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This research developed type 1 and type 2 safety performance functions (SPFs) for roadway segments, intersections and ramps on the entire Caltrans network. Type 1 SPFs involved statistical models with a length offset, and average daily traffic (ADT) while type 2 SPFs included geometrics as well. In the case of intersections, type 2 SPFs included traffic control, ADT and roadway geometrics. For ramps, type 2 SPFs included variables related to metering, HOV lane presence and ramp configuration. The research developed SPFs using data based on the period 2005-2010, and tested the SPFs on the period 2011-2012. Type 1 and type 2 SPFs were compared for predictive effectiveness, and it was found that type 2 SPFs provided for better measures of effectiveness such as mean absolute deviation, mean absolute percent error and mean squared error.

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Final Report

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January 31, 2015

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Executive Summary

This research project involved the development of type 1 and type 2 safety performance functions (SPF) for the three major functional components of the state network, namely, roadway segments, intersections and ramps. Type safety performance functions involve statistical models with average daily traffic as the only predictor, while type 2 safety performance functions included roadway geometrics in addition to traffic volume. A total of 60 type 1 SPFs were developed for the five major severity outcomes, and another 60 type 2 SPFs were developed as well. Twelve type 1 and type 2 SPFs were developed for intersections. Similarly, twelve type 1 and type 2 SPFs were developed for ramps as well. Model transferability tests were conducted to evaluate parameter stability across years. In addition, model predictive measures of effectiveness were evaluated on 2011-2012 out of model estimation samples. It was determined that type 2 SPFs were superior to type 1 SPFs. In developing these SPFs, the entire state network was scanned for complete geometric and traffic volume data. Over 13,000 centerline miles of road segments, over 17,000 intersections and the entire ramp system with ramp metered subsets were evaluated. Roadway segment SPFs excluded intersection ranges. The SPFs were estimated using 2005-2010 historic data. Severity data was developed using SWITRS definitions, including property damage only, complaint of pain, visible injury, severe and fatal injury.

Introduction

This research project was tasked by the California Department of Transportation (Caltrans) to achieve three important objectives: a) to develop type 1 and type 2 safety performance functions for roadway segments on Caltrans highways; b) to develop type 1 and type 2 safety performance functions for intersections on Caltrans highways; and c) to develop type 1 and type 2 safety performance functions for ramps on Caltrans highways. Associated with the development of these safety performance functions (SPF), was the development of data files that can be used for testing in Safety Analyst. Type 1 SPFs include functional forms where the independent variables include an intercept and average daily traffic. The functional form is specified as a logarithmic function representation of the event rate, in this case, the number of crashes occurring per year. In the case of roadway segments, the length of segment is used as an offset, which implies that the coefficient for segment length is unity. The resulting type 1 functional form for roadway segments looks as follows:

$ln\lambda_i = \alpha + \ln(length)_i + \beta\ln(ADT)_i$; or equivalently, $\lambda_i = length_i * e^{\alpha} * {ADT_i}^{\beta}$

The above equation assumes that length linearly affects expected crash rate for a roadway segment. In type 2 SPFs, the estimating equation includes geometric variables in addition to the length and ADT effects. Therefore, given a vector of geometric effects Z_{ij} and associated coefficients γ_j, the estimating equation is now expanded to look as follows: $ln\lambda_i = \alpha + \ln(length)_i + \beta\ln(ADT)_i + \sum_{j=1}^{l} \gamma_j Z_{ij}$; or equivalently,

$\lambda_i = length_i * e^{\alpha} * {ADT_i}^{\beta} * e^{\sum_{j=1}^{l} \gamma_j Z_{ij}}$

The coefficients α, β, and γ_j are estimated by the method of maximum likelihood. Similar to roadway segments, for intersections, type 1 SPFs were estimated as follows: $\lambda_i = \lambda_i = e^{\alpha} * {ADT_i}^{\beta}$; and Type 2 SPFs as follows: : $\lambda_i = \lambda_i = e^{\alpha} * {ADT_i}^{\beta} * e^{\sum_{j=1}^{l} \gamma_j Z_{ij}}$. Some differences exist however. The length variable is not present in the estimating equation since intersections are defined as fixed length ranges of 250 feet from the centerline of the intersecting roadway. Type 2 SPFs for intersections do not include length as a variable; they include the geometrics of the mainline as well as characteristics of the intersecting roadway and attributes of the intersection relating to traffic to intersection geometry, traffic signal control type and turn lane treatments. These effects are represented in the vector Z. Finally, the ADT variable represents the volume effect on mainline intersection crashes which are being predicted. Theoretically, both major and minor street crash outcomes should be predicted with separate estimating equations when predicting intersection crashes on all approaches. Capturing the marginal effect of volume with a single parameter when conflicting flows occur is considered a significant parametric constraint, a condition which should be accommodated only if there is strong statistical basis. In order to provide for a strong statistical basis, geometric data should be consistently measured for all approaches, which was not possible for this study.

Type 1 SPFs for ramps are estimated of the form: , $\lambda_i = e^{\alpha} * ADT_i^{\beta}$ since ramp lengths are unknown. Type 2 SPFs for ramps are estimated by including ramp information such as ramp control type, presence of HOV lane, and whether the ramp is an on-ramp or off-ramp. Type 2 SPFs for ramps therefore look as follows: $\lambda_i = e^{\alpha} * ADT_i^{\beta} * e^{\sum_{j=1}^{l} \gamma_j Z_{ij}}$. All of the type1 and type 2 SPFs discussed above are estimated by the method of maximum likelihood, using the negative binomial density function which assumes a quadratic variance-mean relationship. Therefore, in addition to the parameters described in the estimating equations, an overdispersion parameter is also estimated to test for the plausibility of the negative binomial. The following sections describe the methodology used for developing the SPFs, including a discussion of the dataset development process, a discussion of the SPF classes, and a discussion of the SPF models developed in terms of statistically significant variables. Model discussion also addresses parameter stability and out of sample predictions.

Roadway Segment Data Development for SPFs

Data for roadway segments was assembled for the entire state network consisting of over 50,000 lane miles of roadway. Roadway geometric data such as number of lanes, inside and outside shoulder widths, auxiliary lane information, roadside information (for example, median type, presence of barrier etc.) was used to first determine homogeneous segments. Homogeneous segments are segments where all geometry is of the same value within the segment limits. If any geometry changed, it resulted in a new segment. Further, incomplete data such as missing ADT or missing lane information led to omission of observations. Using the complete segment data, then, two sets of databases were developed for roadways. The first included intersections as part of the mainline running inventory, and the second excluded the intersection ranges. The intersection range data was used for intersection type 2 SPF development. Table 1 below presents at the district level, the breakdown of segment count for with and without intersection mainline inventories.

Table 1. District Level Homogeneous Roadway Segment Counts.

District	With Intersections	Without Intersections
1	2,367	3,140
2	2,875	3,995
3	2,976	3,894
4	5,018	6,062
5	2,501	3,233
6	2,786	3,659
7	3,867	4,378
8	3,090	3,681
9	608	800
10	2,320	3,135
11	2,668	3,208
12	1,228	1,356

Crash data was obtained from the statewide integrated traffic records system (SWITRS) maintained by the California Highway Patrol (CHP). This system allows for a dump of raw crash data for a specified period of reporting. The raw data was then aggregated by the homogeneous segment limits defined for roadway segments, and multi-year panels were created for the period 2005-2010. For prediction testing, out of estimation samples for the period 2011 were used. The SWITRS database provided for the estimation of five crash severity types, namely, fatality, severe injury, visible injury, complaint of pain and property damage only. Tables 2 and 3 show the breakdown of SWITRS crash totals for the homogeneous segments for the period 2005-2010.

Table 2. Year by Year Breakdown of SWITRS Crash Counts for Homogeneous Roadway Segments Without Intersection Ranges.

Year	Property Damage Only	Complaint of Pain	Visible Injury	Severe Injury	Fatality
2005	113,184	33,303	17,851	3,110	1,382
2006	111,813	31,978	16,910	3,002	1,344
2007	105,714	32,241	15,300	3,062	1,223
2008	92,047	28,279	13,780	2,834	1,076
2009	87,973	27,816	12,944	2,543	974
2010	90,829	29,122	12,786	2,441	827

Though the total crash counts decrease toward the later years, the severity distributions have remained relatively stable for the most part. However, it should be noted that even though there appears to be a slight decrease in fatality percentage, a decrease of 0.21 percent points in fatality occurrence is significant. Comparatively, the notable increase is in the complaint of pain category, a 1.68 percentage point increase.

