Appendices A through D are supplemental to *NCHRP Research Report 1103: The Effect of Vehicle on Crash Frequency and Crash Severity* (NCHRP Project 22-49). The full report can be found by searching on the report title on the National Academies Press website (nap.nationalacademies.org).

APPENDIX A

Quasi-Induced Exposure Method for Vehicle Mix Prediction

The research team recognized that for some jurisdictions vehicle mix data is not readily available. Towards addressing this data unavailability challenge, the team considered a quasi-induced exposure (QIE) method to generate vehicle mix data for jurisdictions without vehicle mix data and subsequent SPF and SDF development using these predicted variables. Quasi-induced exposure (QIE) method is an effective technique used for estimating a specific driving or vehicle population exposure when real exposure data are not available (Stamtiadis & Deacon, 1997). The basic idea of this method is that the proportion of a driver/vehicle category not-at-fault in two-vehicle collisions is related to the exposure of that driver/vehicle category in the entire driving population at the location. To achieve reliable estimates, rather than applying the QIE on a site-by-site basis, our approach will aggregate nearby sites to get a large enough sample to estimate the proportion of certain driving populations using the QIE method for inclusion in the count models. The site aggregation will be supplemented by a statistical test to assure the conceptual validity.

Let d denote the vehicle mix variables ($d = 1, \dots, D$) with j levels ($j = 1, \dots, J$) for which we need the vehicle proportions. Let i be a site (segment or intersection). At the site i, let n_i be the total not-at-fault drivers (reported at this site and $c_{d,j,i}$ be the number of not-at-fault drivers falling into the level j for the demographic variable d at this site i. The sample proportion of not-at-fault drivers in level j of vehicle mix variable d at roadway entity i is,

$$p_{d,j,i} = \frac{c_{d,j,i}}{n_i}$$

For the normal distribution to approximate the binomial distribution, the true population proportion, $p_{d,j,i}$ has to be sufficiently large (Agresti, 2007). The site i is checked to fulfill the condition $\sum n_i . p_{d,j,i} \geq 5$, equivalently $\sum c_{d,j,i} \geq 5$, to be considered as sufficiently large. If the condition is not met, the next adjacent site is aggregated with site i and the condition is checked again. This procedure is repeated until the condition $\sum n_i . p_{d,j,i} \geq 5$ is met or the last site on same road is reached. If the condition is still not met when the last site on same road is reached, all sites in current iteration will be aggregated into previous iteration, and the QIE proportions of previous iteration will be adjusted accordingly. Assuming there are I sites that are aggregated in this process. A final proportion can be calculated as

$$p_{d,j,I} = \frac{\sum_{i=1}^{I} c_{d,j,i}}{\sum_{i=1}^{I} n_i}$$

Then this value is used for all sites $i \in I$.

The proposed QIE approach offers an important benefit for incorporating vehicle mix data in crash frequency and severity models. It allows us to accommodate vehicle information purely relying on crash data. Thus, this approach can be applicable universally – all facility types for building vehicle mix data. At the same time, the relative appropriateness of the approach can be easily evaluated. For example, the QIE approach can be applied to locations with observed vehicle mix data allowing us to compare the performance of the method. The research team has applied the QIE method in NCHRP Project 17-85 project for improving severity prediction. Once the QIE data are generated, research approaches outlined for states with data can be directly applied to these states for developing crash frequency and severity models.

Sample Analysis

Here we use a sample analysis to illustrate the above process of generating aggregate-level vehicle mix information. The target vehicle mix variables are proportions of passenger car (PC), truck, and SUV in the total driving population at the site. Crashes are first assigned and aggregated in each site with the aggregation procedure mentioned above. The QIE calculation steps are described below. Frequencies for total not-at-fault (NAF) vehicles by vehicle type (i.e. PC, truck, and SUV) are calculated and assigned to each site by matching mileposts, as illustrated in Table A.1 below.

Table A.1 Frequencies for Total NAF Vehicles in Each Site

Route ID	Start Milepost	End Milepost	NAF Vehicles				
			Total	PC	Truck	SUV	Other
1	0	1	1	0	0	1	0
1	1	2	0	0	0	0	0
1	2	4	2	2	0	0	0
1	4	4.5	0	0	0	0	0
1	4.5	6	2	1	1	0	0
1	6	7	3	2	1	0	0
1	7	8	1	0	0	1	0
1	8	10	7	4	2	0	1
1	10	10.5	1	1	0	0	0
1	10.5	12	0	0	0	0	0
1	12	13	14	10	2	1	1
2	10	10.5	0	0	0	0	0
2	10.5	13	3	1	1	1	0
2	13	15	5	3	1	1	0
2	15	16	5	4	1	0	0
3	0	2	5	2	1	1	1
3	2	4	9	3	2	2	2
3	4	6	7	6	0	1	0
3	6	7	1	1	0	0	0

Within the same site (partitioned by Route ID), each site is examined sequentially to check against the condition of $c_{d,j,i} \geq 5$ until the last site of the same route, that is, at which row the cumulative sum reaches 5. Once met, the frequencies are summed up to that row. For instance, if we consider aggregating PC illustrated in Table A.1, the first 6 rows are summed to reach to a frequency of 5. Since there is a total of 5 NAF PC accumulated in the first 6 sites, 5 is used to calculate the percentage of PC at the first 6 sites. The cumulative count is reset to zero from the next row. Since the aggregation is also partitioned by Route ID, if Route ID changes, the aggregation stops, and a new aggregation begins from the next site. In the case where there are not enough observations to calculate another aggregated proportion such as the last row, we need to aggregate all remaining rows to previous aggregated sites to get a proportion for NAF PC.

Aggregated frequencies are used to calculate the percentage of that group (rows used in aggregation) by taking the total number of NAF vehicles of that group as the nominator and the total NAF vehicles at these sites as the denominator. For example, for the first 6 rows, the

frequency for NAF PC is 5 and the frequency for total NAF PC is 7. Therefore, the proportion of PC becomes $\frac{5}{7} = 0.71$ or 71%. Vehicle mix proportions in each site are shown in Table A.2.

Table A.2 Calculation of Vehicle Mix Proportions

Route ID	Start Milepost	End Milepost	NAF Vehicle	NAF Vehicle Sum	NAF PC	NAF PC Sum	%PC	NAF Truck	NAF Truck Sum	%Truck
1	0	1	1	7	0	5	71%	0	2	29%
1	1	2	0	7	0	5	71%	0	2	29%
1	2	4	2	7	2	5	71%	0	2	29%
1	4	4.5	0	7	0	5	71%	0	2	29%
1	4.5	6	2	7	1	5	71%	1	2	29%
1	6	7	3	7	2	5	71%	1	2	29%
1	7	8	1	9	0	5	56%	0	2	22%
1	8	10	7	9	4	5	56%	2	2	22%
1	10	10.5	1	9	1	5	56%	0	2	22%
1	10.5	12	0	14	0	10	71%	0	2	14%
1	12	13	14	14	10	10	71%	2	2	14%
2	10	10.5	0	13	0	8	62%	0	3	23%
2	10.5	13	3	13	1	8	62%	1	3	23%
2	13	15	5	13	3	8	62%	1	3	23%
2	15	16	5	13	4	8	62%	1	3	23%
3	0	2	5	14	2	5	36%	1	3	21%
3	2	4	9	14	3	5	36%	2	3	21%
3	4	6	7	8	6	7	88%	0	0	0%
3	6	7	1	8	1	7	88%	0	0	0%

APPENDIX B

Mean Absolute Deviation and Mean Squared Prediction Error Values

In this project, the research team estimated and compared three model systems: (a) calibrated HSM model, (b) Negative Binomial-Ordered Probit Fractional Split (NB-OPFS) model, and (c) Multivariate Poisson-lognormal (MVPLN) model for each facility type by employing two different measures of fit: mean absolute deviation (MAD) and mean squared prediction error (MSPE). The lower the value of the measures, the better the model predicts the observed crashes. In this section, the MAD and MSPE values for all severity levels by facility for the three model systems are presented in Table B.1 and Table B.2.

Table B.1: Model Performance Measures for Different Facilities (Estimation Samples)
Table B.2: Model Performance Measures for Different Facilities (Validation Samples)

Table B.1 Model Performance Measures for Different Facilities (Estimation Samples)

Estimation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
Urban Limited Access	ULA4LD	MAD	HSM	11.610	2.562	1.329	0.373	0.111	15.418
			NB-OPFS	8.789	2.189	1.168	0.394	0.147	11.982
			MVPLN	14.461	3.638	1.511	0.389	0.078	19.600
		MSPE	HSM	1,731.776	57.441	13.299	1.093	0.099	2,740.113
			NB-OPFS	1,640.001	51.578	12.262	1.138	0.123	2,553.226
			MVPLN	4,700.710	253.437	31.589	1.870	0.094	8,125.720
	ULA6LD	MAD	HSM	17.252	5.101	2.190	0.635	0.200	23.600
			NB-OPFS	19.543	5.436	2.478	0.749	0.263	26.850
			MVPLN	31.340	7.040	2.830	0.790	0.210	41.350
		MSPE	HSM	2,818.570	197.743	33.726	2.734	0.211	5,207.547
			NB-OPFS	2,725.647	193.371	35.335	2.913	0.282	5,102.852
			MVPLN	10,494.900	429.580	48.590	4.910	0.200	16,765.520
	ULA8LD	MAD	HSM	21.675	7.163	2.836	0.792	0.287	30.385
			NB-OPFS	25.073	8.296	3.202	0.920	0.352	35.585
			MVPLN	27.081	7.831	3.030	0.766	0.282	37.328
		MSPE	HSM	2,978.741	313.672	51.123	2.369	0.294	5,962.961
			NB-OPFS	3,782.189	390.923	57.014	3.247	0.411	7,705.003
			MVPLN	4,289.505	340.893	48.400	2.056	0.287	7,815.705
	ULA10LD	MAD	HSM	23.124	7.388	2.478	0.713	0.280	31.547
			NB-OPFS	23.526	7.860	2.769	0.802	0.333	32.612
			MVPLN	30.052	8.917	2.748	0.736	0.282	40.777
		MSPE	HSM	1,935.451	188.664	19.335	1.508	0.258	3,647.101
			NB-OPFS	1,832.173	211.636	22.320	1.600	0.287	3,629.583
			MVPLN	3,218.922	270.172	23.675	1.634	0.264	5,814.562
Rural Limited Access	RLA4LD	MAD	HSM	3.389	0.836	0.658	0.247	0.135	4.404
			NB-OPFS	3.356	0.842	0.709	0.268	0.166	4.594
			MVPLN	5.479	1.248	0.743	0.287	0.154	7.283
		MSPE	HSM	57.808	3.349	2.163	0.358	0.106	104.973
			NB-OPFS	52.684	3.585	2.681	0.385	0.202	102.313
			MVPLN	1,339.073	112.812	6.469	0.830	0.242	2,519.243

Estimation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
	RLA6LD	MAD	HSM	4.761	1.549	0.885	0.394	0.144	6.484
			NB-OPFS	6.312	1.715	1.297	0.442	0.245	8.974
			MVPLN	8.942	2.217	1.283	0.363	0.163	12.099
		MSPE	HSM	95.587	9.464	2.996	1.520	0.139	185.649
			NB-OPFS	224.020	15.503	11.105	1.371	0.534	498.225
			MVPLN	641.213	38.730	19.942	1.167	0.272	1,275.582
	RLA8LD	MAD	HSM	9.183	3.504	1.628	0.562	0.322	12.836
			NB-OPFS	10.487	3.194	2.390	0.891	0.651	14.785
			MVPLN	26.169	7.545	2.166	0.649	0.382	35.216
		MSPE	HSM	304.540	38.248	9.133	0.892	0.292	625.501
			NB-OPFS	451.354	35.456	22.426	2.667	1.403	924.313
			MVPLN	2,270.475	189.498	14.872	1.155	0.373	4,215.491
Urban Arterials	UA2LUD	MAD	HSM	7.981	1.382	0.977	0.579	0.081	10.162
			NB-OPFS	7.799	1.336	1.074	0.892	0.117	10.208
			MVPLN	9.642	1.525	1.100	0.564	0.070	12.140
		MSPE	HSM	1,966.835	62.672	22.462	5.689	0.154	3,267.853
			NB-OPFS	1,400.254	34.457	18.201	14.102	0.254	2,221.963
			MVPLN	2,244.610	60.160	18.933	3.112	0.088	3,502.308
	UA3L	MAD	HSM	24.092	3.874	2.071	0.774	0.124	30.390
			NB-OPFS	23.084	3.880	2.344	1.293	0.155	29.934
			MVPLN	29.431	5.166	2.308	0.780	0.079	37.096
		MSPE	HSM	6,071.902	153.167	35.435	4.903	0.179	9,106.347
			NB-OPFS	5,698.583	153.618	36.053	8.839	0.190	8,641.417
			MVPLN	19,007.177	554.127	100.270	8.039	0.125	29,717.132
	UA5L	MAD	HSM	13.669	2.653	1.746	1.048	0.133	17.811
			NB-OPFS	12.478	2.771	1.659	1.022	0.146	16.470
			MVPLN	65.800	13.000	6.100	2.000	0.200	86.400
		MSPE	HSM	2,200.357	79.629	40.071	11.783	0.206	3,821.068
			NB-OPFS	1,549.726	80.006	37.329	11.976	0.280	2,848.565
			MVPLN	127,510.100	5,115.900	981.000	53.900	0.700	217,581.600
	UA4LUD	MAD	HSM	8.711	1.464	1.093	0.827	0.068	11.242
			NB-OPFS	8.263	1.713	1.180	0.971	0.103	11.161

Estimation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
			MVPLN	11.175	1.685	1.321	0.790	0.057	14.293
		MSPE	HSM	943.465	32.299	10.512	3.575	0.061	1,538.145
			NB-OPFS	731.642	28.372	15.798	13.470	0.140	1,384.730
			MVPLN	2,542.304	68.634	18.311	3.549	0.055	3,952.839
	UA4LD	MAD	HSM	9.977	1.507	1.087	0.898	0.075	12.581
			NB-OPFS	8.588	1.427	1.092	1.118	0.088	11.146
			MVPLN	11.021	1.703	1.088	0.857	0.071	13.972
		MSPE	HSM	1,335.919	33.522	9.507	4.340	0.078	2,002.542
			NB-OPFS	1,093.293	30.626	11.495	12.805	0.087	1,723.518
			MVPLN	2,411.714	79.197	11.754	3.599	0.070	3,739.226
Rural Arterials	RA2LUD	MAD	HSM	1.262	0.355	0.335	0.166	0.069	1.737
			NB-OPFS	1.294	0.355	0.338	0.172	0.081	1.793
			MVPLN	1.311	0.359	0.350	0.172	0.064	1.842
		MSPE	HSM	11.716	0.966	0.809	0.402	0.064	23.910
			NB-OPFS	14.326	0.914	0.864	0.421	0.078	26.907
			MVPLN	18.171	1.620	0.936	0.518	0.055	39.274
	RA3L	MAD	HSM	--	--	--	--	--	--
			NB-OPFS	1.101	0.315	0.288	0.147	0.068	1.515
			MVPLN	1.143	0.348	0.352	0.173	0.082	1.693
		MSPE	HSM	--	--	--	--	--	--
			NB-OPFS	6.380	0.494	0.351	0.162	0.044	9.747
			MVPLN	6.282	0.638	0.479	0.197	0.046	12.229
	RA5L	MAD	HSM	--	--	--	--	--	--
			NB-OPFS	2.443	1.053	0.605	0.292	0.126	3.703
			MVPLN	2.026	0.970	0.483	0.178	0.094	3.406
		MSPE	HSM	--	--	--	--	--	--
			NB-OPFS	23.261	9.400	1.698	0.422	0.102	65.247
			MVPLN	24.898	9.716	0.958	0.179	0.045	76.442
	RA4LUD	MAD	HSM	1.376	0.286	0.293	0.118	0.052	2.000
			NB-OPFS	1.316	0.301	0.303	0.132	0.061	1.810
			MVPLN	1.484	0.323	0.330	0.166	0.060	2.042
		MSPE	HSM	22.539	0.862	2.295	0.376	0.078	65.808

