington DC. (2014).

interchanges. This process required several input components for each interchange or intersection and included the following:

1. a set of 2017 base year traffic counts (AM peak hour, PM peak hour)
2. a set of 2015 model volumes (AM peak hour, PM peak hour)
3. a set of 2045 model volumes (AM peak hour, PM peak hour)

Peak hour factors from the FAMPO time-of-day assignment models were used to convert the peak period volumes estimated by the model to peak hour volumes. Peak periods for the model are three hours in duration and defined as 6-9 AM and 4-7 PM. This resulted in factors of 0.40 and 0.37 that were applied to the AM and PM period volumes respectively to yield peak hour volumes. For each intersection turning movement, the difference and ratio methods described above were applied using the observed counts, and derived 2015 and 2045 peak hour model estimates. Final adjustments were applied where necessary to ensure that volumes balanced between adjacent intersections.

In addition to the weekday AM and PM peak hour traffic volumes estimated using the travel model, it was necessary to estimate PM peak hour traffic for weekend travel conditions. Traffic count data was compiled which represented 2017 weekend PM peak hour traffic conditions. A pivot model approach was employed which used the differences in weekday and weekend traffic counts, and applied these factors to the 2045 weekday AM peak hour forecasts to derive comparable 2045 weekend traffic forecasts. Two assumptions that were acknowledged in the application of this approach in this phase of analysis are, 1) that the relationship between weekday and weekend observed traffic counts are still valid in 2045, and 2) that the northbound peak direction during the weekday AM peak is similar to weekend PM peak conditions.

Operational Modeling

VISSIM, a stochastic microscopic transportation simulation model, was used to study the operational details and measure performance metrics for the network under study. First, the existing conditions model was calibrated against observed field conditions using travel times for freeways and queuing performance for arterial intersections. Each simulation model was run using 10 random seeds to account for variations in the traffic performance. Model calibration and validation procedures in accordance with Virginia Department of Transportation (VDOT's) Traffic Operations and Safety Analysis Manual (TOSAM) were adopted.

After calibration and validation of the existing conditions VISSIM model, forecasted traffic conditions (from the transportation planning model) along with the programmed roadway and geometric improvements for years 2030 and 2045 were simulated in VISSIM (these simulations are referenced as the No-Build conditions). The 2030 and 2045 No-Build conditions give the baseline traffic performance for the study network with no additional improvements for the forecasted traffic volumes. The hotpots and traffic bottlenecks observed in the 2030 and 2045 No-Build conditions were further mitigated with potential roadway, geometric and intersection modifications and improvements. Additionally, interchange additions, modifications and improvements were also included. Bundling of the above referenced improvements were referenced to as the project Alternatives. The resultant performance metrics from the simulation of different Alternatives in VISSIM served as a basis for high-level screening. The most desirable project Alternatives were further developed for inclusion and consideration in VDOT's Smart Scale Application process.