Table 3. Year by Year Breakdown of SWITRS Crash Counts for Homogeneous Roadway Segments Without Intersection Ranges.

Year	Property Damage Only	Complaint of Pain	Visible Injury	Severe Injury	Fatality
2005	67.04	19.73	10.57	1.84	0.82
2006	67.75	19.38	10.25	1.82	0.81
2007	67.10	20.47	9.71	1.94	0.78
2008	66.69	20.49	9.98	2.05	0.78
2009	66.52	21.03	9.79	1.92	0.74
2010	66.78	21.41	9.40	1.79	0.61

The Caltrans network is made up of twelve districts and 58 counties, and over 240 state routes that include interstates, state highways, and arterials. District level breakdowns of miles of roadway, and general crash patterns are described in the following section.

Figure 1. Caltrans Districts and Counties.

As figure 1 shows, there are twelve districts 1-12 consisting of 58 counties. The integrated dataset used in this study consisted of 15,162 centerline miles and 50,893.55 lane miles. A total of 40,541 roadway segments (excluding intersection ranges), with average lane mile length of 1.032 miles and segment length of 0.277 miles constituted this network.

A total of 897,688 crashes were analyzed for the 6-year period 2005-2010, with an average of 3.69 crashes per segment per year. There were 601,560 property damage only (2.473 segment average per year), 182,739 complaint of pain (0.751 segment average per year), 89,571 visible (0.368 segment average per year), 16,992 severe (0.0698 segment average per year), and 6826 fatal crashes (0.028 fatals per year per segment).

Figure 2 shows district 1 routes, counties and the geographical limits. District 1 consists mainly of 4 counties – namely Del Norte, Humboldt, Lake and Mendocino. The integrated dataset consists of 952.399 centerline miles and 2,399.418 lane miles. A total of 3,140 roadway segments (excluding intersection ranges), with average lane mile length of 0.618 miles and segment length of 0.238 miles constituted this network. A total of 8,939 crashes were analyzed for District 1 for the period 2005-2010, including 5,177 property damage only (PDO) crashes, 1,524 complaint of pain crashes, 1,573 visible crashes, 459 severe crashes and 206 fatal crashes.

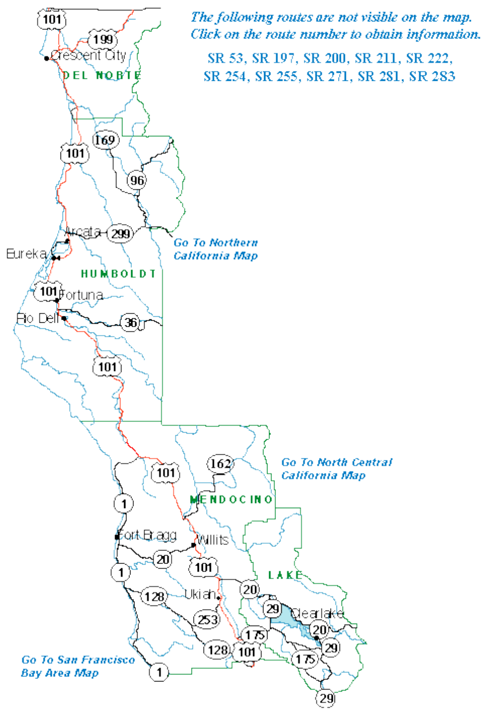


Figure 2. District 1 Routes and Counties.

Figure 3 shows district 2 routes, counties and the geographical limits. District 2 consists mainly of 7 counties – namely Lassen, Modoc, Plumas, Shasta, Siskiyou, Tehama, and Trinity. The integrated dataset consists of 1,781.047 centerline miles and 4,236.959 lane miles. A total of 3,995 roadway segments (excluding intersection ranges), with average lane mile length of 0.618 miles and segment length of 0.269 miles constituted this network.

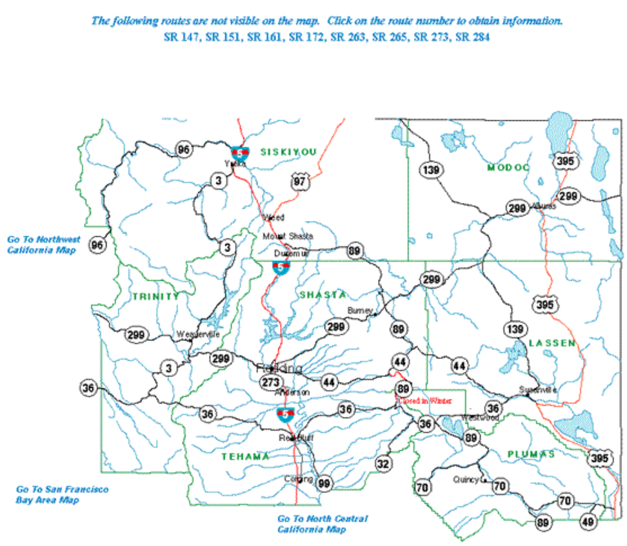


Figure 3. District 2 Routes and Counties.

A total of 10,609 crashes were analyzed for District 2 for the period 2005-2010, including 6,566 property damage only (PDO) crashes, 1,860 complaint of pain crashes, 1,587 visible crashes, 424 severe crashes and 172 fatal crashes.

Figure 4 shows District 3 routes, counties and geographical limits. District 3 consists mainly of 11 counties – namely Butte, Colusa, El Dorado, Glenn, Nevada, Placer, Sacramento, Sierra, Sutter, Yolo and Yuba. The integrated dataset consists of 1,514.463 centerline miles and 4,490.957 lane miles. A total of 3,894 roadway segments (excluding intersection ranges), with average lane mile length of 0.984 miles and segment length of 0.298 miles constituted this network.

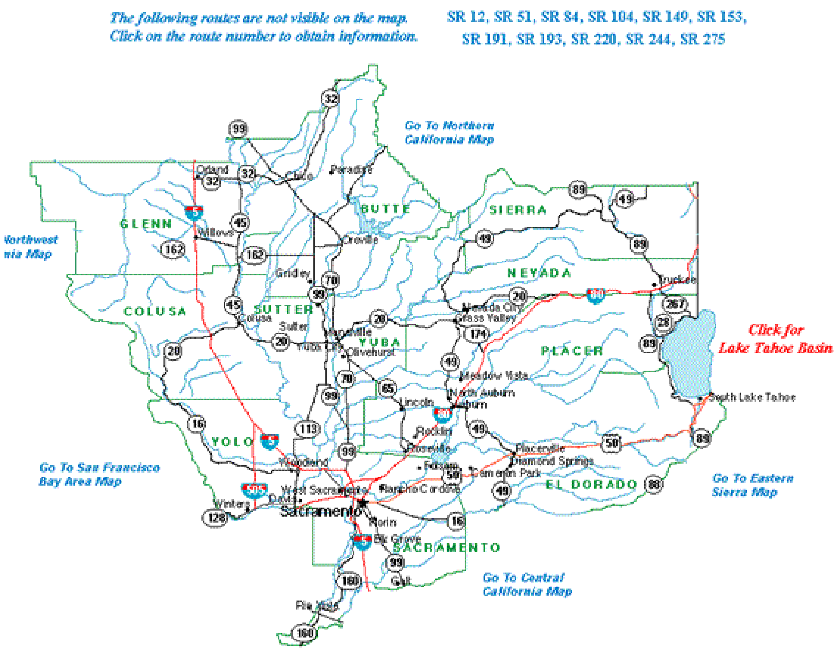


Figure 4. District 3 Routes and Counties.

A total of 60,121 crashes were analyzed for District 3 for the period 2005-2010, including 38,833 property damage only (PDO) crashes, 13,428 complaint of pain crashes, 6,128 visible crashes, 1,220 severe crashes and 512 fatal crashes.

Figure 5 shows District 4 routes, counties and geographical limits. District 4 consists of 9 counties – namely Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. The integrated dataset consists of 1,395.529 centerline miles and 6,237.683 lane miles. A total of 6,062 roadway segments (excluding intersection ranges), with average lane mile length of 0.888 miles and segment length of 0.182 miles constituted this network. A total of 172,629 crashes were analyzed for District 4 for the period 2005-2010, including 117,994 property damage only (PDO) crashes, 35,531 complaint of pain crashes, 15,353 visible crashes, 2,857 severe crashes and 894 fatal crashes.