Estimation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
			NB-OPFS	11.008	0.467	0.446	0.112	0.037	19.488
			MVPLN	16.066	0.575	0.521	0.142	0.036	28.099
	RA4LD	MAD	HSM	2.178	0.492	0.410	0.150	0.064	3.151
			NB-OPFS	1.996	0.478	0.394	0.168	0.074	2.765
			MVPLN	2.276	0.528	0.440	0.161	0.064	3.137
		MSPE	HSM	62.828	3.368	2.470	0.403	0.082	142.156
			NB-OPFS	49.955	2.347	1.345	0.309	0.072	89.212
			MVPLN	61.920	3.189	1.649	0.310	0.076	113.677
Urban Intersections	U3ST	MAD	HSM	10.697	2.614	1.485	0.536	0.103	14.755
			NB-OPFS	7.955	1.957	1.218	0.468	0.141	10.560
			MVPLN	8.282	1.943	1.133	0.434	0.075	10.742
		MSPE	HSM	740.082	28.528	6.912	1.209	0.067	1,170.449
			NB-OPFS	654.272	23.848	6.424	1.133	0.085	988.858
			MVPLN	658.373	23.903	5.408	1.057	0.068	1,000.423
	U4ST	MAD	HSM	22.688	4.585	2.280	0.851	0.138	28.968
			NB-OPFS	15.511	3.982	2.111	0.791	0.198	20.646
			MVPLN	14.399	3.309	1.691	0.698	0.143	18.294
		MSPE	HSM	1,730.148	67.344	14.075	3.894	0.092	2,691.386
			NB-OPFS	1,233.370	63.276	15.251	3.713	0.124	2,001.998
			MVPLN	1,180.145	51.650	10.603	3.515	0.089	1,859.286
	U3SG	MAD	HSM	29.691	6.712	3.410	1.355	0.265	39.201
			NB-OPFS	22.369	5.199	2.982	1.143	0.292	28.590
			MVPLN	22.189	5.100	2.714	1.160	0.255	28.278
		MSPE	HSM	2,706.716	110.706	24.066	5.033	0.194	4,341.123
			NB-OPFS	2,108.212	82.445	20.260	4.509	0.199	3,185.014
			MVPLN	1,956.986	82.438	17.919	4.276	0.187	3,048.832
	U4SG	MAD	HSM	39.847	8.430	3.823	1.172	0.244	51.626
			NB-OPFS	21.342	6.232	2.811	0.951	0.344	27.299
			MVPLN	21.594	5.885	2.494	0.931	0.198	27.973
		MSPE	HSM	4,036.150	177.761	33.299	4.405	0.181	6,509.970
			NB-OPFS	2,105.449	118.666	22.261	3.408	0.284	3,018.289
			MVPLN	1,762.651	108.511	18.065	3.319	0.175	2,841.279

Estimation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
Rural Intersections	R3ST	MAD	HSM	1.007	0.354	0.265	0.101	0.035	1.546
			NB-OPFS	0.703	0.283	0.207	0.090	0.040	1.042
			MVPLN	0.736	0.311	0.210	0.099	0.039	1.116
		MSPE	HSM	6.855	0.840	0.386	0.124	0.022	15.937
			NB-OPFS	4.718	0.686	0.300	0.113	0.022	10.745
			MVPLN	5.427	0.815	0.319	0.112	0.023	12.729
	R4ST	MAD	HSM	2.039	0.939	0.555	0.177	0.126	3.339
			NB-OPFS	1.730	0.805	0.492	0.179	0.144	2.782
			MVPLN	1.622	0.771	0.466	0.157	0.083	2.569
		MSPE	HSM	328.781	60.992	3.149	0.332	0.091	780.322
			NB-OPFS	297.455	56.363	3.147	0.331	0.128	710.693
			MVPLN	329.452	60.327	2.822	0.302	0.083	776.020
	R4SG	MAD	HSM	7.605	2.351	1.139	0.270	0.181	10.781
			NB-OPFS	4.346	1.469	0.823	0.253	0.148	5.806
			MVPLN	4.646	1.663	0.809	0.254	0.128	6.025
		MSPE	HSM	191.295	15.832	3.359	0.239	0.120	372.474
			NB-OPFS	111.508	8.977	2.277	0.226	0.125	202.796
			MVPLN	115.091	14.453	2.219	0.238	0.127	208.971

Table B.2 Model Performance Measures for Different Facilities (Validation Samples)

Validation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
Urban Limited Access	ULA4LD	MAD	HSM	11.183	2.524	1.261	0.336	0.110	14.835
			NB-OPFS	8.319	2.126	1.116	0.375	0.146	11.405
			MVPLN	13.866	3.529	1.485	0.384	0.076	18.874
		MSPE	HSM	1,584.753	58.495	11.990	0.992	0.106	2,566.635
			NB-OPFS	1,474.880	54.402	10.830	1.022	0.128	2,371.210
			MVPLN	6,824.570	356.320	49.690	3.111	0.098	11,973.408
	ULA6LD	MAD	HSM	17.674	4.664	2.096	0.629	0.210	23.451
			NB-OPFS	19.749	5.085	2.393	0.739	0.273	26.403
			MVPLN	30.080	6.590	2.790	0.760	0.220	39.550
		MSPE	HSM	2,076.414	107.300	19.900	1.622	0.218	3,495.032
			NB-OPFS	2,641.533	126.904	25.371	2.146	0.300	4,444.963
			MVPLN	5,407.690	249.300	32.830	2.800	0.240	8,787.640
	ULA8LD	MAD	HSM	20.823	7.058	2.812	0.771	0.262	29.514
			NB-OPFS	24.185	8.243	3.128	0.900	0.326	34.720
			MVPLN	26.690	7.620	3.000	0.770	0.270	36.870
		MSPE	HSM	1,937.886	260.032	37.884	2.533	0.294	4,202.175
			NB-OPFS	2,737.388	335.387	47.021	3.195	0.393	5,938.784
			MVPLN	3,446.720	316.920	43.720	2.630	0.330	6,559.720
	ULA10LD	MAD	HSM	22.911	7.069	2.316	0.639	0.257	30.865
			NB-OPFS	23.621	7.850	2.701	0.816	0.332	32.981
			MVPLN	31.520	9.340	2.580	0.750	0.280	42.520
		MSPE	HSM	2,046.815	188.312	17.392	0.996	0.216	3,687.552
			NB-OPFS	1,899.651	212.830	23.080	1.517	0.281	3,701.770
			MVPLN	3,545.040	309.830	20.860	1.400	0.230	6,404.200
Rural Limited Access	RLA4LD	MAD	HSM	3.746	0.882	0.699	0.263	0.145	4.826
			NB-OPFS	3.748	0.873	0.735	0.281	0.173	5.042
			MVPLN	5.674	1.263	0.778	0.300	0.159	7.538
		MSPE	HSM	99.392	4.872	2.224	0.407	0.126	169.756
			NB-OPFS	98.801	4.558	2.476	0.429	0.162	165.842
			MVPLN	640.647	47.055	4.347	0.624	0.170	1,174.071
	RLA6LD	MAD	HSM	6.001	1.717	1.043	0.368	0.173	8.174
			NB-OPFS	6.700	1.646	1.177	0.425	0.275	9.176
			MVPLN	11.285	2.634	1.257	0.376	0.189	14.858
		MSPE	HSM	327.083	16.297	7.545	0.733	0.161	588.322
			NB-OPFS	259.391	13.336	6.518	0.868	0.613	465.925
			MVPLN	2,300.105	116.324	14.426	0.935	0.348	3,885.785
	RLA8LD	MAD	HSM	8.525	3.399	1.502	0.576	0.374	11.822

Validation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
			NB-OPFS	11.172	3.185	2.358	0.963	0.655	16.119
			MVPLN	28.785	9.078	2.311	0.678	0.423	39.635
		MSPE	HSM	231.007	42.025	6.755	0.815	0.372	483.786
			NB-OPFS	441.207	39.702	17.859	2.641	1.511	910.746
			MVPLN	2,553.720	247.193	15.708	1.047	0.499	4,910.781
Urban Arterials	UA2LUD	MAD	HSM	9.105	1.562	1.099	0.608	0.085	11.660
			NB-OPFS	8.483	1.482	1.124	0.900	0.123	11.036
			MVPLN	9.350	1.468	1.069	0.567	0.078	11.793
		MSPE	HSM	2,500.427	80.909	24.656	5.361	0.141	4,048.183
			NB-OPFS	1,917.131	61.948	22.062	14.100	0.297	3,076.191
			MVPLN	2,125.696	64.186	16.421	2.713	0.120	3,253.599
	UA3L	MAD	HSM	23.489	3.838	2.140	0.911	0.127	29.847
			NB-OPFS	22.315	3.841	2.377	1.360	0.158	29.128
			MVPLN	30.972	5.440	2.377	0.847	0.082	38.971
		MSPE	HSM	4,987.063	147.144	37.219	8.592	0.239	7,748.806
			NB-OPFS	4,244.185	147.902	38.422	12.088	0.258	6,809.689
			MVPLN	21,040.131	655.777	105.462	10.415	0.190	32,967.818
	UA5L	MAD	HSM	17.086	2.814	1.760	0.950	0.123	21.330
			NB-OPFS	16.330	3.048	1.759	0.979	0.147	20.736
			MVPLN	45.266	9.062	4.806	1.588	0.145	60.238
		MSPE	HSM	2,473.710	68.082	22.922	4.311	0.127	3,743.314
			NB-OPFS	2,975.455	94.431	28.119	6.294	0.274	4,632.154
			MVPLN	47,425.956	1,748.358	413.964	19.454	0.320	79,792.879
	UA4LUD	MAD	HSM	8.440	1.360	1.025	0.776	0.067	10.733
			NB-OPFS	7.904	1.616	1.072	0.861	0.096	10.456
			MVPLN	10.394	1.529	1.238	0.763	0.056	13.233
		MSPE	HSM	1,154.729	23.826	8.534	3.199	0.055	1,710.040
			NB-OPFS	806.398	20.310	8.781	6.314	0.078	1,211.554
			MVPLN	1,396.287	35.108	10.770	3.165	0.052	2,130.514
	UA4LD	MAD	HSM	10.743	1.705	1.213	0.891	0.078	13.639
			NB-OPFS	9.434	1.612	1.211	1.138	0.093	12.259
			MVPLN	11.675	1.794	1.167	0.878	0.074	14.777
		MSPE	HSM	2,463.751	56.808	17.231	4.748	0.102	3,574.123
			NB-OPFS	2,160.524	58.814	17.665	12.373	0.118	3,166.138
			MVPLN	2,982.612	80.558	17.378	4.001	0.082	4,430.998
Rural Arterials	RA2LUD	MAD	HSM	1.394	0.381	0.369	0.177	0.074	1.955
			NB-OPFS	1.317	0.371	0.356	0.175	0.083	1.859
			MVPLN	1.321	0.366	0.363	0.173	0.067	1.866

Validation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
		MSPE	HSM	52.214	3.420	2.372	0.556	0.063	115.390
			NB-OPFS	44.504	3.111	2.137	0.567	0.080	99.361
			MVPLN	41.908	3.156	2.087	0.568	0.060	93.585
	RA3L	MAD	HSM	--	--	--	--	--	--
			NB-OPFS	0.346	0.316	0.157	0.082	1.713	1.220
			MVPLN	1.263	0.401	0.418	0.190	0.105	1.961
		MSPE	HSM	--	--	--	--	--	--
			NB-OPFS	9.083	0.681	0.619	0.125	0.051	19.346
			MVPLN	7.234	0.832	0.994	0.148	0.067	19.912
	RA5L	MAD	HSM	--	--	--	--	--	--
			NB-OPFS	1.125	0.373	0.337	0.144	0.071	1.819
			MVPLN	0.846	0.271	0.265	0.085	0.077	1.248
		MSPE	HSM	--	--	--	--	--	--
			NB-OPFS	2.997	0.441	0.305	0.067	0.029	8.494
			MVPLN	2.007	0.343	0.154	0.040	0.033	3.704
	RA4LUD	MAD	HSM	1.379	0.288	0.309	0.130	0.054	1.996
			NB-OPFS	1.319	0.294	0.324	0.138	0.064	1.839
			MVPLN	1.473	0.316	0.350	0.172	0.064	2.043
		MSPE	HSM	20.442	0.779	1.168	0.238	0.058	43.399
			NB-OPFS	9.841	0.405	0.535	0.116	0.045	17.359
			MVPLN	12.201	0.412	0.601	0.142	0.045	21.098
	RA4LD	MAD	HSM	2.738	0.600	0.452	0.164	0.067	3.859
			NB-OPFS	2.322	0.547	0.442	0.180	0.077	3.196
			MVPLN	2.644	0.583	0.489	0.178	0.071	3.612
		MSPE	HSM	241.902	10.522	3.722	0.482	0.084	448.574
			NB-OPFS	169.251	6.628	2.410	0.394	0.071	293.812
			MVPLN	197.469	6.810	2.912	0.447	0.095	344.725
Urban Intersections	U3ST	MAD	HSM	9.526	2.527	1.412	0.544	0.102	13.363
			NB-OPFS	7.083	1.906	1.190	0.472	0.136	9.641
			MVPLN	7.507	1.905	1.101	0.432	0.074	9.972
		MSPE	HSM	454.270	23.621	6.999	1.312	0.068	794.086
			NB-OPFS	379.889	19.127	6.487	1.191	0.084	630.450
			MVPLN	387.403	19.201	5.565	1.125	0.070	643.688
	U4ST	MAD	HSM	23.921	4.736	2.460	0.871	0.158	30.485
			NB-OPFS	13.412	3.630	1.870	0.720	0.207	17.353
			MVPLN	14.784	3.349	1.767	0.695	0.153	18.629
		MSPE	HSM	1,610.712	62.905	15.936	2.917	0.099	2,495.293
			NB-OPFS	938.653	53.076	13.460	2.522	0.138	1,468.905

Validation Sample									
Facility Groups	**Facilities**	**Measures**	**Models**	**O**	**C**	**B**	**A**	**K**	**Total**
			MVPLN	1,083.251	47.536	12.159	2.506	0.097	1,675.861
	U3SG	MAD	HSM	30.665	7.357	3.679	1.490	0.261	40.686
			NB-OPFS	23.204	5.708	3.002	1.245	0.291	29.997
			MVPLN	23.230	5.668	2.848	1.240	0.262	30.006
		MSPE	HSM	2,522.024	133.544	27.348	6.702	0.199	4,233.721
			NB-OPFS	2,042.829	104.446	22.066	6.182	0.208	3,227.394
			MVPLN	1,907.361	106.941	20.814	5.866	0.201	3,090.407
	U4SG	MAD	HSM	39.561	8.704	4.038	1.178	0.226	51.722
			NB-OPFS	21.789	6.447	2.956	0.953	0.334	28.094
			MVPLN	22.630	6.139	2.594	0.931	0.188	29.372
		MSPE	HSM	3,795.830	173.837	35.832	4.350	0.170	6,210.259
			NB-OPFS	1,901.839	120.083	23.126	3.289	0.278	2,780.917
			MVPLN	1,919.262	116.380	18.867	3.305	0.166	3,096.915
Rural Intersections	R3ST	MAD	HSM	1.165	0.390	0.292	0.116	0.043	1.781
			NB-OPFS	0.821	0.300	0.236	0.101	0.046	1.221
			MVPLN	0.846	0.334	0.238	0.108	0.044	1.280
		MSPE	HSM	10.770	0.914	0.508	0.156	0.029	23.722
			NB-OPFS	7.879	0.710	0.422	0.140	0.029	17.006
			MVPLN	8.301	0.867	0.436	0.135	0.030	18.127
	R4ST	MAD	HSM	1.828	0.832	0.574	0.229	0.109	3.038
			NB-OPFS	1.461	0.687	0.480	0.199	0.134	2.316
			MVPLN	1.449	0.687	0.477	0.183	0.074	2.270
		MSPE	HSM	27.342	4.153	1.355	0.245	0.067	64.858
			NB-OPFS	27.289	4.715	1.276	0.220	0.075	67.154
			MVPLN	23.174	4.009	1.123	0.200	0.065	55.513
	R4SG	MAD	HSM	5.522	2.482	1.096	0.429	0.124	8.474
			NB-OPFS	5.643	2.053	1.061	0.344	0.131	7.580
			MVPLN	6.785	1.889	1.012	0.347	0.103	7.570
		MSPE	HSM	67.506	14.777	2.493	0.512	0.063	154.213
			NB-OPFS	107.768	13.406	2.613	0.442	0.066	202.047
			MVPLN	183.256	15.843	2.531	0.490	0.066	229.277

APPENDIX C

Model Parameters

The research team developed Negative Binomial-Ordered Probit Fractional Split (NB-OPFS) model and Multivariate Poisson-lognormal (MVPLN) model for each facility type incorporating vehicle mix data. In this section, we provide the detailed model estimation results with t-statistics of all the facilities for both NB-OPFS and MVPLN model systems. The model estimation results are presented from Table C.1 to Table C.48.