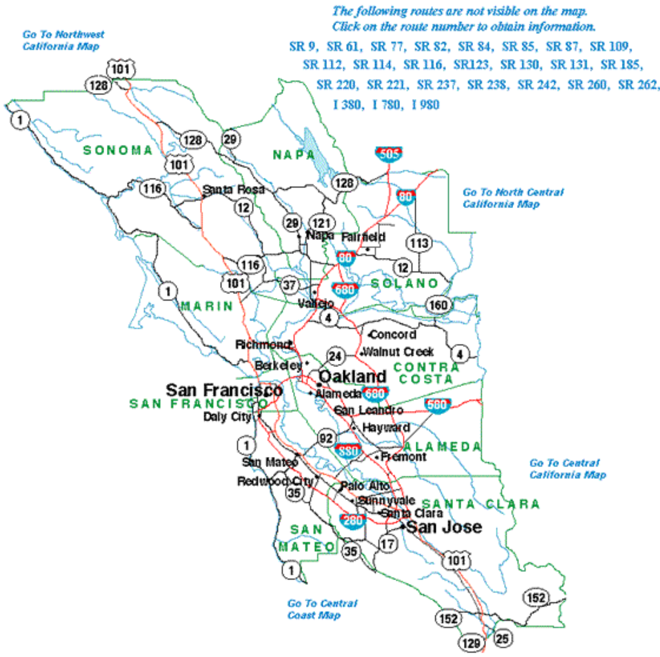


Figure 5. District 4 Routes and Counties.

Figure 6 shows District 5 routes, counties and geographical limits. District 5 consists of 5 counties – namely Monterrey, San Benito, San Luis Obispo, Santa Barbara, and Santa Cruz. The integrated dataset consists of 1,153.46 centerline miles and 3,182.205 lane miles. A total of 3,233 roadway segments (excluding intersection ranges), with average lane mile length of 0.804 miles and segment length of 0.280 miles constituted this network. A total of 34,608 crashes were analyzed for District 5 for the period 2005-2010, including 23,520 property damage only (PDO) crashes, 5,942 complaint of pain crashes, 3,840 visible crashes, 972 severe crashes and 334 fatal crashes.

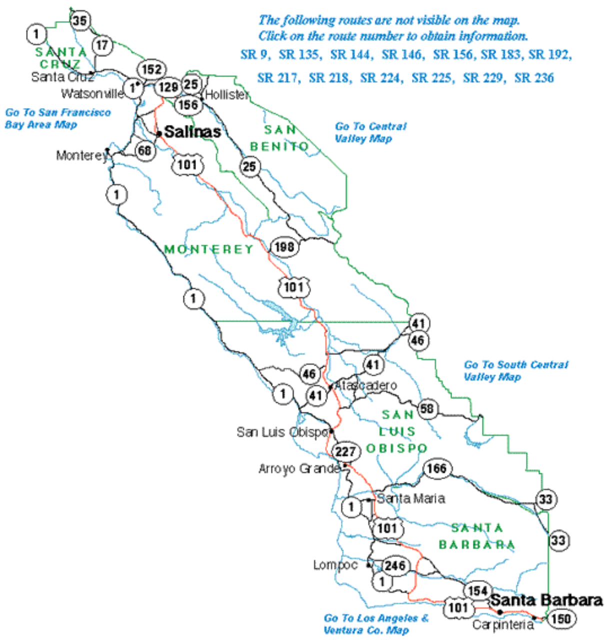


Figure 6. District 5 Routes and Counties.

Figure 7 shows District 6 routes, counties and geographical limits. District 6 consists of 5 counties – namely Fresno, Kern, Kings, Madera and Tulare. The integrated dataset consists of 2,026.216 centerline miles and 5,726.586 lane miles. A total of 3,659 roadway segments (excluding intersection ranges), with average lane mile length of 1.169 miles and segment length of 0.376 miles constituted this network. A total of 45,174 crashes were analyzed for District 6 for the period 2005-2010, including 29,267 PDO crashes, 8,386 complaint of pain crashes, 5,651 visible crashes, 1,187 severe crashes and 683 fatal crashes.

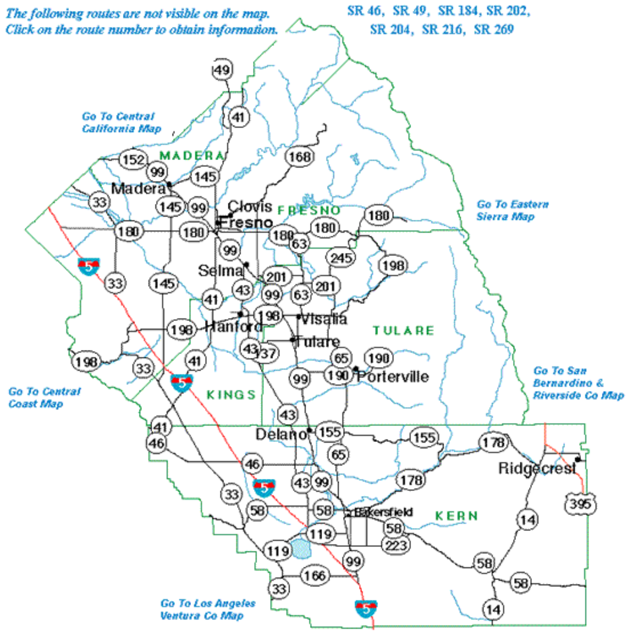


Figure 7. District 6 Routes and Counties.

Figure 8 shows District 7 routes, counties and geographical limits. District 7 consists of 2 counties – namely Los Angeles and Ventura. The integrated dataset consists of 1,134.706 centerline miles and 46,618.883 lane miles. A total of 4,378 roadway segments (excluding intersection ranges), with average lane mile length of 1.357 miles and segment length of 0.205 miles constituted this network.. A total of 268,349 crashes were analyzed for District 7 for the period 2005-2010, including 187,925 PDO crashes, 52,471 complaint of pain crashes, 23,247 visible crashes, 3,480 severe crashes and 1,226 fatal crashes.

Figure 8. District 7 Routes and Counties.

Figure 9 shows District 8 routes, counties and geographical limits. District 8 consists of 2 counties – namely San Bernadino and Riverside. The integrated dataset consists of

1,904.634 centerline miles and 6,780.674 lane miles. A total of 3,681 roadway segments (excluding intersection ranges), with average lane mile length of 1.579 miles and segment length of 0.406 miles constituted this network... A total of 111,291 crashes were analyzed for District 8 for the period 2005-2010, including 71,998 property damage only (PDO) crashes, 23,570 complaint of pain crashes, 11,772 visible crashes, 2,624 severe crashes and 1,327 fatal crashes.

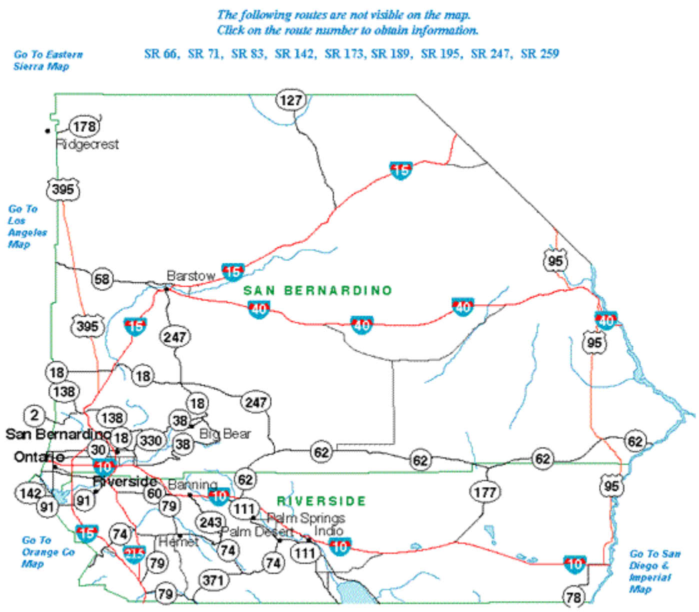


Figure 9. District 8 Routes and Counties.

Figure 10 shows District 9 routes, counties and geographical limits. District 9 consists of 4 counties – namely Inyo, Kern , Mono, and San Bernadino. The integrated dataset consists of 718.4 centerline miles and 1,703.636 lane miles. A total of 800 roadway segments (excluding intersection ranges), with average lane mile length of 1.749 miles and segment length of 0.744 miles constituted this network... A total of 1,780 crashes were analyzed for District 9 for the period 2005-2010, including 1,065 property damage only (PDO) crashes, 252 complaint of pain crashes, 292 visible crashes, 133 severe crashes and 38 fatal crashes.