Table C.1-Table C.8 show the NB-OPFS and MVPLN model results of the urban limited access facility types:

Table C.1: NB-OPFS Model Coefficients for ULA4LD Segments
Table C.2: MVPLN Model Coefficients for ULA4LD Segments
Table C.3: NB-OPFS Model Coefficients for ULA6LD Segments
Table C.4: MVPLN Model Coefficients for ULA6LD Segments
Table C.5: NB-OPFS Model Coefficients for ULA8LD Segments
Table C.6: MVPLN Model Coefficients for ULA8LD Segments
Table C.7: NB-OPFS Model Coefficients for ULA10LD Segments
Table C.8: MVPLN Model Coefficients for ULA10LD Segments

Table C.9-Table C.14 show the NB-OPFS and MVPLN model results of the rural limited access facility types:

Table C.9: NB-OPFS Model Coefficients for RLA4LD Segments
Table C.10: MVPLN Model Coefficients for RLA4LD Segments
Table C.11: NB-OPFS Model Coefficients for RLA6LD Segments
Table C.12: MVPLN Model Coefficients for RLA6LD Segments
Table C.13: NB-OPFS Model Coefficients for RLA8LD Segments
Table C.14: MVPLN Model Coefficients for RLA8LD Segments

Table C.15-Table C.24 show the NB-OPFS and MVPLN model results of the urban arterial facility types:

Table C.15: NB-OPFS Model Coefficients for UA2LUD Segments
Table C.16: MVPLN Model Coefficients for UA2LUD Segments
Table C.17: NB-OPFS Model Coefficients for UA3L Segments
Table C.18: MVPLN Model Coefficients for UA3L Segments
Table C.19: NB-OPFS Model Coefficients for UA5L Segments
Table C.20: MVPLN Model Coefficients for UA5L Segments
Table C.21: NB-OPFS Model Coefficients for UA4LUD Segments
Table C.22: MVPLN Model Coefficients for UA4LUD Segments
Table C.23: NB-OPFS Model Coefficients for UA4LD Segments
Table C.24: MVPLN Model Coefficients for UA4LD Segments

Table C.25-Table C.34 show the NB-OPFS and MVPLN model results of the rural arterial facility types:

Table C.25: NB-OPFS Model Coefficients for RA2LUD Segments
Table C.26: MVPLN Model Coefficients for RA2LUD Segments

Table C.27: NB-OPFS Model Coefficients for RA3L Segments
Table C.28: MVPLN Model Coefficients for RA3L Segments
Table C.29: NB-OPFS Model Coefficients for RA5L Segments
Table C.30: MVPLN Model Coefficients for RA5L Segments
Table C.31: NB-OPFS Model Coefficients for RA4LUD Segments
Table C.32: MVPLN Model Coefficients for RA4LUD Segments
Table C.33: NB-OPFS Model Coefficients for RA4LD Segments
Table C.34: MVPLN Model Coefficients for RA4LD Segments

Table C.35-Table C.42 show the NB-OPFS and MVPLN model results of the urban intersection facility types:

Table C.35: NB-OPFS Model Coefficients for U3ST Intersections
Table C.36: MVPLN Model Coefficients for U3ST Intersections
Table C.37: NB-OPFS Model Coefficients for U4ST Intersections
Table C.38: MVPLN Model Coefficients for U4ST Intersections
Table C.39: NB-OPFS Model Coefficients for U3SG Intersections
Table C.40: MVPLN Model Coefficients for U3SG Intersections
Table C.41: NB-OPFS Model Coefficients for U4SG Intersections
Table C.42: MVPLN Model Coefficients for U4SG Intersections

Table C.43-Table C.48 show the NB-OPFS and MVPLN model results of the rural intersection facility types:

Table C.43: NB-OPFS Model Coefficients for R3ST Intersections
Table C.44: MVPLN Model Coefficients for R3ST Intersections
Table C.45: NB-OPFS Model Coefficients for R4ST Intersections
Table C.46: MVPLN Model Coefficients for R4ST Intersections
Table C.47: NB-OPFS Model Coefficients for R4SG Intersections
Table C.48: MVPLN Model Coefficients for R4SG Intersections

Urban Limited Access Facility Group

Urban limited access 4-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for ULA4LD facility are shown in Tables below.

Table C.1 NB-OPFS Model Coefficients for ULA4LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-2.781	-6.145	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.327	13.693
Threshold between C-B	--	--	0.914	36.385
Threshold between B-A	--	--	1.567	51.278
Threshold between A-K	--	--	2.114	50.092
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	--	--

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Lane width (base: ≤12 feet)				
LW>12	0.369	3.528	--	--
Inside shoulder width (base: ≥6 feet)				
ISW<2	0.365	3.703	--	--
ISW2-3	0.626	5.532	--	--
ISW4-5	0.205	3.295	--	--
Outside shoulder width (base: ≥8 feet)				
OSW<8	0.301	2.820	--	--
Shoulder type (base: paved)				
Unpaved	--	--	-0.230	-7.662
Speed limit (base: >65 mph)				
SL≤60	-0.247	-3.009	-0.062	-1.685
SL61-65	-0.386	-5.444	-0.085	-2.344
Traffic Characteristics				
Ln (AADT)	0.471	11.501	--	--
%Truck	-0.031	-5.377	-0.006	-3.383
%SUT	-0.084	-4.434	-0.012	-1.689
HTZ (base: Indicator for <85th percentile of truck percentage)	0.760	4.815	--	--
Interaction Effects				
HTZ*Unpaved shoulder	-0.626	-4.207	--	--
State Indicators	*(Base: Texas, Florida, Minnesota, and Washington)*		*(Base: Texas, California, Illinois, and Florida)*	
State-California	0.660	9.203	--	--
State-Illinois	1.043	11.627	--	--
State-Minnesota	--	--	-0.341	-6.102
State-Washington	--	--	-0.277	-8.205
Overdispersion parameter				
Constant	4.011	33.651	--	--
State-California	-3.049	-21.793	--	--
BIC	43,180.880			
Log-Likelihood	-21,456.600			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.2 MVPLN Model Coefficients for ULA4LD Segments

Variable Names	O	C	B	A	K
Constant	-5.358	-6.648	-6.181	-6.138	-5.392
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: ≤ 12 ft)					
LW>12	0.459	0.478	0.339	0.393	--
Median width (base: ≤ 20 feet)					
MW>20	0.309	0.288	0.289	0.405	0.511
Shoulder type (base: paved)					
Unpaved	0.294	0.301	0.322	0.360	--
Speed limit (base: >65 mph)					
SL≤60	-0.450	-0.531	-0.399	-0.355	-0.341
SL61-65	-0.349	-0.37	-0.348	-0.457	--
Traffic Characteristics					
Ln (AADT)	0.396	0.378	0.314	0.206	--
%Truck	-0.042	-0.049	-0.037	-0.035	-0.03
HTZ (base: Indicator for <85th percentile of truck percentage)	1.752	1.661	1.519	1.461	1.006
Interaction Effects					
HTZ*Unpaved shoulder	-1.608	-1.331	-1.463	-1.556	-0.622
State Indicators (base: Texas)					
State- California	2.965	3.419	2.888	2.414	1.771
State-Florida	4.173	4.089	3.549	3.364	2.320
State-Illinois	2.892	1.045	2.277	2.169	0.802
State-Minnesota	3.134	3.067	2.415	1.227	--
State-Washington	2.365	2.537	1.508	0.986	0.622
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	2.893	2.976	2.645	2.392	1.687
C		3.190	2.790	2.512	1.778
B			2.567	2.286	1.613
A				2.203	1.479
K					1.201
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.98	0.971	0.948	0.905
C		-	0.975	0.948	0.908
B			-	0.961	0.918
A				-	0.909
K					-
BIC	47, 689				
Log-Likelihood	-23, 398				

Note: -- denotes that the variable is not significant at 90% significant level.

Urban limited access 6-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for ULA6LD facility are shown in Tables below.

Table C.3 NB-OPFS Model Coefficients for ULA6LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-2.990	-3.424	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	-0.211	-1.149
Threshold between C-B	--	--	0.431	2.338
Threshold between B-A	--	--	1.147	6.166
Threshold between A-K	--	--	1.713	9.041
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	--	--
Lane width (≥12 feet)				
LW<12	0.350	4.800	--	--
Median width (base: ≤20 feet)				
MW>20	-0.540	-10.814	0.031	1.804
Outside shoulder width (base: ≥8 feet)				
OSW<8	-0.195	-3.086	0.238	7.552
Shoulder type (base: paved)				
Unpaved	--	--	-0.236	-8.358
Speed limit (base: >65 mph)				
SL≤60	0.551	10.005	-0.217	-8.322
SL61-65	--	--	-0.120	-4.043
Traffic Characteristics				
Ln (AADT)	0.617	8.551	-0.054	-3.517
%Truck	-0.025	-5.175	-0.008	-4.990
%SUT)	-0.085	-4.135	--	--
HTZ (base: Indicator for <85th percentile of truck percentage)	0.320	3.866	--	--
Interaction Effects				
HTZ*SL≤60	--	--	0.153	2.839
State Indicators	*(Base: California, Illinois, Florida, and Minnesota)*		*(Base: California, Illinois and Florida)*	
State-Minnesota	--	--	-0.335	-8.422
State-Texas	-0.531	-7.606	0.114	4.482
State-Washington	-0.148	-3.197	-0.268	-11.234
Overdispersion parameter				
Constant	2.413	41.460	--	--
State-Washington	-1.560	-21.311	--	--
BIC	64,143.380			
Log-Likelihood	-31,937.850			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.4 MVPLN Model Coefficients for ULA6LD Segments

Variable Names	O	C	B	A	K
Constant	-6.039	-7.637	-7.01	-6.93	-5.432
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: 12 feet)					
LW>12	0.301	0.375	--	--	--
LW<12	-0.703	-0.634	-0.604	-0.718	-0.805
Outside shoulder width (base: ≥8 feet)					
OSW<8	-0.465	-0.491	-0.5	-0.521	-0.639
Median width (base: ≤20 feet)					
MW>20	-0.520	-0.528	-0.456	-0.378	-0.284
Shoulder Type (base: paved)					
Unpaved	0.252	--	0.308	0.257	--
Speed limit (base: >65 mph)					
SL≤60	0.516	0.534	0.445	0.42	0.518
SL61-65	--	--	--	-0.182	--
Traffic Characteristics					
Ln (AADT)	0.800	0.850	0.711	0.553	0.332
%Truck	-0.020	-0.026	-0.026	--	--
HTZ (base: Indicator for <85th percentile of truck percentage)	--	0.294	--	--	--
Interaction Effects					
HTZ*Unpaved shoulder	0.884	0.350	0.493	0.454	0.693
State Indicators (base: California)					
State-Florida	0.498	--	--	0.678	--
State-Illinois	-0.313	-3.052	-0.695	--	-1.331
State-Minnesota	-0.266	-0.634	-0.644	-1.566	-1.419
State-Texas	-2.147	-2.342	-1.878	-1.573	-1.444
State-Washington	-0.132	-0.351	-0.948	-1.012	-0.818
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	2.291	2.251	2.042	1.851	1.324
C		2.299	2.065	1.864	1.340
B			1.954	1.732	1.243
A				1.685	1.160
K					0.951
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.981	0.965	0.942	0.897
C		-	0.974	0.947	0.907
B			-	0.955	0.912
A				-	0.917
K					-
BIC	82,107.95				
Log-likelihood	-40,563.23				

Note: -- denotes that the variable is not significant at 90% significant level.

Urban limited access 8-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for ULA8LD facility are shown in Tables below.

Table C.5 NB-OPFS Model Coefficients for ULA8LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-2.092	-2.670	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	-0.583	-2.589
Threshold between C-B	--	--	0.202	0.897
Threshold between B-A	--	--	0.950	4.216
Threshold between A-K	--	--	1.504	6.625
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.011	1.640
Median width (base: ≤20 feet)				
MW>20	-0.171	-3.945	--	--
Outside shoulder width (base: ≥8 feet)				
OSW<8	-0.184	-2.240	0.075	2.011
Inside shoulder width (base: ≥8 feet)				
ISW<4	0.251	4.396	-0.051	-3.061
ISW4-5	0.178	3.131	--	--
ISW6-7	0.290	3.621	--	--
Shoulder type (base: paved)				
Unpaved	0.176	2.214	-0.090	-2.656
Speed limit (base: >65 mph)				
SL≤60	--	--	-0.170	-5.563
SL61-65	--	--	-0.086	-2.574
Traffic Characteristics				
Ln (AADT)	0.519	8.076	-0.079	-4.219
% SUT	-0.365	-6.316	-0.053	-3.403
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.068	3.142
State Indicators	*(Base: California and Florida)*		*(Base: California, Illinois, Florida and Minnesota)*	
State-Illinois	1.260	6.111	--	--
State-Minnesota	-0.540	-3.091	--	--
State-Texas	1.024	5.453	0.141	3.263
State-Washington	0.395	6.061	-0.151	-5.791
Overdispersion parameter				
Constant	1.278	36.995	--	--
State-Texas	3.798	11.440	--	--
BIC	61,487.802			
Log-Likelihood	-30,582.960			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.6 MVPLN Model Coefficients for ULA8LD Segments

Variable Names	O	C	B	A	K
Constant	-8.855	-9.747	-7.645	-8.323	-10.326
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: 12 feet)					
LW>12	0.208	0.159	--	--	--
LW<12	-0.191	-0.121	-0.110	-0.193	--
Outside shoulder width (base: ≥8 feet)					
OSW<8	-0.551	-0.470	-0.466	-0.463	--
Median width (base: ≤20 feet)					
MW>20	-0.329	-0.231	-0.178	-0.154	--
Shoulder Type (base: paved)					
Unpaved	0.290	0.230	0.265	--	--
Speed limit (base: >65 mph)					
SL≤ 60	--	--	-0.217	-0.259	--
SL61-65	--	-0.223	-0.247	-0.221	--
Traffic Characteristics					
Ln (AADT)	1.022	1.006	0.748	0.659	0.714
%Truck	0.031	0.027	0.025	0.036	0.035
%SUT	-0.396	-0.409	-0.423	-0.334	-0.292
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.568	--	--	--	--
Interaction Effects					
HTZ*Unpaved shoulder	0.567	--	--	--	--
State Indicators (base: California)					
State-Florida	0.777	--	--	0.875	--
State-Illinois	1.619	-1.493	1.375	2.009	--
State-Minnesota	-0.603	-0.817	-0.744	-1.633	-1.121
State-Texas	--	--	0.548	0.446	--
State-Washington	0.622	0.498	-0.186	-0.317	--
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	1.277	1.175	1.032	0.909	0.685
C		1.14	0.990	0.875	0.651
B			0.937	0.816	0.613
A				0.804	0.569
K					0.649
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.974	0.943	0.897	0.752
C		-	0.958	0.914	0.756
B			-	0.94	0.787
A				-	0.788
K					-
BIC	90, 054.58				
Log-likelihood	-44, 996.57				

Note: -- denotes that the variable is not significant at 90% significant level.