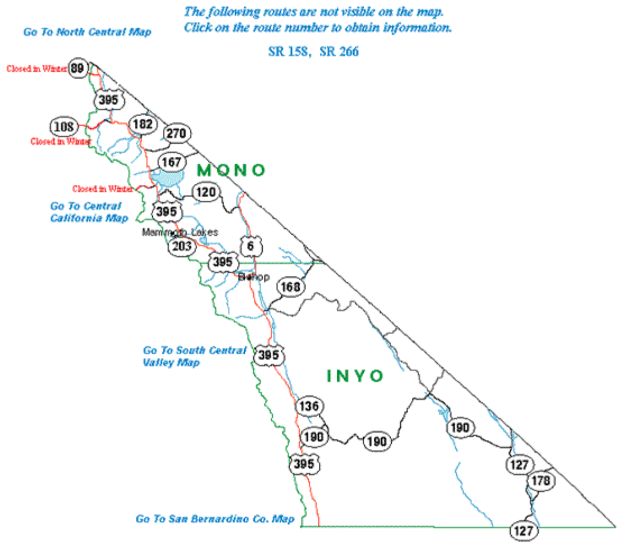


Figure 10. District 9 Routes and Counties.

Figure 11 shows District 10 routes, counties and geographical limits. District 10 consists of 8 counties – namely Amador, Alpine, Calaveras, Mariposa, Merced, San Joaquin, Stanislaus and Tuolumne. The integrated dataset consists of 1,320.156 centerline miles and 3,510.31 lane miles. A total of 3,135 roadway segments, with average lane mile length of 0.780 miles and segment length of 0.263 miles constituted this network. A total of 35,924 crashes were analyzed for District 10 for the period 2005-2010, including 22,821 PDO, 7,098 complaint of pain crashes, 4,594 visible crashes, 964 severe crashes and 447 fatal crashes.

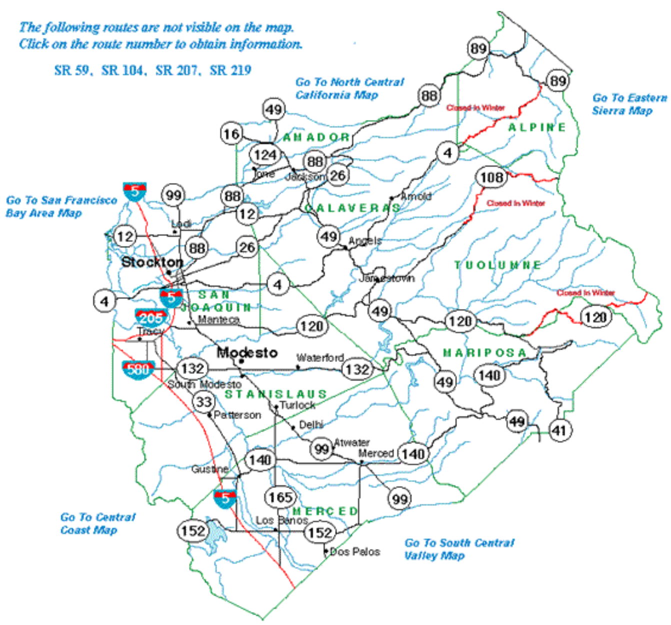


Figure 11. District 10 Routes and Counties.

Figure 12 shows District 11 routes, counties and geographical limits. District 11 consists of 2 counties – namely San Diego and Imperial. The integrated dataset consists of 978.023

centerline miles and 4,025.168 lane miles. A total of 3,208 roadway segments (excluding intersection ranges), with average lane mile length of 1.159 miles and segment length of 0.255 miles constituted this network.

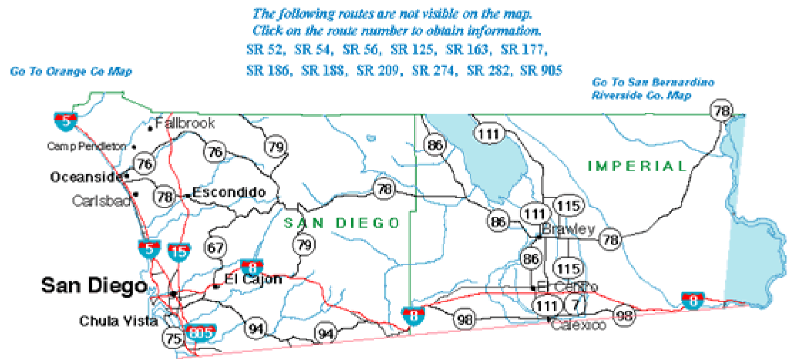


Figure 12. District 11 Routes and Counties.

A total of 66,285 crashes were analyzed for District 11 for the period 2005-2010, including 37,678 property damage only (PDO) crashes, 17,360 complaint of pain crashes, 8,859 visible crashes, 1,703 severe crashes and 685 fatal crashes.

Figure 13 shows District 12 routes, counties and geographical limits. District 12 consists of 1 county – namely Orange. The integrated dataset with 282.967 centerline miles, 1,981.071 lane miles, 1,356 roadway segments (excluding intersection ranges), with average lane mile length of 1.313 miles and segment length of 0.175 miles constituted this network.

Figure 13. District 12 Routes and Counties.

A total of 81,979 crashes were analyzed for District 12 for the period 2005-2010, including 58,716 property damage only (PDO) crashes, 15,317 complaint of pain crashes, 6,675 visible crashes, 969 severe crashes and 302 fatal crashes. To summarize the district level crash characteristics with respect to roadway segments, Table 4 shows the details below.

Table 4. District Level Distributions of Crash Frequencies by Severity on Roadway Segments for the period 2005-2010.

District	Lane Miles	Total Segment Length (Miles)	PDO	CPAIN	VISIBLE	SEVERE	FATAL	Total
1	1,941.487	747.419	5,177	1,524	1,523	459	206	8,939
2	2,715.502	1,072.741	6,566	1,860	1,587	424	172	10,609
3	3,832.659	1,160.735	38,833	13,428	6,128	1,220	512	60,121
4	5,382.614	1,100.713	117,994	35,531	15,353	2,857	894	172,629
5	2,599.617	907.532	23,520	5,942	3,840	972	334	34,608
6	4,275.709	1,375.299	29,267	8,386	5,651	1,187	683	45,174
7	5,939.087	899.359	187,925	52,471	23,247	3,480	1,226	268,349
8	5,812.746	1,493.365	71,998	23,570	11,772	2,624	1,327	111,291
9	1,399.544	595.443	1,065	252	292	133	38	1,780
10	2,445.609	823.892	22,821	7,098	4,594	964	447	35,924
11	3,717.372	817.559	37,678	17,360	8,859	1,703	685	66,285
12	1,780.678	237.02	58,716	15,317	6,675	969	302	81,979
All Districts			601,560	182,739	89,571	16,992	6,826	897,688

Table 5. District Level Severity Distributions for the Period 2005-2010.

District	PDO	CPAIN	VISIBLE	SEVERE	FATAL	Total
1	57.91	17.05	17.60	5.13	2.30	100
2	61.89	17.53	14.96	4.00	1.62	100
3	64.59	22.33	10.19	2.03	0.85	100
4	**68.35**	**20.58**	**8.89**	**1.65**	**0.52**	**100**
5	67.96	17.17	11.10	2.81	0.97	100
6	64.79	18.56	12.51	2.63	1.51	100
7	**70.03**	**19.55**	**8.66**	**1.30**	**0.46**	**100**
8	64.69	21.18	10.58	2.36	1.19	100
9	59.83	14.16	16.40	7.47	2.13	100
10	63.53	19.76	12.79	2.68	1.24	100
11	56.84	26.19	13.37	2.57	1.03	100
12	**71.62**	**18.68**	**8.14**	**1.18**	**0.37**	**100**
All Districts	67.01	20.36	9.98	1.89	0.76	100

Table 5 shows the equivalent severity distributions by districts. As can be seen, the severity distributions are not homogeneous across districts. This may be indicative of collision priorities that can be strategized at the district level as well. For example, districts

1,2,6,8,9,10 and 11 have lower PDO percentages and higher severe+fatal percentages compared to the whole network. District 5 appears comparable in terms of PDO percentage, but appears to have a higher severe+fatal percentage. District 3 on the other hand has a lower PDO percentage but a comparable severe+fatal percentage compared to the whole network. District 4, 7 and 12 appear to be lower on PDO percentages and lower on the severe+fatal percentages as well compared to the whole network.

Segment Length Distributions

Segment length distributions were examined by SPF class. A total of 11 SPF classes were created based on rural-urban distinctions and lane cross section leading to the following: a) two-lane rural, b) four-lane rural, c) four-plus-rural, d) multilane undivided rural, e) multilane divided, f) two-lane urban, g) four-lane urban, h) five-to-seven lane urban, i) eight or more lane urban, j) multilane undivided urban, and k) multilane divided urban. Table 6 shows the distribution of segment lengths in the above mentioned SPF classes. As seen in Table 6, 59.70% of the network has segment lengths less than or equal to 0.1 miles. The percentages vary by SPF class for lengths less than or equal to 0.1 miles. This has implications for network screening. If the distribution of segment lengths less than or equal to 0.05 miles is used, then, the average percentage for the entire network is 44.08%.

Table 6. Segment Length Distributions by SPF Class (Segment Count in Parentheses).

SPF Class	<=0.1 mi	<=0.2 mi	<=0.3 mi	<=0.4 mi	<=0.5 mi	<=1 mi
2-lane rural (4,202)	50.00%	60.11%	67.42%	72.68%	76.80%	86.51%
4-lane rural (9,149)	55.98%	67.46%	73.77%	78.02%	81.54%	90.45%
4-plus-rural (220)	55.45%	63.64%	72.73%	77.73%	81.36%	92.27%
Multilane undivided rural (114)	36.84%	50.00%	64.04%	75.44%	78.07%	91.23%
Multilane divided rural (33)	75.76%	81.82%	87.88%	87.88%	90.91%	93.94%
2-lane urban (5,598)	67.76%	76.99%	82.51%	86.67%	89.42%	95.61%
4-lane urban (7,182)	61.97%	74.77%	80.94%	84.68%	87.52%	94.37%
5-to-7-lane urban (4,268)	60.33%	75.75%	83.15%	87.18%	89.55%	95.15%
8-plus-urban (5,694)	48.24%	68.77%	80.80%	86.97%	90.60%	96.82%
Multilane undivided urban (845)	76.45%	84.50%	88.76%	92.07%	93.25%	97.75%
Multilane divided urban (3,236)	79.64%	88.32%	91.66%	93.79%	95.18%	98.30%
All Classes	59.70%	72.33%	79.28%	83.61%	86.64%	93.63%

The high percentage of lengths under 0.1 miles is due to the fact that several geometric elements are used to determine homogeneous segments. These definitions affect the specification of estimating models. If the lengths are altered to decrease sensitivity to geometric criteria, then, the implications for model development are significant. For example, models where a particular geometric variable is found to be significant by the universal homogeneous geometry definition, will require a modified definition if that variable is removed from the homogeneity criteria list for the purpose of decreased homogeneity sensitivity. As a result, one can have models with homogeneous geometric variables and non-homogeneous geometric variables, which can contribute to inconsistent model estimation. This is a significant estimation issue that should not be overlooked at the expense of simplified segmentation assumptions for the purpose of network screening.

Network screening therefore might involve an involved iterative process where based on the model specifications, segmentations can be redefined based on the identified geometric universe of statistically significant variables. This is the preferred approach versus the alternative approach where network screening involves SPF specific windows, based on the SPF specific model variables.

Intersection Dataset for SPFs

A total of 17,200 intersections were assembled using the integration of mainline roadway segment geometrics and intersection specific attributes. The following conditions were used to define intersections:

a) Locate postmile of intersection as centerline postmile of mainline segmentation dataset
b) Isolate mainline intersection range as consisting of +/- 0.05 mile w.r.t centerline postmile
c) Determine total crash count and SWITRS injury counts for the period 2005-2010
d) Merge mainline segment geometry from roadway segment dataset to match the +/- 0.05 mile intersection range
e) Intersection range can have multiple segments
f) Use minimum and maximum geometry values for continuous variables
g) Use dummy value of 1 if a dummy variable is valued at 1 in at least one segment(s) in the intersection range

It should be noted here that mainline intersection crashes are being analyzed in the development of intersection SPFs since cross street crash histories were not available. The six-year period 2005-2010 was used to derive SWITRS crash counts by severity type for the 17,200 intersections. Table 7 shows the distribution of severities for this period.

Table 7. Six-Year Severity Distributions for State Route Intersections.

	PDO	CPAIN	VISIBLE	SEVERE	FATAL	TOTAL
Severity Count	76,338	32,835	14,805	3,248	1,161	128,387
Severity Percentage	59.46%	25.58%	11.53%	2.53%	0.90%	100%

A balanced panel of intersections was used for the six year period, meaning every intersection has 6 years of crash history. A total of 128,387 crashes were analyzed over the six year period (does not include cross street crashes). Intersection related mainline crashes account for roughly 13.8% of all mainline and ramp crashes, while intersection related lengths constituted less than 700 miles of the network on state route mainlines. A total of 76,338 property damage only crashes, 32,835 complaint of pain crashes, 14,805 visible injury, 3,248 severe injury crashes were analyzed and 1,161 fatal crashes were analyzed.

Intersection characteristics in terms of geometry and traffic control had substantial heterogeneity. The route specific geometric heterogeneity also contributed to this effect. For example, 126 state routes had at least 30 intersections which would imply a substantial percentage of the non-freeway network (126 routes out of 213 routes used in the 17,200 intersection sample) had route specific geometric variations affecting intersection crash performance. This might also be contributing to the shift in the severity distribution toward the higher severities (3.43% for severe+fatal at intersections versus 2.65% for severe+fatal for roadway segments) due to their interactions with the multidirectional flows that occur at intersections.

Table 8 shows the distribution of key intersection characteristics.

Intersection Characteristic	Count	Percentage
Divided Mainline	5,994	34.85%
Undivided Mainline	10,881	63.26%
Rural	9,971	57.97%
Urban	5,052	29.37%
Suburban	2,178	12.66%
T-intersection	9,943	57.81%
Four-way intersection	5,337	31.03%
Y-intersection	1,015	5.90%
Five-leg intersection	146	0.85%
Offset-intersection	174	1.01%
No-control	587	3.41%
Stop-controlled cross street	12,141	70.59%
Four-way stop	81	0.47%
Two-phase pretimed	253	1.47%
Two-phase semiactuated	119	0.69%
Two-phase fully actuated	227	1.32%
Multi-phase fully actuated	1,722	10.01%
Lighted intersection	8,032	46.7%
Mainline mastarm	2,270	13.20%
No mainline left turn lane	10,855	63.11%
Painted mainline left turn lane	4,807	27.95%
Mainline left turn lane with curb	1,469	8.54%
No mainline right turn lane	15,332	89.14%

The characteristics shown above in Table 8 were evaluated along with segment level attributes of the mainline passing through the intersection. As mentioned before, mainline attributes such as shoulder widths, number of lanes, roadside treatments (median barrier, guardrail for example) were integrated to form a comprehensive intersection geometric attribute dataset. Still, certain key intersection variables were missing – such as alignment data and cross street geometry. Such omitted variable effects can contribute to overdispersion in the crash models due to heterogeneity that arises from the missing geometric effects. How these overdispersion effects vary by severity is evaluated through type 2 SPFs for intersection models as discussed in a following section. As Table 8 shows, the heterogeneity in observed geometry is significant, from five-leg geometry being present at 174 intersections to absence of mainline right turn lane at 15,332 intersection sites.

Ramp Dataset

Ramp information was obtained from the web using the ramp volume data on the Caltrans website. The information included 14,394 ramps containing a subset of metered ramps as well. The distribution of ramps is heterogeneous by districts, as shown in Table 9 below.

Table 9. Ramp Distribution by District.

District	Off-Ramp	On-Ramp	Directional Ramps	Total
1	146	157	20	325
2	151	178	30	359
3	505	612	51	1,169
4	1,255	1,527	252	3,037
5	359	388	1	798
6	436	542	88	1,067
7	1,364	1,738	347	3,452
8	606	642	45	1,293
9	2	7	5	14
10	133	157	24	314
11	675	808	63	1,647
12	359	474	81	919

Table 10. Ramp Crash Distribution by District.

District	PDO	CPAIN	VISIBLE	SEVERE	FATAL	Total
1	401	96	64	12	0	573
2	637	250	123	14	11	1,035
3	6,186	2,331	847	144	43	9,551
4	19,831	6,019	2,395	462	125	28,832
5	3,290	812	401	91	22	4,616
6	4,403	1,412	601	126	43	6,585
7	32,561	8,818	4,244	575	212	46,140
8	10,418	3,250	1,153	185	65	15,071
9	10	2	2	0	2	16
10	1,175	363	179	28	9	1,754
11	7,728	3,831	1,822	306	78	13,625
12	9,334	2,723	1,348	182	53	13,641

As tables 10 and 11 show, the distribution of severities across districts is in general consistent with what one would expect of ramp crashes – a diminished fatal+severe percentage compared to mainline crashes. District 9 appears to deviate from this norm but that is due to a low number of total crashes, which can cause even a total of 2 fatal crashes to appear as a high fatal+severe percentage of 12.5%.