Urban limited access 10-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for ULA10LD facility are shown in Tables below.

Table C.7 NB-OPFS Model Coefficients for ULA10LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-1.879	-2.362	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	-0.583	-2.589
Threshold between C-B	--	--	0.202	0.897
Threshold between B-A	--	--	0.950	4.216
Threshold between A-K	--	--	1.504	6.625
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.011	1.640
Lane width (base: ≥12 feet)				
LW<12	-0.216	-3.156	--	--
Median width (base: ≤20 feet)				
MW>20	-0.171	-3.945	--	--
Outside shoulder width (base: ≥8 feet)				
OSW<8	-0.184	-2.240	0.075	2.011
Inside shoulder width (base: ≥8 feet)				
ISW<4	0.251	4.396	-0.051	-3.061
ISW4-5	0.178	3.131	--	--
ISW6-7	0.290	3.621	--	--
Shoulder type (base: paved)				
Unpaved	0.176	2.214	-0.090	-2.656
Traffic Characteristics				
Ln (AADT)	0.519	8.076	-0.084	-4.520
%SUT	-0.161	-5.569	-0.053	-3.403
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.068	3.142
State Indicators	*(Base: California, Florida and Texas)*		*(Base: California, Illinois Florida and Minnesota)*	
State-Illinois	0.798	5.870	--	--
State-Minnesota	-0.540	-3.091	--	--
State-Texas	--	--	0.141	3.263
State-Washington	0.395	6.061	-0.151	-5.791
Overdispersion parameter	1.278	36.995	--	--
BIC	61,487.802			
Log-Likelihood	-30,582.960			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.8 MVPLN Model Coefficients for ULA10LD Segments

Variable Names	O	C	B	A	K
Constant	-4.381	-4.326	-2.968	-4.103	-3.900
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: 12 feet)					
LW>12	0.208	0.159	--	--	--
LW<12	-0.191	-0.121	-0.110	-0.193	--
Median width (base: ≤20 feet)					
MW>20	-0.329	-0.231	-0.178	-0.154	--
Outside shoulder width (base: ≥8 feet)					
OSW<8	-0.217	-0.470	-0.466	-0.463	--
Shoulder Type (base: paved)					
Unpaved	0.290	0.230	0.265	--	--
Speed limit (base: >65 mph)					
SL≤60	-0.583	-0.575	-0.831	-0.567	--
SL61-65	--	-0.223	-0.247	-0.221	--
Traffic Characteristics					
Ln (AADT)	0.669	0.577	0.373	0.32	0.191
%Truck	0.031	0.027	0.025	0.036	0.035
%SUT	-0.396	-0.409	-0.423	-0.334	-0.292
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.568	--	--	-0.967	--
Interaction Effects					
HTZ*Unpaved shoulder	0.567	--	-0.683	0.931	--
State Indicators (base: California)					
State-Florida	0.777	--	--	0.875	--
State-Illinois	1.619	-1.493	1.375	2.009	--
State-Minnesota	-0.603	-0.817	-0.744	-1.633	-1.121
State-Texas	--	--	0.548	0.446	--
State-Washington	0.622	0.498	-0.186	-0.317	--
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	1.277	1.175	1.032	0.909	0.685
C		1.140	0.990	0.875	0.651
B			0.937	0.816	0.613
A				0.804	0.569
K					0.649
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.974	0.943	0.897	0.752
C		-	0.958	0.914	0.756
B			-	0.940	0.787
A				-	0.788
K					-
BIC	90, 054.58				
Log-Likelihood	-44, 996.57				

Note: -- denotes that the variable is not significant at 90% significant level.

Rural Limited Access Facility Group

Rural limited access 4-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for RLA4LD facility are shown in Tables below.

Table C.9 NB-OPFS Model Coefficients for RLA4LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-6.089	-6.458	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.409	21.096
Threshold between C-B	--	--	0.854	42.921
Threshold between B-A	--	--	1.528	62.903
Threshold between A-K	--	--	1.977	61.841
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.033	3.604
Lane width (base: ≤12 feet)				
LW>12	--	--	-0.151	-2.617
Median width (base: ≤20 feet)				
MW>20	-0.143	-2.038	--	--
Outside shoulder width (base: ≥8 feet)				
OSW<8	0.412	5.590	0.225	3.467
Shoulder type (base: paved)				
Unpaved	--	--	-0.172	-3.706
Speed limit (base: >60 mph)				
SL≤60	0.377	2.689	--	--
SL61-65	0.162	2.230	--	--
Traffic Characteristics				
Ln (AADT)	0.760	8.446	--	--
%Truck	-0.017	-9.853	-0.005	-3.217
%SUT	-0.062	-6.050	-0.023	-2.730
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.162	2.400
Interaction Effects				
HTZ*Unpaved shoulder	--	--	-0.162	-1.869
State Indicators	*(Base: California, Florida and Washington)*		*(Base: California, Illinois, Florida, Minnesota and Washington)*	
State-Connecticut	0.301	2.392	-0.227	-3.051
State-Illinois	0.714	14.148	--	--
State-Minnesota	0.473	4.258	--	--
State-Texas	0.310	5.085	0.200	3.972
Overdispersion parameter				
Constant	1.486	24.380	--	--
State-Illinois	-0.999	-14.546	--	--
State-Minnesota	-0.745	-3.940	--	--

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
BIC	43,205.016			
Log-Likelihood	-21,441.900			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.10 MVPLN Model Coefficients for RLA4LD Segments

Variable Names	O	C	B	KA
Constant	-8.878	-12.153	-9.18	-9.648
Ln (Year = 5)	1.000	1.000	1.000	1.000
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000
Lane width (base: 12 feet)				
LW>12	0.237	0.399	--	--
LW<12	0.632	0.504	--	--
Median width (base: ≤ 20 feet)				
MW>20	--	--	-0.242	--
Outside shoulder width (base: ≥8 feet)				
OSW<8	--	0.265	--	--
Inside shoulder width (base: ≥8 feet)				
ISW<4	--	--	-0.476	-0.730
ISW4-7	-0.428	-0.327	-0.458	-0.492
Shoulder Type (base: paved)				
Unpaved	--	--	--	--
Speed limit (base: >60 mph)				
SL≤60	--	0.373	--	--
Traffic Characteristics				
Ln (AADT)	1.001	1.173	0.884	0.828
%Truck	-0.008	-0.020	-0.017	-0.016
%SUT	0.034	-0.103	-0.031	--
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.248	--	--	--
Interaction Effects				
HTZ*Unpaved shoulder	0.430	--	0.294	--
State Indicators (base: California, Illinois, Minnesota, and Washington)				
State- Connecticut	--	-0.412	--	-1.809
State-Florida	1.052	0.636	1.005	1.488
State-Texas	-1.929	-1.378	-1.392	-0.987
Variance-Covariance Matrix	**O**	**C**	**B**	**KA**
O	1.253	1.215	1.066	0.917
C		1.337	1.104	0.938
B			1.03	0.841
KA				0.841
Pearson Correlation Coefficients	**O**	**C**	**B**	**KA**
O	-	0.939	0.939	0.893
C		-	0.941	0.884
B			-	0.904
KA				-
BIC	50,042			
Log-Likelihood	-24,539			

Note: -- denotes that the variable is not significant at 90% significant level.

Rural limited access 6-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for RLA6LD facility are shown in Tables below.

Table C.11 NB-OPFS Model Coefficients for RLA6LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-6.089	-6.458	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.409	21.096
Threshold between C-B	--	--	0.854	42.921
Threshold between B-A	--	--	1.528	62.903
Threshold between A-K	--	--	1.977	61.841
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.033	3.604
Lane width (base: ≤12 feet)				
LW>12	--	--	-0.151	-2.617
Median width (base: ≤20 feet)				
LW>20	-0.143	-2.038	--	--
Outside shoulder width (base: ≥8 feet)				
OSW<8	0.412	5.590	0.225	3.467
Shoulder type (base: paved)				
Unpaved	-0.296	-2.447	-0.172	-3.706
Speed limit (base: >60 mph)				
SL≤60	0.377	2.689	--	--
SL61-65	0.162	2.230	--	--
Traffic Characteristics				
Ln (AADT)	0.790	9.555	-0.007	-2.207
%Truck	-0.017	-9.853	-0.005	-3.217
%SUT	-0.062	-6.050	-0.023	-2.730
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.162	2.400
Interaction Effects				
HTZ*Unpaved shoulder	--	--	-0.162	-1.869
State Indicators	*(Base: California, Florida and Washington)*		*(Base: California, Illinois, Florida, Minnesota and Washington)*	
State-Connecticut	0.301	2.392	-0.227	-3.051
State-Illinois	0.714	14.148	--	--
State-Minnesota	0.473	4.258	--	--
State-Texas	0.310	5.085	0.200	3.972
Overdispersion parameter				
Constant	1.486	24.380	--	--
State-Illinois	-0.999	-14.546	--	--
State-Minnesota	-0.745	-3.940	--	--
BIC; Log-Likelihood	43,205.016; -21,441.900			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.12 MVPLN Model Coefficients for RLA6LD Segments

Variable Names	O	C	B	KA
Constant	-9.16	-12.376	-9.642	-10.143
Ln (Year = 5)	1.000	1.000	1.000	1.000
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000
Lane width (base: 12 feet)				
LW>12	0.237	0.399	--	--
LW<12	0.632	0.504	--	--
Median width (base: ≤20 feet)				
MW>20	--	--	-0.242	--
Outside shoulder width (base: ≥8 feet)				
OSW<8	--	0.265	--	--
Inside shoulder width (base: ≥8 feet)				
ISW<4	--	--	-0.476	-0.730
ISW4-7	-0.428	-0.327	-0.458	-0.492
Speed limit (base: >60 mph)				
SL≤60	-0.937	-0.878	--	--
Traffic Characteristics				
Ln (AADT)	1.001	1.173	0.884	0.828
%Truck	0.011	0.004	0.007	-0.016
%SUT	0.034	-0.182	-0.105	--
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.248	--	--	--
Interaction Effects				
HTZ*Unpaved shoulder	0.430	--	0.294	--
State Indicators (base: California, Illinois, Minnesota, and Washington)				
State- Connecticut	--	-0.412	--	-1.809
State-Florida	1.052	0.636	1.005	1.488
State-Texas	-1.929	-1.378	-1.392	-0.987
Variance-Covariance Matrix	**O**	**C**	**B**	**KA**
O	1.253	1.215	1.066	0.917
C		1.337	1.104	0.938
B			1.03	0.841
KA				0.841
Pearson Correlation Coefficients	**O**	**C**	**B**	**KA**
O	-	0.939	0.939	0.893
C		-	0.941	0.884
B			-	0.904
KA				-
BIC	50,042			
Log-Likelihood	-24,539			

Note: -- denotes that the variable is not significant at 90% significant level.

Rural limited access 8-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for RLA8LD facility are shown in Tables below.

Table C.13 NB-OPFS Model Coefficients for RLA8LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-11.947	-5.115	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.409	21.096
Threshold between C-B	--	--	0.854	42.921
Threshold between B-A	--	--	1.528	62.903
Threshold between A-K	--	--	1.977	61.841
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.033	3.604
Lane width (base: ≤12 feet)				
LW>12	--	--	-0.151	-2.617
Median width (base: ≤20 feet)				
MW>20	-0.143	-2.038	--	--
Outside shoulder width (base: ≥8 feet)				
OSW<8	0.412	5.590	0.225	3.467
Shoulder type (base: paved)				
Unpaved	--	--	-0.172	-3.706
Speed limit (base: >65 mph)				
SL≤60	0.377	2.689	--	--
SL61-65	0.162	2.230	--	--
Traffic Characteristics				
Ln (AADT)	1.309	6.463	--	--
%Truck	-0.017	-9.853	-0.005	-3.217
%SUT	-0.062	-6.050	-0.023	-2.730
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.162	2.400
Interaction Effects				
HTZ*Unpaved shoulder	--	--	-0.162	-1.869
State Indicators	*(Base: California, Florida and Washington)*		*(Base: California, Illinois, Florida, Minnesota and Washington)*	
State-Connecticut	0.301	2.392	-0.227	-3.051
State-Illinois	0.714	14.148	--	--
State-Minnesota	0.473	4.258	--	--
State-Texas	0.310	5.085	0.200	3.972
Overdispersion parameter				
Constant	1.486	24.380	--	--
State-Illinois	-0.999	-14.546	--	--
State-Minnesota	-0.745	-3.940	--	--
BIC; Log-Likelihood	43,205.016; -21,441.900			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.14 MVPLN Model Coefficients for RLA8LD Segments

Variable Names	O	C	B	KA
Constant	-8.878	-12.153	-9.18	-9.648
Ln (Year = 5)	1.000	1.000	1.000	1.000
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000
Lane width (base: =12 feet)				
LW>12	0.237	0.399	--	--
LW<12	0.632	0.504	--	--
Median width (base: ≤ 20 feet)				
MW>20	--	--	-0.549	-0.456
Outside shoulder width (base: ≥8 feet)				
OSW<8	--	0.265	--	--
Inside shoulder width (base: ≥8 feet)				
ISW<4	--	--	-0.476	-0.73
ISW4-7	-0.428	-0.327	-0.458	-0.492
Speed limit (base: >60 mph)				
SL≤ 60	--	0.373	--	--
Traffic Characteristics				
Ln (AADT)	1.001	1.173	0.884	0.828
%Truck	-0.008	-0.020	-0.017	-0.016
%SUT	0.034	-0.103	-0.031	--
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.248	--	--	--
Interaction Effects				
HTZ*Unpaved shoulder	0.430	--	0.294	--
State Indicators (base: California, Illinois, Minnesota, and Washington)				
State- Connecticut	--	-0.412	--	-1.809
State-Florida	1.052	0.636	1.005	1.488
State-Texas	-1.929	-1.378	-1.392	-0.987
Variance-Covariance Matrix	**O**	**C**	**B**	**KA**
O	1.253	1.215	1.066	0.917
C		1.337	1.104	0.938
B			1.030	0.841
KA				0.841
Pearson Correlation Coefficients	**O**	**C**	**B**	**KA**
O	-	0.939	0.939	0.893
C		-	0.941	0.884
B			-	0.904
KA				-
BIC	50,042			
Log-Likelihood	-24,539			

Note: -- denotes that the variable is not significant at 90% significant level.

Urban Arterial Facility Group

Urban arterial 2-lane undivided segments

The model estimation results of NB-OPFS and MVPLN models for UA2LUD facility are shown in Tables below.

Table C.15 NB-OPFS Model Coefficients for UA2LUD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	0.375	1.207	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.789	6.367
Threshold between C-B	--	--	1.163	9.307
Threshold between B-A	--	--	1.673	13.291
Threshold between A-K	--	--	2.611	19.555
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.039	4.313
Speed limit (base: >25 mph)				
SL≤25	0.358	3.570	--	--
Traffic Characteristics				
Ln (AADT)	0.341	10.737	0.025	1.835
Ln (AADT) * Indicator for AADT ≤8,500	-0.075	-9.735	--	--
Ln (AADT) * Indicator for AADT ≤15,500	-0.045	-6.239	--	--
Ln (AADT) * Indicator for AADT ≤30,000	-0.025	-1.882	--	--
%Truck	-0.017	-2.467	--	--
%SUT	-0.042	-3.616	--	--
Interaction Effects				
HTZ*SL26-40	0.390	3.990	--	--
HTZ*SL>55	-0.656	-3.203	--	--
State Indicators	*(Base: California, Florida, and Illinois)*			
State- Minnesota	-1.640	-25.749	--	--
State- Texas	-1.369	-19.910	--	--
State- Washington	-1.162	-16.252	--	--
Overdispersion parameter				
Constant	1.956	34.075	--	--
State-Washington	-1.205	-9.361	--	--
BIC	41,782.671			
Log-Likelihood	-20,788.725			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.16 MVPLN Model Coefficients for UA2LUD Segments

Variable Names	O	C	B	A	K
Constant	-3.954	-7.552	-5.282	-6.083	-7.177
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: ≥12 feet)					
LW<12	-0.127	-0.167	-0.124	-0.260	--
Outside shoulder width (base: ≥8 feet)					
OSW<8	0.113	0.160	0.166	--	--
Shoulder type (base: paved)					
Unpaved	0.252	--	0.308	0.257	--
Speed limit (base: 41-55 mph)					
SL≤25	0.959	0.78	0.297	0.652	--
SL26-40	0.670	0.439	0.409	0.567	--
SL>55	-0.354	-0.292	--	--	--
Traffic Characteristics					
Ln (AADT)	0.556	0.606	0.498	0.562	0.353
%Truck	-0.017	-0.016	-0.021	--	--
%SUT	--	--	--	-0.047	--
State Indicators (base: Illinois)					
State-California	-0.560	1.869	--	-1.461	--
State-Florida	0.587	2.187	0.515	-0.698	1.420
State-Minnesota	-1.120	0.585	-1.774	-3.127	-1.137
State-Texas	-1.512	0.345	-1.482	-2.735	-0.503
State-Washington	-0.570	1.539	-1.005	-2.119	--
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	1.649	1.48	1.414	1.471	0.864
C		1.474	1.365	1.406	0.839
B			1.391	1.458	0.846
A				1.786	0.929
K					0.700
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.949	0.934	0.857	0.804
C		-	0.953	0.866	0.826
B			-	0.925	0.858
A				-	0.83
K					-
BIC	46, 878.75				
Log-Likelihood	-23, 015.55				

Note: -- denotes that the variable is not significant at 90% significant level.