Table 11. Ramp Crash Distribution by Severity Percentage.

District	PDO	CPAIN	VISIBLE	SEVERE	FATAL	Total
1	69.98	16.75	11.17	2.09	0.00	100
2	61.55	24.15	11.88	1.35	1.06	100
3	64.77	24.41	8.87	1.51	0.45	100
4	68.78	20.88	8.31	1.60	0.43	100
5	71.27	17.59	8.69	1.97	0.48	100
6	66.86	21.44	9.13	1.91	0.65	100
7	70.16	19.00	9.14	1.24	0.46	100
8	69.13	21.56	7.65	1.23	0.43	100
9	62.50	12.50	12.50	0.00	12.50	100
10	66.99	20.70	10.21	1.60	0.51	100
11	56.14	27.83	13.24	2.22	0.57	100
12	68.43	19.96	9.88	1.33	0.39	100

A subset of this ramp system was also evaluated for crash propensities. The ramp metering subsystem contains 2,802 metered locations according to the 2013 Caltrans ramp development report (RMDP). Table 12 shows the locations by district and Table 13 shows the crash distributions for the 2,164 locations that are operational with measured ADT values and ramp type information. This information is used to generate type 1 SPFs for ramps.

Table 12. District Level Distribution of Ramp Meters and Ramp Meter Dataset Distribution by District Comparison.

	2013 RMDP Data			Evaluated Dataset Locations					
Dist.	Existing	Planned		L	H	C	S	D	Total
1	0	0		0	0	0	0	0	0
2	1	10		0	0	0	0	0	0
3	189	163		43	0	0	77	0	120
4	637	684		87	0	48	174	19	328
5	3	10		1	0	0	2	0	3
6	64	111		20	0	0	38	0	58
7	999	69		199	230	20	405	0	854
8	209	224		19	0	0	190	0	209
9	0	0		0	0	0	0	0	0
10	2	167		1	0	0	1	0	2
11	310	130		54	58	12	162	0	289**
12	345	2		106	56	0	139	0	301

** Includes 3 direct ramps

As shown in Table 12, several districts have a large number of meters planned for in the near future (3, 4, 6, 8, 10 and 11 in particular). The evaluated dataset locations (2,164 sites) are shown in the right side of Table 12 and did not include districts 1, 2 and 9. Five major ramp types are evaluated (L for loop, H for hook, C for freeway-to-freeway connector, S for slip/diagonal, D for collector-distributor, see Figure 14). The majority of the evaluated ramp types are slip/diagonal or loop. To a smaller extent the hook configuration appears prominently in the District 7, 11 and 12 systems evaluation. Collector/distributor configurations are evaluated in District 4 alone.

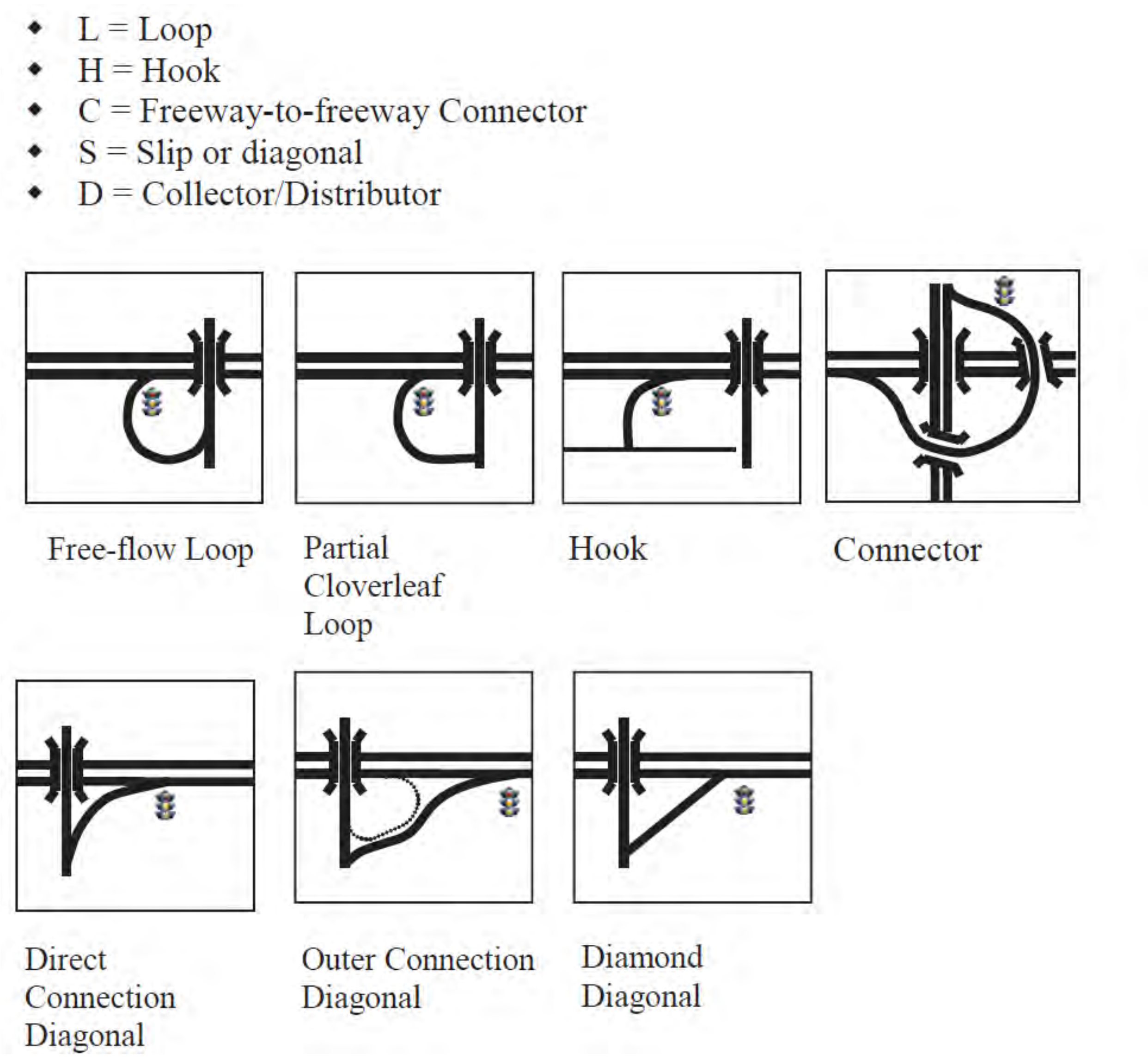


Figure 14. Ramp Metering System Configuration Types.

Table 13. Ramp Metering System Crash Distributions.

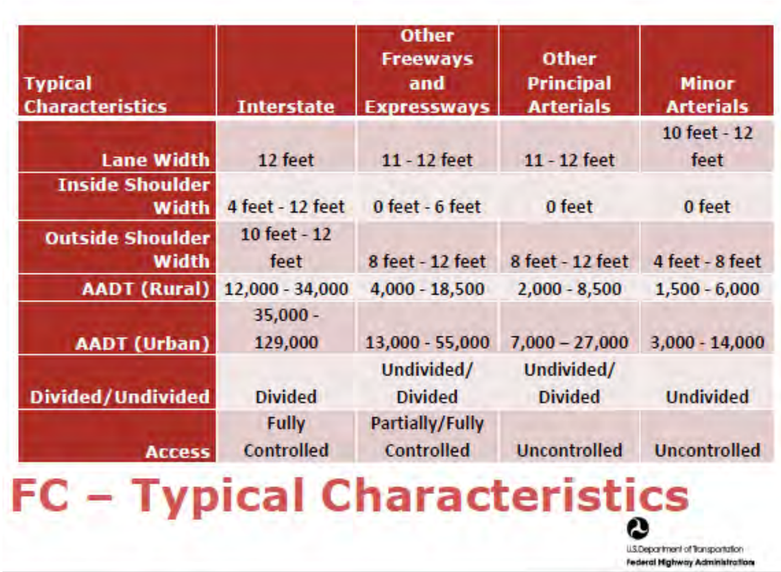
District	PDO	CPAIN	VISIBLE	SEVERE	FATAL	Total
3	145	53	14	2	1	215
4	2,565	784	275	34	12	3,670
5	17	13	1	0	0	31
6	432	124	38	9	3	606
7	452	118	55	5	3	633
8	230	73	20	3	1	327
10	8	1	0	0	0	9
11	213	111	53	8	3	388
12	2,839	791	376	38	9	4,053

For type 2 SPFs for ramps, additional information relating to number of lanes, HOV meter presence and ramp type (for example, loop, slip, etc.) is required on a consistent basis for all observations. Considering the initial set of 2,162 sites, ADT, meter, HOV and ramp type information was available for 803 locations. The significant attrition in the ramp metering dataset is due to the absence of identifying information for number of lanes on the ramp and the HOV metering aspect. Quite a few sites had zero number of lanes or blanks for the number of lanes value. There are three typical characters used for defining HOV metering (using the HOVPL designation of Caltrans) – N or NM for no HOV meter, and M for HOV meter. Quite a few sites had blanks for the HOVPL column.