Urban arterial 3-lane segments

The model estimation results of NB-OPFS and MVPLN models for UA3L facility are shown in Tables below.

Table C.17 NB-OPFS Model Coefficients for UA3L Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-0.119	-1.130	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.902	5.732
Threshold between C-B	--	--	1.330	8.459
Threshold between B-A	--	--	1.856	11.677
Threshold between A-K	--	--	2.855	17.194
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	--	--
Lane width (base: 12 feet)				
LW<12	0.464	6.901	--	--
LW>12	-0.223	-2.882	0.100	2.471
Outside shoulder width (base: ≥8 feet)				
OSW<8	--	--	-0.106	-2.840
Inside shoulder width (base: ≥8 feet)				
ISW<8	0.381	2.543	--	--
Shoulder type (base: paved)				
Unpaved	0.337	2.699	0.076	1.959
Speed limit (base: ≤55 mph)				
SL>55	-0.413	-2.943	0.114	1.849
Traffic Characteristics				
Ln (AADT)	0.286	18.286	0.033	2.153
Ln (AADT) * Indicator for AADT ≤8,000	-0.053	-5.335	--	--
Ln (AADT) * Indicator for AADT ≤32,000	-0.041	-5.312	--	--
Ln (AADT) * Indicator for AADT ≤50,000	-0.032	-2.956	--	--
%Truck	--	--	-0.010	-2.942
State Indicators	*(Base: California, Florida, Texas and Minnesota)*		*(Base: California, Texas and Minnesota)*	
State-Illinois	0.800	10.229	-0.095	-2.386
State-Florida	--	--	-0.089	-2.819
State-Washington	-0.218	-2.155	-0.177	-3.157
Overdispersion parameter				
Constant	18.252	20.927	--	--
State-Illinois	-16.615	-18.999	--	--
State-Florida	-13.721	-15.005	--	--
State-Washington	-17.098	-18.852	--	--
BIC	37112.388			
Log-Likelihood	-18391.125			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.18 MVPLN Model Coefficients for UA3L Segments

Variable Names	O	C	B	A	K
Constant	-4.119	-5.613	-5.589	-7.5	-9.703
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: ≤ 12 feet)					
LW>12	-0.216	--	--	--	--
Outside shoulder width (base: ≥8 feet)					
OSW<8	0.390	0.333	0.390	0.273	--
Inside shoulder width (base: ≥8 feet)					
ISW<8	-0.748	-0.715	-0.960	-0.656	-0.959
Median width (base: ≤20 feet)					
MW21-40	-0.395	-0.401	-0.354	-0.362	--
MW>40	-0.460	-0.399	-0.339	--	--
Shoulder type (base: paved)					
Unpaved	0.433	0.392	0.397	0.506	--
Speed limit (base: 41-55 mph)					
SL≤25	0.869	0.604	0.592	--	--
SL26-40	0.668	0.556	0.526	0.458	0.364
SL>55	0.533	0.513	0.603	0.636	0.861
Traffic Characteristics					
Ln (AADT)	0.219	0.217	0.196	0.214	0.430
%Truck	--	--	--	--	--
%SUT	--	0.077	--	--	--
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	--	--	--
Interaction Effects					
HTZ*SL>55	-0.789	-1.139	-1.164	--	-1.848
State Indicators (base: Texas)					
State-California	2.701	3.595	2.907	3.040	2.430
State-Florida	4.650	4.619	4.317	4.319	3.479
State-Illinois	3.590	1.610	3.403	5.011	2.158
State-Minnesota	2.293	2.569	1.747	--	--
State-Washington	2.919	3.111	2.219	1.710	0.941
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	3.108	2.965	2.781	2.644	1.541
C		2.969	2.766	2.648	1.589
B			2.697	2.549	1.533
A				2.742	1.610
K					1.194
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.976	0.960	0.906	0.800
C		-	0.978	0.928	0.844
B			-	0.937	0.854
A				-	0.890
K					-
BIC; Log-Likelihood	44,511.85; -21,542.11				

Note: -- denotes that the variable is not significant at 90% significant level.

Urban arterial 5-lane segments

The model estimation results of NB-OPFS and MVPLN models for UA5L facility are shown in Tables below.

Table C.19 NB-OPFS Model Coefficients for UA5L Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	0.012	0.122	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.902	5.732
Threshold between C-B	--	--	1.330	8.459
Threshold between B-A	--	--	1.856	11.677
Threshold between A-K	--	--	2.855	17.194
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	--	--
Lane width (base: 12 feet)				
LW<12	0.464	6.901	--	--
LW>12	-0.223	-2.882	0.100	2.471
Outside shoulder width (base: ≥8 feet)				
OSW<8	--	--	-0.106	-2.840
Inside shoulder width (base: ≥8 feet)				
ISW<8	0.381	2.543	--	--
Shoulder type (base: paved)				
Unpaved	0.337	2.699	0.076	1.959
Speed limit (base: 26-55 mph)				
SL≤25	--	--	1.181	1.699
SL>55	-0.413	-2.943	0.114	1.849
Traffic Characteristics				
Ln (AADT)	0.286	18.286	0.033	2.153
Ln (AADT) * Indicator for AADT ≤8,000	-0.053	-5.335	--	--
Ln (AADT) * Indicator for AADT ≤32,000	-0.041	-5.312	--	--
Ln (AADT) * Indicator for AADT ≤50,000	-0.032	-2.956	--	--
%Truck	--	--	-0.010	-2.942
State Indicators	*(Base: California, Florida, Texas and Minnesota)*		*(Base: California, Texas and Minnesota)*	
State-Illinois	0.800	10.229	-0.095	-2.386
State-Florida	--	--	-0.089	-2.819
State-Washington	-0.218	-2.155	-0.177	-3.157
Overdispersion parameter				
Constant	2.558	10.964	--	--
State-Illinois	-1.029	-3.847	--	--
State-Florida	1.182	2.390	--	--
State-Washington	-1.862	-7.188	--	--
BIC	37112.388			
Log-Likelihood	-18391.125			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.20 MVPLN Model Coefficients for UA5L Segments

Variable Names	O	C	B	A	K
Constant	-2.119	-3.59	-3.692	-5.891	-8.633
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: ≤ 12 feet)					
LW>12	-0.216	0.358	0.450	--	--
Outside shoulder width (base: ≥8 feet)					
OSW<8	0.390	0.333	0.390	0.273	--
Inside shoulder width (base: ≥8 feet)					
ISW<8	-0.748	-0.715	-0.960	-0.656	-0.959
Median width (base: ≤20 feet)					
MW21-40	-0.395	-0.401	-0.354	-0.362	--
MW>40	-0.460	-0.399	-0.339	--	--
Shoulder type (base: paved)					
Unpaved	-0.790	-0.752	-0.646	-0.297	--
Speed limit (base: 41-55 mph)					
SL≤25	-1.857	-2.118	-1.242	--	--
SL26-40	0.668	0.556	0.526	0.458	0.364
SL>55	0.533	0.513	0.603	0.636	0.861
Traffic Characteristics					
Ln (AADT)	0.219	0.217	0.196	0.214	0.430
%Truck	--	--	--	--	--
%SUT	--	0.077	--	--	--
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.447	-0.526	--	--	--
Interaction Effects					
HTZ*SL>55	-0.789	-1.139	-1.164	--	-1.848
State Indicators (base: Texas)					
State-California	2.701	3.595	2.907	3.040	2.430
State-Florida	4.650	4.619	4.317	4.319	3.479
State-Illinois	3.590	1.610	3.403	5.011	2.158
State-Minnesota	2.293	2.569	1.747	--	--
State-Washington	2.919	3.111	2.219	1.710	0.941
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	3.108	2.965	2.781	2.644	1.541
C		2.969	2.766	2.648	1.589
B			2.697	2.549	1.533
A				2.742	1.610
K					1.194
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.976	0.960	0.906	0.800
C		-	0.978	0.928	0.844
B			-	0.937	0.854
A				-	0.89
K					-
BIC; Log-Likelihood	44,511.85; -21,542.11				

Note: -- denotes that the variable is not significant at 90% significant level.

Urban arterial 4-lane undivided segments

The model estimation results of NB-OPFS and MVPLN models for UA4LUD facility are shown in Tables below.

Table C.21 NB-OPFS Model Coefficients for UA4LUD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-2.677	-5.437	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.555	29.458
Threshold between C-B	--	--	0.964	49.124
Threshold between B-A	--	--	1.451	68.050
Threshold between A-K	--	--	2.500	55.427
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.029	3.359
Lane width (base: ≥12 feet)				
LW<12	0.204	3.795	--	--
Outside shoulder width	base: ≥ 8feet		base: <2 feet & ≥4 feet	
OSW2-3	--	--	0.104	1.679
OSW<8	0.410	5.765	--	--
Traffic Characteristics				
Ln (AADT)	0.489	10.263	--	--
Ln (AADT) * indicator for AADT ≤4,000	0.076	3.538	--	--
Ln (AADT) * indicator for AADT ≤18,000	-0.042	-6.347	--	--
%Truck	-0.043	-7.498	--	--
Interaction Effects				
HTZ*SL≤ 25	1.396	2.558	-0.405	-4.037
HTZ*SL26-40	0.863	5.287	--	--
HTZ*OSW<8	-0.310	-2.499	--	--
State Indicators	*(Base: California, Texas, Washington and Minnesota)*		*(Base: California, Florida, Illinois, Minnesota, Texas and Washington)*	
State-Illinois	1.228	23.113	--	--
State-Florida	1.602	12.143	--	--
Overdispersion parameter				
Constant	2.557	28.859	--	--
State-Illinois	-1.052	-9.405	--	--
State-Florida	1.570	3.201	--	--
BIC	49,500.994			
Log-Likelihood	-24,643.425			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.22 MVPLN Model Coefficients for UA4LUD Segments

Variable Names	O	C	B	A	K
Constant	-4.935	-5.765	-6.448	-7.951	-9.995
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: ≥12 feet)					
LW<12	0.243	0.113	0.169	0.137	--
Outside shoulder width (base: ≥8 feet)					
OSW<4	0.548	0.450	0.328	0.314	--
OSW4-7	0.259	--	--	--	0.858
Shoulder type (base: paved)					
Unpaved	-0.366	-0.263	--	-0.444	--
Speed limit (base: 41-55 mph)					
SL≤25	1.106	1.005	0.997	0.820	--
SL26-40	0.614	0.561	0.501	0.570	--
SL>55	--	--	--	--	--
Traffic Characteristics					
Ln (AADT)	0.529	0.487	0.491	0.497	0.589
%Truck	-0.026	-0.035	-0.040	-0.052	0
Interaction Effects					
HTZ*SL41-55	-0.434	-0.670	--	--	--
HTZ*SL>55	-1.133	-1.070	-0.602	--	--
HTZ*Unpaved shoulder	0.275	0.364	0.314	--	--
State Indicators (base: Texas and Minnesota)					
State-California	--	1.257	1.217	1.287	1.209
State-Florida	2.250	1.953	1.91	2.168	1.382
State-Illinois	1.558	-0.398	1.466	3.273	0.000
State-Washington	0.936	1.054	0.473	0.791	0.986
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	2.290	2.137	1.971	2.064	1.063
C		2.208	1.984	2.052	1.094
B			1.947	1.948	1.064
A				2.133	1.151
K					0.899
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.950	0.934	0.934	0.741
C		-	0.957	0.945	0.776
B			-	0.956	0.804
A				-	0.831
K					-
BIC	56,242				
Log-Likelihood	-27,585				

Note: -- denotes that the variable is not significant at 90% significant level.

Urban arterial 4-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for UA4LD facility are shown in Tables below.

Table C.23 NB-OPFS Model Coefficients for UA4LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	0.685	1.648	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.748	4.847
Threshold between C-B	--	--	1.050	6.784
Threshold between B-A	--	--	1.495	9.653
Threshold between A-K	--	--	2.706	16.693
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.030	2.950
Lane width (base: ≤12 feet)				
LW>12	-0.242	-2.329	--	--
Median width (base: ≤20 feet)				
MW>20	-0.202	-2.796	-0.070	-2.400
Outside shoulder width (base: ≥8 feet)				
OSW<8	0.225	3.468	--	--
Inside shoulder width (base: ≥8 feet)				
ISW<8	0.355	3.402	-0.106	-2.082
Shoulder type (base: paved)				
Unpaved	0.730	9.576	--	--
Speed limit (base: ≤25 mph)				
SL26-40	0.795	13.281	--	--
SL>55	--	--	0.208	4.478
Traffic Characteristics				
Ln (AADT)	0.181	4.841	0.031	2.112
Ln (AADT)* Indicator for AADT ≤14,000	-0.045	-5.333	--	--
Ln (AADT)* Indicator for AADT ≤24,000	-0.044	-7.560	--	--
Ln (AADT)* Indicator for AADT ≤40,000	-0.054	-6.993	--	--
%Truck	-0.018	-2.635	-0.011	-2.831
%SUT	-0.025	-2.259	0.018	2.845
Interaction Effects				
HTZ*SL26-40	0.333	2.296	--	--
HTZ*ISW<8	--	--	-0.117	-2.148
Overdispersion parameter				
Constant	1.725	35.224	--	--
State-Texas	3.112	10.026	--	--
BIC	48,159.380			
Log-Likelihood	-23,945.850			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.24 MVPLN Model Coefficients for UA4LD Segments

Variable Names	O	C	B	A	K
Constant	-3.902	-7.244	-5.162	-5.976	-4.92
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: ≥ 12 feet)					
LW<12	0.234	0.221	0.225	0.171	--
Outside shoulder width (base: ≥8 feet)					
OSW<8	0.220	0.182	0.203	0.303	--
Inside shoulder width (base: ≥8 feet)					
ISW<8	--	--	-0.240	--	-0.639
Median width (base: ≤20 feet)					
MW>20	-0.208	-0.222	-0.288	-0.251	-0.354
Shoulder type (base: paved)					
Unpaved	--	--	-0.240	--	-0.639
Speed limit (base: >40 mph)					
SL≤25	0.964	--	0.695	--	--
SL26-40	0.637	0.570	0.583	0.489	--
Traffic Characteristics					
Ln (AADT)	0.570	0.585	0.505	0.576	0.201
%Truck	-0.034	-0.041	-0.040	-0.038	--
HTZ (base: Indicator for <85th percentile of truck percentage)	--	-0.635	-0.743	--	-1.214
Interaction Effects					
HTZ*SL>40	-0.447	--	--	-0.409	--
HTZ*Unpaved shoulder	0.766	1.091	1.105	0.697	1.543
State Indicators (base: Illinois)					
State-California	-0.513	2.316	--	-1.454	1.158
State-Florida	0.795	2.520	0.721	-0.784	1.538
State-Minnesota	-0.951	1.183	-1.165	-3.513	--
State- Texas	-1.650	0.379	-1.196	-2.755	--
State-Washington	-0.561	1.572	-0.787	-2.656	--
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	1.814	1.691	1.578	1.648	1.059
C		1.730	1.58	1.644	1.056
B			1.564	1.611	1.034
A				1.860	1.131
K					0.880
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.955	0.937	0.897	0.838
C		-	0.960	0.917	0.856
B			-	0.945	0.881
A				-	0.884
K					-
BIC	144,624.14				
Log-Likelihood	-71,742.62				

Note: -- denotes that the variable is not significant at 90% significant level.

Rural Arterial Facility Group

Rural arterial 2-lane undivided segments

The model estimation results of NB-OPFS and MVPLN models for RA2LUD facility are shown in Tables below.

Table C.25 NB-OPFS Model Coefficients for RA2LUD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-5.259	-9.686	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.426	10.505
Threshold between C-B	--	--	0.855	20.611
Threshold between B-A	--	--	1.485	33.551
Threshold between A-K	--	--	2.042	39.937
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.055	4.554
Lane width (≤12 feet)				
LW>12	--	--	0.130	2.573
Outside shoulder width (base: >5 feet)				
OSW<2	0.267	3.935	--	--
OSW2-3	0.331	6.100	--	--
OSW4-5	0.184	3.303	--	--
Shoulder type (base: paved)				
Unpaved	0.600	11.874	-0.112	-3.093
Speed limit (base: 41-55 mph)				
SL≤40	0.459	6.230	--	--
SL>55	-0.184	-2.843	0.106	2.228
Traffic Characteristics				
Ln (AADT)	0.657	11.171	--	--
Ln (AADT)* Indicator for AADT≤2,500	-0.034	-3.199	--	--
Ln (AADT)* Indicator for AADT≤8,000	-0.044	-4.709	--	--
%Truck	-0.014	-4.639	-0.011	-3.639
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.261	3.197
Interaction Effects				
HTZ*SL>55	-0.235	-1.723	--	--
State Indicators	*(Base: Florida, Illinois, Minnesota, and Texas)*		*(Base: Connecticut, Florida, Illinois, Texas, and Washington)*	
State-California	0.405	5.012	0.388	7.903
State-Connecticut	0.479	5.061	--	--
State-Minnesota	--	--	0.172	3.817
State-Washington	0.261	4.361	--	--
Overdispersion parameter	0.965	19.472	--	--
BIC; Log-Likelihood	28,354.880; -14,043.600			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.26 MVPLN Model Coefficients for RA2LUD Segments

Variable Names	O	C	B	A	K
Constant	-7.583	-9.777	-8.210	-7.832	-9.602
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Outside shoulder width (base: >8 feet)					
OSW<4	0.248	0.259	0.393	0.392	--
OSW4 -7	0.106	--	0.186	--	--
Speed limit (base: 41-55 mph)					
SL≤25	1.053	--	1.202	--	--
SL26-40	0.270	--	0.341	0.339	--
SL>55	-0.179	-0.408	--	-0.383	--
Traffic Characteristics					
Ln (AADT)	0.792	0.897	0.700	0.577	0.709
%Truck	-0.010	-0.019	-0.018	--	--
%SUT	-0.030	-0.032	-0.046	-0.074	-0.119
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.387	--	--	-0.544	--
Interaction Effects					
HTZ*Unpaved shoulder	0.444	0.803	0.659	1.136	--
State Indicators (base: Texas)					
State-California	0.424	0.910	0.642	0.391	--
State- Connecticut	0.803	--	0.382	-1.528	-2.438
State-Florida	0.814	0.616	0.568	0.494	--
State-Illinois	1.286	--	0.381	--	--
State-Minnesota	-0.258	--	-0.406	-1.757	-1.388
State-Washington	0.543	0.401	--	-0.551	-0.830
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	0.910	0.829	0.759	0.741	0.546
C		0.908	0.800	0.824	0.611
B			0.897	0.853	0.632
A				1.078	0.715
K					0.652
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.912	0.840	0.748	0.709
C		-	0.887	0.832	0.793
B			-	0.867	0.827
A				-	0.852
K					-
BIC	31,399.761				
Log-Likelihood	-15,155.188				

Note: -- denotes that the variable is not significant at 90% significant level.

Rural arterial 3-lane segments

The model estimation results of NB-OPFS and MVPLN models for RA3L facility are shown in Tables below.

Table C.27 NB-OPFS Model Coefficients for RA3L Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-7.695	-6.410	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.324	5.251
Threshold between C-B	--	--	0.743	11.883
Threshold between B-A	--	--	1.382	19.532
Threshold between A-K	--	--	1.947	21.804
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	--	--
Outside shoulder width (base: ≥8 feet)				
OSW<6	0.236	2.085	--	--
OSW6-7	0.460	2.901	--	--
Shoulder type (base: paved)				
Unpaved	0.589	4.220	-0.237	-2.918
Speed limit (base: ≤55 mph)				
SL>55	-0.296	-2.524	0.153	2.172
Traffic Characteristics				
Ln (AADT)	0.975	7.789	--	--
Ln (AADT)* Indicator for AADT≤8,500	0.026	1.710	--	--
%Truck	-0.020	-2.332	-0.009	-2.094
%SUT	-0.119	-3.393	--	--
State Indicators	*(Base: California, Connecticut, Florida, Illinois, and Texas)*		*(Base: California, Connecticut, Florida, Illinois, and Texas)*	
State-Minnesota	-0.949	-3.958	-0.349	-1.832
State-Washington	-0.592	-3.951	-0.342	-2.233
Overdispersion parameter				
Constant	1.766	10.361	--	--
State-Washington	-1.510	-7.250	--	--
BIC	7,213.624			
Log-Likelihood	-3,504.200			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.28 MVPLN Model Coefficients for RA3L Segments

Variable Names	O	C	B	A	K
Constant	-8.584	-11.175	-10.822	-9.829	-14.343
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Outside shoulder width (base: >8 feet)					
OSW<4	0.292	--	0.420	--	--
OSW4-7	0.347	0.438	0.610	--	0.842
Shoulder type (base: paved)					
Unpaved	0.659	--	0.375	--	--
Speed limit (base: ≤55 mph)					
SL>55	-0.328	--	--	--	--
Traffic Characteristics					
Ln (AADT)	0.947	1.097	1.030	0.842	1.222
%Truck	-0.031	-0.037	-0.041	-0.059	--
%SUT	-0.056	-0.192	--	--	--
State Indicators (base: California, Connecticut, Florida, Illinois, and Texas)					
State-Minnesota	-0.629	-0.877	--	-5.835	-2.555
State-Washington	--	--	-1.009	-0.873	-1.635
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	1.578	1.616	1.382	1.473	0.949
C		1.903	1.529	1.642	1.055
B			1.485	1.534	0.977
A				1.901	1.087
K					0.937
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.932	0.903	0.851	0.781
C		-	0.909	0.863	0.790
B			-	0.913	0.828
A				-	0.814
K					-
BIC	7,537.64				
Log-Likelihood	-3,618.95				

Note: -- denotes that the variable is not significant at 90% significant level.

Rural arterial 5-lane segments

The model estimation results of NB-OPFS and MVPLN models for RA5L facility are shown in Tables below.

Table C.29 NB-OPFS Model Coefficients for RA5L Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-7.695	-6.410	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.324	5.251
Threshold between C-B	--	--	0.743	11.883
Threshold between B-A	--	--	1.382	19.532
Threshold between A-K	--	--	1.947	21.804
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	--	--
Outside shoulder width (base: ≥8 feet)				
OSW<6	0.236	2.085	--	--
OSW6-7	0.460	2.901	--	--
Shoulder type (base: paved)				
Unpaved	0.589	4.220	-0.237	-2.918
Speed limit (base: ≤55 mph)				
SL>55	-0.296	-2.524	0.153	2.172
Traffic Characteristics				
Ln (AADT)	1.064	10.541	--	--
Ln (AADT)* Indicator for AADT≤8,500	0.026	1.710	--	--
%Truck	-0.020	-2.332	-0.009	-2.094
%SUT	-0.436	-3.266	-0.137	-2.057
State Indicators	*(Base: California, Connecticut, Florida, Illinois, and Texas)*		*(Base: California, Connecticut, Florida, Illinois, and Texas)*	
State-Minnesota	-0.949	-3.958	-0.349	-1.832
State-Washington	-0.592	-3.951	-0.342	-2.233
Overdispersion parameter				
Constant	1.766	10.361	--	--
State-Washington	-1.510	-7.250	--	--
BIC	7,213.624			
Log-Likelihood	-3,504.200			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.30 MVPLN Model Coefficients for RA5L Segments

Variable Names	O	C	B	A	K
Constant	-8.584	-11.175	-10.822	-9.829	-14.343
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Outside shoulder width (base: >8 feet)					
OSW<3	0.292	--	0.420	--	--
OSW4-7	0.347	0.438	0.610	--	0.842
Shoulder type (base: paved)					
Unpaved	0.659	--	0.375	--	--
Speed limit (base: ≤55 mph)					
SL>55	-0.328	--	--	--	--
Traffic Characteristics					
Ln (AADT)	0.947	1.097	1.030	0.842	1.222
%Truck	-0.031	-0.037	-0.041	-0.059	--
%SUT	-0.056	-0.573	--	-1.394	--
State Indicators (base: California, Connecticut, Florida, Illinois, and Texas)					
State-Minnesota	-0.629	-0.877	--	-5.835	-2.555
State-Washington	--	--	-1.009	-0.873	-1.635
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	1.578	1.616	1.382	1.473	0.949
C		1.903	1.529	1.642	1.055
B			1.485	1.534	0.977
A				1.901	1.087
K					0.937
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.932	0.903	0.851	0.781
C		-	0.909	0.863	0.790
B			-	0.913	0.828
A				-	0.814
K					-
BIC	7,537.64				
Log-Likelihood	-3,618.95				

Note: -- denotes that the variable is not significant at 90% significant level.

Rural arterial 4-lane undivided segments

The model estimation results of NB-OPFS and MVPLN models for RA4LUD facility are shown in Tables below.

Table C.31 NB-OPFS Model Coefficients for RA4LUD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-4.560	-4.886	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	-0.229	-0.791
Threshold between C-B	--	--	0.154	0.534
Threshold between B-A	--	--	0.804	2.766
Threshold between A-K	--	--	1.365	4.694
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.036	1.847
Lane width (≤12 feet)				
LW>12	-0.237	-2.809	--	--
Outside shoulder width (base: ≥6 feet)				
OSW<6	0.161	2.032	--	--
Shoulder type (base: paved)				
Unpaved	0.236	1.822	--	--
Speed limit (base: 41-55 mph)				
SL≤40	--	--	-0.223	-2.455
SL>55	-0.247	-3.471	--	--
Traffic Characteristics				
Ln (AADT)	0.651	6.767	-0.068	-2.145
Ln(AADT)*Indicator for AADT≤10,000	0.029	1.891	--	--
Ln(AADT)*Indicator for AADT≤14,000	-0.038	-2.980	--	--
%Truck	-0.030	-5.073	--	--
%SUT	-0.100	-4.686	--	--
State Indicators	*(Base: California, Connecticut, Florida, Texas, and Washington)*		*(Base: California, Connecticut, Florida, Minnesota, and Texas)*	
State-Illinois	1.250	4.879	-0.470	-3.153
State-Minnesota	-0.542	-3.251	--	--
State-Washington	--	--	-0.290	-1.961
Overdispersion parameter	2.574	15.734	--	--
BIC	16,587.213			
Log-Likelihood	-8,191.400			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.32 MVPLN Model Coefficients for RA4LUD Segments

Variable Names	O	C	B	A	K
Constant	-5.697	-6.921	-5.772	-7.21	-8.03
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: ≤12 feet)					
LW>12	-0.401	-0.398	-0.619	-0.424	--
Outside shoulder width (base: ≥6 feet)					
OSW<6	0.227	--	0.262	--	--
Speed limit (base: 41-55 mph)					
SL≤40	--	--	-0.665	--	--
SL>55	-0.268	-0.265	--	--	1.027
Traffic Characteristics					
Ln (AADT)	0.611	0.568	0.440	0.459	0.418
%Truck	-0.026	-0.032	-0.040	--	-0.052
%SUT	-0.111	-0.096	-0.074	--	--
HTZ (base: Indicator for <85th percentile of truck percentage)	-0.476	--	--	-0.581	0.77
State Indicators (base: California, Connecticut, Florida, and Texas)					
State- Illinois	1.574	--	1.280	1.874	--
State- Minnesota	-0.443	--	--	-1.654	--
State- Washington	1.204	1.135	--	--	--
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	2.436	2.314	2.223	2.027	1.553
C		2.375	2.169	1.950	1.506
B			2.244	1.949	1.496
A				1.914	1.386
K					1.222
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.962	0.951	0.939	0.900
C		-	0.940	0.915	0.884
B			-	0.940	0.903
A				-	0.906
K					-
BIC	17, 019.000				
Log-Likelihood	-8,126.246				

Note: -- denotes that the variable is not significant at 90% significant level.

Rural arterial 4-lane divided segments

The model estimation results of NB-OPFS and MVPLN models for RA4LD facility are shown in Tables below.

Table C.33 NB-OPFS Model Coefficients for RA4LD Segments

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-6.632	-16.644	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.431	9.008
Threshold between C-B	--	--	0.885	18.627
Threshold between B-A	--	--	1.519	29.337
Threshold between A-K	--	--	2.081	33.876
Roadway Characteristics				
Ln (Segment_Length, miles)	1.000	--	0.041	3.102
Lane width (≥12 feet)				
LW<12	--	--	0.254	2.478
Outside shoulder width (base: ≥8 feet)				
OSW<4	0.270	1.994	--	--
OSW4-5	0.341	1.775	--	--
OSW6-7	0.644	4.411	-0.273	-2.733
Inside shoulder width (base: ≥8 feet)				
ISW<2	0.301	2.852	--	--
ISW2-3	0.561	5.682	--	--
ISW4-5	0.500	5.542	-0.168	-3.633
ISW6-7	0.515	5.772	--	--
Median width (base: ≤20 feet)				
MW21-40	-0.353	-4.071	--	--
MW41-60	-0.258	-3.141	-0.094	-2.187
MW>60	-0.231	-2.816	-0.075	-1.753
Shoulder type (base: paved)				
Unpaved	0.361	3.300	-0.225	-4.694
Speed limit (base: 41-55 mph)				
SL≤40	0.494	2.091	--	--
SL>55	--	--	0.138	3.109
Traffic Characteristics				
Ln (AADT)	0.817	20.097	--	--
Ln (AADT)* Indicator for AADT >5,000 to ≤8,500	-0.044	-6.089		
Ln (AADT)* Indicator for AADT >8,500 to ≤14,000	-0.019	-3.356		
%Truck	-0.024	-6.456	0.005	2.018
%SUT	-0.057	-3.180	-0.025	-2.895
State Indicators	*(Base: California, Connecticut, Florida, and Texas)*		*(Base: Connecticut, Florida, Illinois, Minnesota, Texas, and Washington)*	

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
State-California	--	--	0.199	2.835
State-Illinois	0.579	4.602	--	--
State-Minnesota	-0.388	-3.524	--	--
State-Washington	-0.495	-2.819	--	--
Overdispersion parameter				
Constant	3.216	25.305	--	--
State-Minnesota	-2.585	-17.059	--	--
BIC	28,072.106			
Log-Likelihood	-13,857.600			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.34 MVPLN Model Coefficients for RA4LD Segments

Variable Names	O	C	B	A	K
Constant	-7.998	-10.422	-9.341	-8.474	-9.371
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Ln (Segment_Length, miles)	1.000	1.000	1.000	1.000	1.000
Lane width (base: ≥ 12 feet)					
LW<12	-0.618	--	--	-0.723	--
Outside shoulder width (base: ≥8 feet)					
OSW<4	0.355	0.434	0.361	--	--
OSW4-5	0.559	0.497	0.561	--	--
OSW6-7	0.920	0.773	0.560	--	--
Inside shoulder width (base: ≥8 feet)					
ISW<6	0.216	--	--	0.296	--
ISW6-7	0.531	0.600	0.597	--	0.690
Median width (base: ≤20 feet)					
MW>20	--	--	--	--	--
Shoulder type (base: paved)					
Unpaved	--	0.317	0.358	--	--
Speed limit (base: 41-55 mph)					
SL≤40	--	--	--	--	--
SL>55	-0.308	-0.402	--	--	--
Traffic Characteristics					
Ln (AADT)	0.809	0.886	0.748	0.575	0.526
%Truck	-0.041	-0.049	-0.044	-0.033	-0.029
%SUT	-0.051	--	--	-0.078	--
Interaction Effects					
HTZ*Unpaved shoulder	--	0.757	0.676	--	0.938
State Indicators (base: Connecticut, Florida, Texas, and Washington)					
State-California	0.716	1.164	0.812	--	--
State- *Illinois*	1.335	-0.429	--	--	--
State-Minnesota	--	0.483	--	-1.278	-0.951
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	2.503	2.428	2.326	2.216	1.915
C		2.557	2.369	2.263	1.953
B			2.345	2.170	1.900
A				2.197	1.830
K					1.760
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.960	0.960	0.945	0.912
C		-	0.967	0.955	0.921
B			-	0.956	0.935
A				-	0.931
K					-
BIC	29,023.16				
Log-Likelihood	-13, 998.53				

Note: -- denotes that the variable is not significant at 90% significant level.