Safety Performance Function Development

Roadway Segment SPFs

Safety performance functions for roadway segments were developed on the basis of classifications of roadways. The Federal Highway Administration (FHWA) provides for a table that characterizes roadway functional classes with respect to a range of ADTs on the roadways. Figure 15 shows the suggested functional class definitions.



Typical Characteristics	Interstate	Other Freeways and Expressways	Other Principal Arterials	Minor Arterials
Lane Width	12 feet	11 - 12 feet	11 - 12 feet	10 feet - 12 feet
Inside Shoulder Width	4 feet - 12 feet	0 feet - 6 feet	0 feet	0 feet
Outside Shoulder Width	10 feet - 12 feet	8 feet - 12 feet	8 feet - 12 feet	4 feet - 8 feet
AADT (Rural)	12,000 - 34,000	4,000 - 18,500	2,000 - 8,500	1,500 - 6,000
AADT (Urban)	35,000 - 129,000	13,000 - 55,000	7,000 – 27,000	3,000 - 14,000
Divided/Undivided	Divided	Undivided/ Divided	Undivided/ Divided	Undivided
Access	Fully Controlled	Partially/Fully Controlled	Uncontrolled	Uncontrolled

FC – Typical Characteristics

U.S. Department of Transportation Federal Highway Administration

Figure 15. Typical Functional Characteristics (per FHWA).

Using the information in figure 15, the following parameters were used as the basis for defining urban and rural functional thresholds: An upper ADT bound of 35,000 was used to define rural interstate freeways. Comparatively, a lower ADT bound of 13,000 was used for urban state freeways and expressways. Finally, a lower ADT bound of 3,000 was used for urban non-freeways/non-expressways, including arterials. Using these definitions, the following SPF architecture was developed, as shown in figure 16.

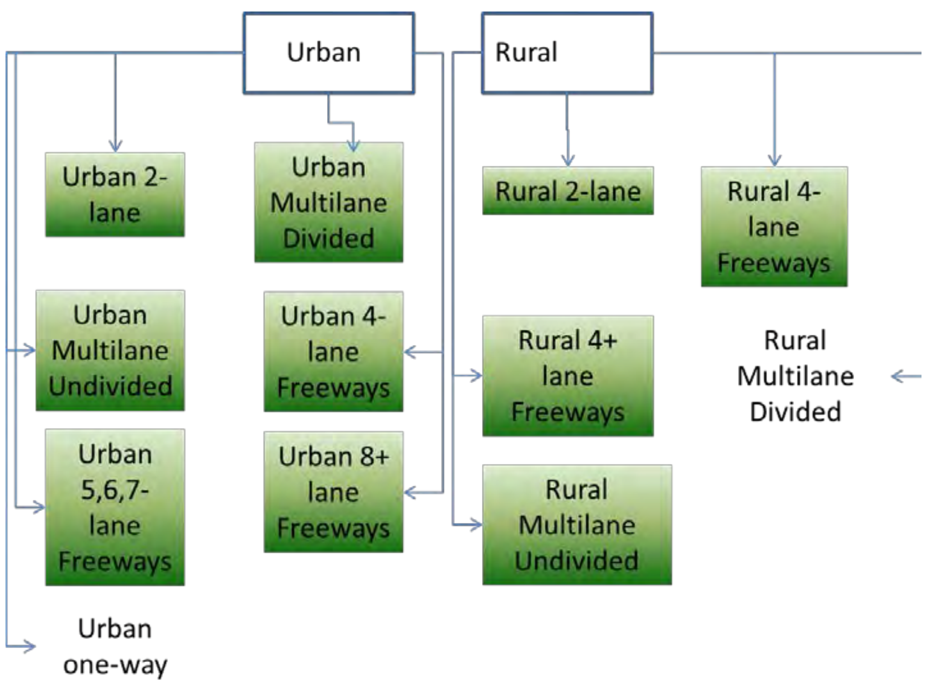


Figure 16. Type 1 and Type 2 SPF Modeling Architecture.

As figure 16 shows, the boxes highlighted in green indicate SPF classes for which statistical models were developed. Table 6 in a previous section shows the observation (segment) count for each of these classes. The observation count provided for reliable estimation of all parameters including type 2 SPF specifications (in addition to the overdispersion parameter). As a result, the architecture resulted in a total of 10 SPF classes, with five severity types and total crash counts as the six major outcomes being predicted. This resulted in a total of 120 models there were developed in this study. The detailed models are shown in appendix A. Further, in appendix A, models for total injuries, total fatalities and total noninjuries are included as well. For the purpose of the main document, a summary of the SPFs is included is in tables 14 and 15. Table 14 shows the type 1 SPFs by the ten SPF classes for total crashes, while table 15 shows the type 1 SPFs for the same ten SPF classes for the five severities, PDO, CPAIN, VISIBLE, SEVERE and FATAL. As can be seen, the universe of type 2 SPF variables is substantial, even though the specifications vary by model. A discussion of the elasticity of the SPF2 variables (where continuous) is also included. Elasticity is defined as the percent change in the outcome variable due to a one percent change in the independent (predictor) variable. For the form used in the estimating equation, the elasticity of a continuous variable is defined as the product of the coefficient and the mean value of the independent variable.

Table 14. Type 1 SPFs for Roadway Segments for Total Crashes.*

SPF Class	α	β	θ
2-lane rural	-5.13	0.68	1.19
4-lane rural	-4.36	0.60	1.18
4-plus-rural	1.52	0.12	3.12
Multilane undivided rural	-4.49	0.60	0.98
2-lane urban	-7.09	0.98	2.18
4-lane urban	-5.78	0.82	1.40
5-to-7-lane urban	-6.49	0.89	0.91
8-plus-urban	-10.75	1.24	0.64
Multilane undivided urban	-5.86	0.91	3.36
Multilane divided urban	-7.11	1.01	2.62

*All coefficients significant at 95% or better

α *is coefficient for constant (intercept)*

β *is coefficient for* $ln(ADT)$

θ *is overdispersion parameter*

Table 15. Type 1 SPFs for Roadway Segments for PDO, CPAIN, VISIBLE, SEVERE and FATAL crash types.

SPF Class	PDO			CPAIN			VISIBLE			SEVERE			FATAL		
	α	β	θ	α	β	θ	α	β	θ	α	β	θ	α	β	θ
2-lane rural	-6.36	0.75	1.15	-7.66	0.77	1.48	-6.04	0.59	1.38	-4.95	0.31	1.39	-6.71	0.40	0.74
4-lane rural	-5.55	0.66	1.20	-5.42	0.50	1.41	-4.73	0.42	0.89	-4.58	0.27	0.75	-7.14	0.47	0.41
4-plus-rural	1.08	0.12	3.56	-0.95	0.20	6.08	-5.10	0.52	1.43	-9.06	0.75	0.23	-0.37	-0.20	0.59
Multilane undivided rural**	-5.80	0.70	1.29	-2.34	0.09	0.47	-9.94	1.08	2.48	-6.49	0.46		-20.17	1.98	
2-lane urban	-8.81	1.11	2.62	-9.39	1.04	2.72	-5.66	0.56	1.43	-7.24	0.61	2.17	-7.68	0.56	1.29
4-lane urban	-7.60	0.94	1.43	-8.40	0.90	1.58	-8.61	0.85	0.65	-8.33	0.67	0.55	-7.70	0.53	0.69
5-to-7-lane urban	-8.64	1.04	0.91	-9.17	0.98	0.79	-9.35	0.92	0.44	-8.64	0.70	0.37	-7.84	0.55	0.32
8-plus-urban	-12.43	1.35	0.70	-13.09	1.30	0.52	-10.40	1.00	0.33	-10.04	0.82	0.24	-8.07	0.57	0.19
Multilane undivided urban	-6.13	0.89	4.25	-11.08	1.26	4.28	-6.22	0.67	3.11	-4.76	0.35	1.12	-9.39	0.75	0.40
Multilane divided urban	-7.23	0.97	3.05	-12.06	1.35	3.21	-9.87	1.03	2.27	-9.60	0.83	1.59	-7.18	0.51	0.28

All coefficients significant at 95% or better (exceptions: 4-lane rural OD)

** poisson model for severe and fatal severity types

Tables 16-20 present type 2 SPFs for rural two-lane roadway segments.