Urban Intersection Facility Group

Urban 3-leg stop controlled intersections

The model estimation results of NB-OPFS and MVPLN models for U3ST facility are shown in Tables below.

Table C.35 NB-OPFS Model Coefficients for U3ST Intersections

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-12.268	-27.741	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.300	1.299
Threshold between C-B	--	--	0.901	3.873
Threshold between B-A	--	--	1.629	6.909
Threshold between A-K	--	--	2.287	9.348
Roadway Characteristics				
Major road speed limit (base: >25 mph)				
MajSL≤25	--	--	-0.137	-2.930
Traffic Characteristics				
Ln (MajAADT)	0.784	16.810	0.043	1.881
Ln (MinAADT)	0.433	17.632	-0.070	-5.406
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.095	1.900
State Indicators	*(Base: California)*		*(Base: California, Connecticut, Florida, Minnesota)*	
State-Connecticut	2.040	22.428	--	--
State-Florida	3.031	34.869	--	--
State-Minnesota	1.831	6.371	--	--
Interaction Effects				
HTZ*MajSL26-40	--	--	-0.154	-1.791
Overdispersion parameter				
Constant	1.231	10.932	--	--
State-Connecticut	-0.952	-7.207	--	--
BIC	19,383.295			
Log-Likelihood	-9,619.590			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.36 MVPLN Model Coefficients for U3ST Intersections

Variable Names	O	C	B	A	K
Constant	-13.399	-13.782	-12.796	-14.074	-12.755
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Presence of light (base: no light)	0.199	0.409	--	--	--
Major road speed limit (base: 41-55 mph)					
MajSL≤ 25	--	-0.304	-0.413	-0.515	--
MajSL26-40	--	-0.129	-0.236	-0.400	-0.386
MajSL>55	0.297	--	--	--	--
Traffic Characteristics					
Ln (MajAADT)	0.750	0.741	0.685	0.646	0.589
Ln (MinAADT)	0.454	0.407	0.336	0.335	--
Indicator for MajAADT>25,000 * Ln (MajAADT)	--	--	-0.020	-0.028	--
HTZ (base: Indicator for < 85th percentile of truck percentage)	--	--	--	0.216	--
State Indicators (base: California)					
State- Connecticut	2.639	1.689	1.754	1.551	--
State-Florida	3.616	3.096	2.791	3.141	2.306
State-Minnesota	1.812	1.529	1.016	1.253	--
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	0.920	0.803	0.749	0.624	0.448
C		0.842	0.768	0.681	0.511
B			0.799	0.704	0.516
A				1.051	0.635
K					0.754
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.912	0.873	0.634	0.538
C		-	0.936	0.724	0.641
B			-	0.768	0.664
A				-	0.714
K					-
BIC	24,523.303				
Log-Likelihood	-11,987.400				

Note: "--" denotes that the variable is not significant at the 90% significant level.

Urban 4-leg stop controlled intersections

The model estimation results of NB-OPFS and MVPLN models for U4ST facility are shown in Tables below.

Table C.37 NB-OPFS Model Coefficients for U4ST Intersections

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-6.352	-17.760	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	-0.508	-2.538
Threshold between C-B	--	--	0.193	0.959
Threshold between B-A	--	--	0.938	4.653
Threshold between A-K	--	--	1.578	7.439
Roadway Characteristics				
Major road speed limit (base: 41-55 mph)				
MajSL≤25	--	--	-0.198	-4.238
MajSL26-40	--	--	-0.135	-4.256
MajSL>55	--	--	0.272	3.910
Traffic Characteristics				
Ln (MajAADT)	0.529	13.486	-0.081	-4.153
Ln (MinAADT)	0.461	15.487	--	--
%MajTruck	0.022	2.853	0.007	1.820
%MinTruck	-0.061	-3.231	-0.067	-6.668
State Indicators	*(Base: Florida)*		*(Base: California, Connecticut, Florida, Minnesota)*	
State-California	-2.920	-37.138	--	--
State- Connecticut	-1.161	-11.592	--	--
State-Minnesota	-1.559	-22.171	--	--
Overdispersion parameter				
Constant	1.720	20.486	--	--
State-California	-0.507	-3.780	--	--
State- Connecticut	-1.212	-9.836	--	--
State-Minnesota	-0.526	-3.252	--	--
BIC	24,425.999			
Log-Likelihood	-12,112.920			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.38 MVPLN Model Coefficients for U4ST Intersections

Variable Names	O	C	B	A	K
Constant	-8.619	-8.784	-7.755	-8.962	-12.616
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Presence of light (base: no light)	-0.226	--	--	--	-0.782
Major road speed limit (base: 41-55 mph)					
MajSL≤25	-0.164	-0.259	-0.304	-0.473	-0.758
MajSL26-40	--	-0.133	-0.238	-0.373	-0.736
Traffic Characteristics					
Ln (MajAADT)	0.625	0.571	0.441	0.436	0.574
Ln (MinAADT)	0.525	0.432	0.389	0.39	0.345
Indicator for MinAADT>20,000 * Ln (MinAADT)	--	--	0.026	--	0.070
% Majtruck	0.021	--	--	--	--
% Mintruck	--	--	-0.084	-0.078	--
HTZ (base: Indicator for < 85th percentile of truck percentage)	--	--	--	--	0.610
Interactions					
HTZ*Light	0.269	--	--	--	--
HTZ*MajSL>55	0.412	--	0.535	--	--
State Indicators (base: Florida)					
State-California	-3.101	-2.455	-2.590	-2.744	--
State-Connecticut	-0.887	-1.167	-0.762	-1.954	--
State-Minnesota	-1.647	-1.301	-1.625	-1.995	--
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	0.859	0.780	0.704	0.652	0.472
C		0.839	0.751	0.728	0.549
B			0.766	0.745	0.555
A				1.172	0.729
K					0.682
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.918	0.868	0.650	0.616
C		-	0.936	0.733	0.725
B			-	0.786	0.767
A				-	0.816
K					-
BIC	33,989.67				
Log-Likelihood	-16,594.52				

Note: "--" denotes that the variable is not significant at the 90% significant level.

Urban 3-leg signalized intersections

The model estimation results of NB-OPFS and MVPLN models for U3SG facility are shown in Tables below.

Table C.39 NB-OPFS Model Coefficients for U3SG Intersections

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-7.892	-16.021	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.719	2.659
Threshold between C-B	--	--	1.349	4.971
Threshold between B-A	--	--	2.139	7.823
Threshold between A-K	--	--	2.831	10.269
Roadway Characteristics				
Major road speed limit (base: 26-55 mph)				
MajSL≤25	-0.444	-3.572	--	--
MajSL>55	0.672	2.956	--	--
Traffic Characteristics				
Ln (MajAADT)	0.802	16.823	0.104	4.038
Ln (MinAADT)	0.282	9.634	-0.103	-5.596
Interaction Effects				
HTZ*Light	-0.857	-2.321	--	--
State Indicators	*(Base: Florida)*		*(Base: California, Connecticut, Florida, Minnesota)*	
State-California	-3.261	-34.441	--	--
State-Connecticut	-1.063	-21.147	--	--
State-Minnesota	-0.759	-2.509	--	--
Overdispersion parameter				
Constant	1.715	17.668	--	--
State-California	-0.471	-2.371	--	--
State-Connecticut	-1.392	-11.757	--	--
BIC	15,568.895			
Log-Likelihood	-7,722.285			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.40 MVPLN Model Coefficients for U3SG Intersections

Variable Names	O	C	B	A	K
Constant	-8.721	-10.217	-8.692	-12.449	-14.525
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Presence of light (base: no light)	--	0.347	--	--	--
Major road speed limit (base: 41-55 mph)					
MajSL≤40	--	-0.139	-0.209	-0.55	-0.577
MajSL>55	0.464	--	--	--	--
Traffic Characteristics					
Ln (MajAADT)	0.705	0.765	0.621	0.790	0.798
Indicator for MajAADT>40,000 * Ln (MajAADT)	0.026	--	--	--	--
Ln (MinAADT)	0.300	0.215	0.165	0.138	--
State Indicators (base: Connecticut and Minnesota)					
State-California	-2.733	-1.984	-1.654	-1.776	--
State-Florida	1.049	1.255	1.021	2.025	3.306
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	0.509	0.46	0.400	0.405	0.357
C		0.528	0.449	0.479	0.422
B			0.488	0.504	0.442
A				0.879	0.572
K					0.651
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.887	0.802	0.606	0.621
C		-	0.884	0.703	0.720
B			-	0.769	0.784
A				-	0.756
K					-
BIC	24,523.303				
Log-Likelihood	-11,987.40				

Note: "--" denotes that the variable is not significant at the 90% significant level.

Urban 4-leg signalized intersections

The model estimation results of NB-OPFS and MVPLN models for U4SG facility are shown in Tables below.

Table C.41 NB-OPFS Model Coefficients for U4SG Intersections

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-9.401	-27.444	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.1788	0.84
Threshold between C-B	--	--	0.9327	4.392
Threshold between B-A	--	--	1.7338	8.132
Threshold between A-K	--	--	2.2777	10.45
Roadway Characteristics				
Major road speed limit (base: 41-55 mph)				
MajSL≤25	--	--	-0.222	-3.157
MajSL26-40	--	--	-0.150	-5.849
MajSL>55	0.352	4.572	--	--
Traffic Characteristics				
Ln (MajAADT)	0.731	22.000	0.091	4.200
Ln (MinAADT)	0.233	9.521	-0.112	-10.533
%MajTruck	--	--	-0.028	-6.889
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.125	2.792
State Indicators	*(Base: California)*		*(Base: California, Connecticut, Florida, Minnesota)*	
State-Connecticut	2.102	37.880	--	--
State-Florida	3.079	63.877	--	--
State-Minnesota	1.930	32.676	--	--
Interaction Effects				
HTZ*MajSL≤25	--	--	0.760	2.335
Overdispersion parameter	--	--	--	--
Constant	1.773	30.496	--	--
BIC	28,004.406			
Log-Likelihood	-13,906.929			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.42 MVPLN Model Coefficients for U4SG Intersections

Variable Names	O	C	B	A	K
Constant	-11.657	-11.453	-10.668	-12.857	-12.409
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Major road speed limit (base: ≤55 mph)					
MajSL> 55	0.396	0.210	--	--	--
Traffic Characteristics					
Ln (MajAADT)	0.834	0.820	0.721	0.792	0.694
Indicator for MajAADT>25,000 * Ln (MajAADT)	--	--	--	--	--
Ln (MinAADT)	0.27	0.217	0.153	0.122	--
Indicator for MinAADT≤20,000 * Ln (MinAADT)	-0.026	-0.025	-0.016	-0.027	--
% Majtruck	-0.013	--	-0.026	-0.035	--
% Mintruck	0.041	--	--	--	--
Interactions					
HTZ*Light	0.195	--	--	--	--
State Indicators (base: California)					
State-Connecticut	2.799	1.578	1.623	0.997	-0.755
State-Florida	3.714	2.552	2.594	2.997	1.720
State-Minnesota	2.261	1.656	1.319	1.168	0.776
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	0.584	0.531	0.453	0.433	0.287
C		0.613	0.516	0.518	0.392
B			0.521	0.538	0.401
A				0.839	0.444
K					0.587
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.888	0.821	0.619	0.489
C		-	0.913	0.723	0.653
B			-	0.813	0.725
A				-	0.632
K					-
BIC	45,574.715				
Log-Likelihood	-22,367.02				

Note: "--" denotes that the variable is not significant at the 90% significant level.

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The model estimation results of NB-OPFS and MVPLN models for R3ST facility are shown in Tables below.

Table C.43 NB-OPFS Model Coefficients for R3ST Intersections

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-10.075	-19.150	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	-0.366	-1.355
Threshold between C-B	--	--	0.191	0.701
Threshold between B-A	--	--	0.898	3.310
Threshold between A-K	--	--	1.435	5.191
Roadway Characteristics				
Major road speed limit (base: 41-55 mph)				
MajSL≤40	--	--	-0.251	-2.599
MajSL>55	-0.163	-1.918	--	--
Traffic Characteristics				
Ln (MajAADT)	0.528	9.046	-0.077	-2.479
Ln (MajAADT) * Indicator for MajAADT≤6,000	-0.030	-2.382	--	--
Ln (MinAADT)	0.462	16.569	--	--
State Indicators	*(Base: California)*		*(Base: California, Connecticut, and Florida)*	
State-Connecticut	1.536	9.204	--	--
State-Florida	3.029	30.052	--	--
State-Minnesota	2.113	22.149	0.145	2.218
Overdispersion parameter				
Constant	0.905	10.798	--	--
State-Florida	-0.436	-3.989	--	--
BIC	7,327.135			
Log-Likelihood	-3,591.510			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.44 MVPLN Model Coefficients for R3ST Intersections

Variable Names	O	C	B	KA
Constant	-12.063	-13.628	-11.408	-12.394
Ln (Year = 5)	1.000	1.000	1.000	1.000
Roadway Characteristics				
Major road speed limit (base: 41-55 mph)				
MajSL≤40	--	--	-0.367	--
MajSL>55	-0.249	--	-0.550	--
Traffic Characteristics				
Ln (MajAADT)	0.592	0.660	0.358	0.355
Ln (MinAADT)	0.573	0.532	0.545	0.526
%MajTruck	--	--	--	0.048
%MinTruck	--	--	--	--
Interaction Effects				
HTZ*Light	--	--	-1.785	--
State Indicators (base: California and Connecticut)				
State-Florida	2.760	2.624	2.957	3.112
State-Minnesota	1.705	1.999	2.074	1.718
Variance-Covariance Matrix	**O**	**C**	**B**	**KA**
O	0.894	0.859	0.732	0.617
C		1.049	0.828	0.721
B			0.828	0.641
KA				0.929
Pearson Correlation Coefficients	**O**	**C**	**B**	**KA**
O	-	0.887	0.851	0.677
C		-	0.888	0.730
B			-	0.731
KA				-
BIC	8,295.118			
Log-Likelihood	-3,907.36			

Note: -- denotes that the variable is not significant at 90% significant level.

Rural 4-leg stop controlled intersections

The model estimation results of NB-OPFS and MVPLN models for R4ST facility are shown in Tables below.

Table C.45 NB-OPFS Model Coefficients for R4ST Intersections

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-9.266	-27.940	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	-0.740	-3.372
Threshold between C-B	--	--	-0.120	-0.547
Threshold between B-A	--	--	0.548	2.520
Threshold between A-K	--	--	0.935	4.323
Roadway Characteristics				
Major road speed limit (base: ≤55 mph)				
MajSL>55	-0.211	-2.513	0.136	2.216
Traffic Characteristics				
Ln (MajAADT)	0.826	10.094	-0.099	-4.064
Ln (MajAADT) * Indicator for MajAADT ≤25,000	0.031	2.832	--	--
Ln (MajAADT) * Indicator for MajAADT ≤60,000	-0.163	-2.153	--	--
Ln (MinAADT)	0.424	14.697	--	--
Ln (MinAADT) * Indicator for MinAADT ≤3,500	0.034	2.117	--	--
% MajTruck	-0.016	-2.690	--	--
% MinTruck	0.033	1.829	--	--
State Indicators	*(Base: Connecticut and Minnesota)*		*(Base: California and Minnesota)*	
State-California	-1.511	-16.233	--	--
State-Connecticut	--	--	-0.397	-2.671
State-Florida	1.450	15.122	-0.154	-2.340
Overdispersion parameter				
Constant	0.726	12.681	--	--
State-California	0.945	3.244	--	--
BIC	13,206.580			
Log-Likelihood	-6,515.220			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.46 MVPLN Model Coefficients for R4ST Intersections

Variable Names	O	C	B	A	K
Constant	-10.209	-10.243	-10.266	-9.561	-8.536
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Major road speed limit (base: 41-55 mph)					
MajSL≤40	--	--	--	-0.617	-1.363
MajSL>55	-0.281	--	--	--	--
Traffic Characteristics					
Ln (MajAADT)	0.660	0.588	0.575	0.271	--
Ln (MinAADT)	0.483	0.472	0.405	0.466	0.426
%Total Truck	--	-0.016	--	--	--
State Indicators (base: Connecticut and Minnesota)					
State-California	-1.439	-1.850	-1.758	-1.616	-0.800
State-Florida	1.700	1.084	1.595	1.840	1.187
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	0.795	0.771	0.692	0.718	0.648
C		0.874	0.729	0.775	0.708
B			0.783	0.715	0.698
A				0.937	0.638
K					0.951
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.925	0.876	0.832	0.745
C		-	0.881	0.857	0.776
B			-	0.834	0.809
A				-	0.676
K					-
BIC	15,700.628				
Log-Likelihood	-7,590.107				

Note: -- denotes that the variable is not significant at 90% significant level.

Rural 4-leg signalized intersections

The model estimation results of NB-OPFS and MVPLN models for R4SG facility are shown in Tables below.

Table C.47 NB-OPFS Model Coefficients for R4SG Intersections

Variable Names	NB Model Component		OPFS Model Component	
	Estimates	**t-stat**	**Estimates**	**t-stat**
Constant	-8.685	-23.398	--	--
Ln (Year = 5)	1.000	--	--	--
Threshold Parameters				
Threshold between O-C	--	--	0.179	0.837
Threshold between C-B	--	--	0.933	4.378
Threshold between B-A	--	--	1.734	8.106
Threshold between A-K	--	--	2.278	10.416
Roadway Characteristics				
Major road speed limit (base: 41-55 mph)				
MajSL≤25	--	--	-0.222	-3.157
MajSL26-40	--	--	-0.150	-5.849
MajSL>55	0.330	4.538	--	--
Traffic Characteristics				
Ln (MajAADT)	0.690	21.092	0.072	3.086
Ln (MinAADT)	0.176	6.792	-0.112	-10.533
Ln (MinAADT) * Indicator for MinAADT≤7,000	-0.040	-6.607	--	--
% MajTruck	--	--	-0.028	-6.889
% MinTruck	--	--	0.061	3.312
HTZ (base: Indicator for <85th percentile of truck percentage)	--	--	0.125	2.792
State Indicators	*(Base: California)*		*(Base: California, Connecticut, Florida, Minnesota)*	
State-Connecticut	2.116	39.388	--	--
State-Florida	3.084	66.844	--	--
State-Minnesota	1.968	33.886	--	--
Interaction Effects				
HTZ*MajSL≤25	--	--	0.760	2.335
Overdispersion parameter				
Constant	0.659	3.888	--	--
BIC	29,907.839			
Log-Likelihood	-14,853.840			

Note: -- denotes that the variable is not significant at 90% significant level.

Table C.48 MVPLN Model Coefficients for R4SG Intersections

Variable Names	O	C	B	A	K
Constant	-11.851	-11.884	-10.83	-12.291	-12.014
Ln (Year = 5)	1.000	1.000	1.000	1.000	1.000
Roadway Characteristics					
Major road speed limit (base: ≤55 mph)					
MajSL>55	0.402	0.213	--	--	--
Traffic Characteristics					
Ln (MajAADT)	0.823	0.805	0.714	0.692	0.638
Ln (MinAADT)	0.278	0.227	0.164	0.136	--
%MajTruck	-0.016	-0.015	-0.026	-0.039	--
%MinTruck	-0.025	--	--	0.067	--
Interaction Effects					
HTZ*Light	0.203	--	--	--	--
State Indicators (base: California)					
State-Connecticut	2.794	1.574	1.627	1.036	-0.759
State-Florida	3.716	2.554	2.606	3.024	1.754
State-Minnesota	2.256	1.655	1.335	1.207	0.792
Variance-Covariance Matrix	**O**	**C**	**B**	**A**	**K**
O	0.591	0.539	0.454	0.445	0.303
C		0.622	0.519	0.533	0.413
B			0.519	0.545	0.425
A				0.860	0.480
K					0.657
Pearson Correlation Coefficients	**O**	**C**	**B**	**A**	**K**
O	-	0.889	0.820	0.625	0.487
C		-	0.913	0.729	0.645
B			-	0.816	0.727
A				-	0.639
K					-
BIC	45,441.31				
Log-Likelihood	22,360.37				

Note: -- denotes that the variable is not significant at 90% significant level.

APPENDIX D

Elasticity Analysis

The research team conducted an exhaustive elasticity analysis to examine if the variables identified in our model development as significant have a non-trivial impact on crash frequency. The process involved computing elasticity values for each significant variable in our selected model by facility type. We present the exhaustive results of the elasticity exercise in this Appendix. The first part of the Appendix provides details of the mathematical formulas for elasticity computation and the second part of the Appendix provides the results. It should be noted that the NB-OPFS model and MVPLN model have different dependent variables. Hence, in the NB-OPFS model elasticity measures were computed for Total Crashes. The rationale was that if variables have a non-trivial effect on total crashes these variables need to be retained. Hence, for these variables, we do not need to compute elasticities for the severity proportion components. On the other hand, for the MVPLN model elasticity measures were computed directly by injury severity (as the models are estimated separately by injury severity). The results of the elasticity are provided in Tables D.1 through Table D.4.

Estimation of Elasticity

The research team employed the formulas and procedures well established in safety literature for computing elasticities (see for example Eluru and Bhat, 2007; Afghari et al., 2018; Washington et al., 2010). Onukwugha et al. (2015) provide detailed formulas for various variable forms to compute the elasticity of the variables. We follow this paper structure for ease of presentation and discussion. As the variables in our models are continuous and categorical indicator variables, different formulas are required to estimate elasticity effects. We summarize the formulas by variable type in subsequent sections.

Case 1: Continuous variable

Let's consider a count model with x_1 and x_2 continuous variables. So, with log-link function, the expected crash count y is,

$$E(y|x_1, x_2) = exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2)$$

where β_1 and β_2 are the coefficients to be estimated. So, marginal effect of the variable x_2 is,

$$ME_2: \frac{\partial E(y|x_1, x_2)}{\partial x_2} = exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2)\, \beta_2$$

So, elasticity effect of the variable x_2 is,

$$\frac{ME_2}{E(y|x_1, x_2)} * x_2 = \beta_2 x_2$$

The elasticity is computed as an average across all observations.

Case 21: Continuous variable in the logarithmic form for ln(AADT)

Let's consider a count model with x_1 and x_2 continuous variables where x_2 is a logarithmic variable such as ln(AADT). So, with log-link function, the expected crash count y is,

$$E(y|x_1, x_2) = exp(\beta_0 + \beta_1 x_1 + \beta_2 \ln(x_2))$$

where β_1 and β_2 are the coefficients to be estimated. So, marginal effect of the variable x_2 is,

$$ME_2: \frac{\partial E(y|x_1, x_2)}{\partial x_2} = \frac{exp(\beta_0 + \beta_1 x_1 + \beta_2 ln(x_2))\beta_2}{x_2}$$

So, elasticity effect of the variable x_2 is,

$$\frac{ME_2}{E(y|x_1, x_2)} * x_2 = \beta_2$$

Case 3: Indicator variable

Let's consider x_1 is an indicator variable in the above equation. Therefore, the marginal effect of x_1 is,

$$ME_1: exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2)|_{x_1=1} - exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2)|_{x_1=0} = exp(\beta_0 + \beta_1 + \beta_2 x_2) - exp(\beta_0 + \beta_2 x_2)$$

So, the elasticity of the variable x_1 is,

$$\frac{exp(\beta_0 + \beta_1 + \beta_2 x_2) - exp(\beta_0 + \beta_2 x_2)}{exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2)}$$

Discussion of Elasticity Results

The elasticity results represent the change in crash frequency due to a change in the independent variable. For continuous variables, the interpretation is straight forward. The elasticity represents the percentage change in crash frequency for a 1% change in the independent variable. The following observations are made from the results.

First, it is very encouraging to see that the vehicle mix variables - % Truck and % SUT - considered in our analysis have elasticity effects that are comparable to other variables in the model whenever significant. This finding provides credibility to our research effort to include vehicle mix variables. Second, it is interesting to note that the relative magnitude of elasticities does not vary drastically across the variables in any model i.e. the results indicate that all variables in our models have non-trivial impacts on the crash frequency variables. Thus, the research team recommends the adoption of the models with all variables.

Finally, the elasticity impacts of indicator variables are quite large. However, it is important to recognize that changing the indicator variables is substantially harder than changing the continuous variables. Thus, it is important to consider these elasticity effects recognizing this distinction.

Table D.1 Elasticity Effects of the Variables for Segment Facilities (NB-OPFS Models)

Variables	Elasticity Effects of the Variables for Total Crashes										
	Urban Limited Access	Urban Arterials					Rural Arterials				
	ULA4LD	UA2LUD	UA3L	UA5L	UA4LUD	UA4LD	RA2LUD	RA3L	RA5L	RA4LUD	RA4LD
LW<12	--	--	0.508	0.508	0.224	--	--	--	--	--	--
LW>12	0.435	--	-0.183	-0.183	--	-0.280	--	--	--	-0.226	--
OSW<2	--	--	--	--	--	--	0.282	--	--	--	--
OSW2-3	--	--	--	--	--	--	0.368	--	--	--	--
OSW<4	--	--	--	--	--	--	--	--	--	--	0.260
OSW4-5	--	--	--	--	--	--	0.179	--	--	--	0.409
OSW<6	--	--	--	--	--	--	--	0.228	0.228	0.165	--
OSW6-7	--	--	--	--	--	--	--	0.599	0.599	--	1.043
OSW<8	0.339	--	--	--	0.354	0.185	--	--	--	--	--
ISW<2	0.420	--	--	--	--	--	--	--	--	--	0.331
ISW2-3	0.827	--	--	--	--	--	--	--	--	--	0.650
ISW4-5	0.214	--	--	--	--	--	--	--	--	--	0.565
ISW6-7	--	--	--	--	--	--	--	--	--	--	0.602
ISW<8	--	--	0.390	0.390	--	0.273	--	--	--	--	--
SL≤25	--	0.426	--	--	--	--	--	--	--	--	--
SL≤40	--	--	--	--	--	--	0.602	--	--	--	0.660
SL26-40	--	--	--	--	--	0.789	--	--	--	--	--
SL>55	--	--	-0.345	-0.345	--	--	-0.168	-0.313	-0.313	-0.260	--
SL≤60	-0.233	--	--	--	--	--	--	--	--	--	--
SL61-65	-0.346	--	--	--	--	--	--	--	--	--	--
MW>20	--	--	--	--	--	-0.186	--	--	--	--	--
MW21-40	--	--	--	--	--	--	--	--	--	--	-0.306
MW41-60	--	--	--	--	--	--	--	--	--	--	-0.214
MW>60	--	--	--	--	--	--	--	--	--	--	-0.232
ST (Unpaved)	--	--	0.305	0.305	--	0.602	0.589	0.684	0.684	0.229	0.416
AADT	0.471	0.546	0.435	0.435	0.480	0.452	0.801	0.887	0.975	0.634	0.891
%Truck	-0.313	-0.129	--	--	-0.231	-0.083	-0.185	-0.295	-0.200	-0.451	-0.356
%SUT	-0.213	-0.108	--	--	--	-0.088	--	-0.435	-0.767	-0.456	-0.203

Variables	Elasticity Effects of the Variables for Total Crashes										
	Urban Limited Access	Urban Arterials					Rural Arterials				
	ULA4LD	UA2LUD	UA3L	UA5L	UA4LUD	UA4LD	RA2LUD	RA3L	RA5L	RA4LUD	RA4LD
HTZ	1.065	--	--	--	--	--	--	--	--	--	--

Table D.2 Elasticity Effects of the Variables for Urban Stop Controlled Intersection Facilities (MVPLN Models)

Variables	Elasticity Effects of the Variables for Crash Count by Severities									
	U3ST					U4ST				
	O	C	B	A	K	O	C	B	A	K
Light	0.224	0.494	--	--	--	-0.170	--	--	--	-0.604
MajSL≤25	--	-0.267	-0.349	-0.420	--	-0.158	-0.228	-0.260	-0.405	-0.544
MajSL26-40	--	-0.121	-0.219	-0.365	-0.358	--	-0.130	-0.226	-0.365	-0.673
MajSL≤40	--	--	--	--	--	--	--	--	--	--
MajSL>55	0.364	--	--	--	--	0.064	--	--	--	--
MajAADT	0.736	0.693	0.592	0.534	0.534	0.625	0.562	0.429	0.426	0.511
MinAADT	0.454	0.409	0.341	0.348	--	0.528	0.439	0.395	0.402	0.402
%MajTruck	--	--	--	--	--	0.111	--	--	--	--
%MinTruck	--	--	--	--	--	--	--	-0.121	-0.108	--
HTZ	--	--	--	0.247	--	0.017	--	--	--	0.770

Table D.3 Elasticity Effects of the Variables for Urban Signalized Intersection Facilities (MVPLN Models)

Variables	Elasticity Effects of the Variables for Crash Count by Severities									
	U3SG					U4SG				
	O	C	B	A	K	O	C	B	A	K
Light	--	0.417	--	--	--	0.038	--	--	--	--
MajSL≤25	--	--	--	--	--	--	--	--	--	--
MajSL26-40	--	--	--	--	--	--	--	--	--	--
MajSL≤40	--	-0.136	-0.211	-0.516	-0.541	--	--	--	--	--
MajSL>55	0.579	0.402	--	--	--	0.492	0.236	--	--	--
MajAADT	0.863	0.828	0.657	0.687	0.556	0.823	0.805	0.714	0.692	0.638
MinAADT	0.304	0.218	0.167	0.137	--	0.278	0.227	0.164	0.136	--
%MajTruck	--	--	--	--	--	-0.066	-0.062	-0.108	-0.161	--
%MinTruck	--	--	--	--	--	0.059	--	--	0.085	--
HTZ	--	--	--	--	--	0.042	--	--	--	--

Table D.4 Elasticity Effects of the Variables for Rural Intersection Facilities (NB-OPFS Models)

Variables	Elasticity Effects of the Variables for Total Crashes		
	Rural Stop Controlled		Rural Signalized
	R3ST	R4ST	R4SG
Light	--	--	--
MajSL≤25	--	--	--
MajSL26-40	--	--	--
MajSL≤40	--	--	--
MajSL>55	-0.167	-0.265	0.419
MajAADT	0.611	0.755	0.731
MinAADT	0.462	0.416	0.233
%MajTruck	--	-0.081	--
%MinTruck	--	0.027	--