Table 16. Rural Two-lane SPF 2 – Property Damage Only Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-5.43	0.22	-24.43
Logarithm of ADT	0.86	0.03	29.65
DES_SP	-0.03	0.002	-14.04
IMP	-0.65	0.16	-4.06
VEN	0.60	0.09	6.32
INY	-0.63	0.12	-5.30
RT140	0.74	0.16	4.60
RT88	0.63	0.12	5.15
RT32	0.36	0.17	2.11
RT146	2.02	0.15	13.07
YEAR06	-0.15	0.06	-2.32
YEAR07	-0.17	0.07	-2.56
YEAR08	-0.22	0.07	-3.33
YEAR09	-0.29	0.07	-4.17
YEAR10	-0.18	0.07	-2.61
Scale parameter for overdispersion	0.81	0.06	14.42
Log-likelihood at convergence	-8,920.207		
Number of observations	25,218		

Table 17. Rural Two-lane SPF 2 – Complaint of Pain Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-5.96	0.33	-17.93
Logarithm of ADT	0.87	0.05	19.23
Logarithm of length of segment in miles	1.0		
DES_SP	-0.05	0.004	-13.64
SIS	-0.49	0.19	-2.55
SJ	0.83	0.45	1.84
RT88	0.94	0.19	4.86
RT32	0.49	0.24	2.00
SDIEGO	0.41	0.13	3.18
Scale parameter for overdispersion	0.88	0.13	6.69
Number of observations	25,218		

As noticed in tables 16 and 17, in addition to design speed, the majority of statistically significant effects are county and route dummies. Year specific dummies represent time related shifts in specific years, such as 2006, for example. For specifying year dummies, year 2005 is used as the baseline. A negative sign for year specific dummies indicates that crashes are expected to be fewer in that year compared to year 2005.

Table 18. Rural Two-lane SPF 2 – Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-4.43	0.30	-14.62
Logarithm of ADT	0.68	0.04	17.28
DES_SP	-0.04	0.003	-14.54
MNO	-0.39	0.21	-1.86
LA	1.18	0.25	4.80
SDIEGO	0.86	0.11	7.86
RT140	0.63	0.19	3.31
RT88	0.62	0.20	3.15
RT190	-0.82	0.17	-4.78
VEN	0.78	0.12	6.72
YEAR06	-0.15	0.07	-2.06
YEAR09	-0.14	0.07	-2.02
YEAR10	-0.32	0.08	-3.89
Scale parameter for overdispersion	0.69	0.09	7.31
Number of observations	25,218		

Table 19. Rural Two-lane SPF 2 – Severe Injury Collision Counts.

Variable	Mean	Standard Errors	T-statistic
Constant	-4.81	0.41	-11.70
Logarithm of ADT	0.54	0.06	9.64
DES_SP	-0.03	0.005	-6.95
LA	1.47	0.28	5.29
LT_OS_WI	-0.05	0.02	-2.95
VEN	1.41	0.13	10.49
YEAR08	0.24	0.10	2.44
YEAR09	-0.30	0.12	-2.44
Scale parameter for overdispersion	0.44	0.17	2.52
Log-likelihood at convergence	-2,571.195		
Number of observations	25,218		

Table 20. Rural Two-lane SPF 2 – Fatal Injury Collision Counts.

Variable	Mean	Standard Errors	T-statistic
Constant	-6.54	0.65	-10.07
Logarithm of ADT	0.39	0 .09	4.35
RT140	0.73	0.40	1.83
YEAR09	-0.46	0.20	-2.30
YEAR10	-0.69	0.23	-2.96
Scale parameter for overdispersion	0.70	0.40	1.86
Log-likelihood at convergence	-1,119.706		
Number of observations	25,218		

As seen in tables 18-20, in addition to design speed, left outside shoulder width is statistically significant (severe injury model), with the rest of the effects being county, route and year dummies. This indicates on the whole that for two-lane rural roadway segments, spatial effects, time effects and design effects are at play, in addition ADT. The elasticity of ADT does not exceed unity, since the coefficient directly represents the effect of a one percent change of ADT in the outcome. The highest elasticity of ADT is seen in complaint of pain outcomes, with a value of 0.87. The elasticity of design speed is highest for complaint of pain outcomes as well, with a value of -2.546, indicating a substantial elastic effect of design in two-lane rural roadways. This indicates that speed management on two-lane rural roadways can have substantive beneficial effects on safety.

Tables 21-25 present type 2 SPFs for 4-lane rural roadways. The results are interpreted along with the tables.

Table 21. Rural Four-lane SPF 2 –PDO Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-4.99	0.12	-41.92
Logarithm of ADT	0.82	0.01	61.81
DES_SP	-0.03	0.001	-30.05
RT_IS_WI	-0.01	0.005	-2.00
MESTRUC	1.48	0.06	25.81
MEBRAIL	-1.00	0.08	-13.07
SB	0.89	0.06	14.87
RT29	0.49	0.05	9.33
RT2	0.81	0.09	9.24
RT23	1.02	0.08	13.55
RT198	0.74	0.07	11.40
RT84	-0.42	0.11	-3.69
RT80	1.03	0.07	14.81
RT101	0.27	0.04	6.45
YEAR06	-0.08	0.03	-2.48
YEAR07	-0.16	0.03	-4.75
YEAR08	-0.19	0.03	-5.76
YEAR09	-0.23	0.03	-6.84
YEAR10	-0.23	0.03	-6.96
Scale parameter for overdispersion	0.94	0.02	43.42
Log-likelihood at convergence	-33,902.384		
Number of observations	54,894		

Table 21 shows that in addition to ADT, design speed, inside right shoulder width, and median side object dummies such as structure and rail are statistically significant. In addition, county dummies (SB), route dummies and year dummies are significant. The negative sign of the year dummies indicates that crashes in year 2005 are expected to be higher than years 2006-2010. Route dummies are mixed in sign, with negative effects indicating fewer crashes than the routes not included in the model.

Table 22. Rural Four-lane SPF 2 – Complaint of Pain Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-5.57	0.17	-32.14
Logarithm of ADT	0.75	0.02	35.85
DES_SP	-0.04	0.002	-21.52
DN	0.72	0.12	6.01
NEV	0.89	0.10	8.77
PLA	0.80	0.13	6.23
SM	0.57	0.09	6.73
SON	0.34	0.15	2.32
SB	0.72	0.12	5.86
SLO	0.26	0.09	2.95
VEN	0.60	0.14	4.21
RT29	0.82	0.08	9.97
RT12	0.89	0.12	7.55
RT2	1.31	0.12	11.28
RT5	-0.28	0.07	-4.12
RT99	0.34	0.11	3.07
RT4	0.29	0.09	3.28
RT68	1.75	0.40	4.35
RT180	0.40	0.08	4.99
RT14	-0.53	0.21	-2.48
YEAR06	-0.08	0.04	-1.91
Scale parameter for overdispersion	1.06	0.05	20.86
Log-likelihood at convergence	-15,727.764		
Number of observations	54,894		

Table 22 shows the results for complain of pain type 2 SPF. As seen in the table, the main geometric effect is design speed. All county dummies appear positive which indicates a higher crash frequency than counties excluded from the model. Several route dummies are also significant, but the time effects appear limited to year 2006 which indicates a lower complaint of pain crash frequency compared to other years. The significance of numerous spatial effect dummies indicates that spatial heterogeneity appears to dominate complain of pain outcomes. The elasticity of the design speed variable is high at -2.29, which indicates a 2.29% decrease in complaint of pain outcomes for a 1% decrease in design speed. The design speed effect is strongest in complaint of pain outcomes while ADT elasticity is strongest in PDO outcomes with a value of 0.82. An elasticity of unity for ADT would signify that ADT would be a linear multiplier for crash frequency while an elasticity greater than unity would indicate a super-linear (greater than unity exponent) effect. The length variable is not reported in any of the models since it is constrained to be equal to unity. Though the ADT parameter appears close to unity, the standard error indicates that is sublinear in elasticity, i.e., significantly different from unity.

Table 23. Rural Four-lane SPF 2 – Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-4.94	0.16	-30.23
Logarithm of ADT	0.63	0.02	32.54
DES_SP	-0.02	0.002	-12.03
DN	0.62	0.09	6.54
SM	0.44	0.10	4.35
VEN	0.90	0.11	7.94
RT4	0.18	0.08	2.17
RT35	0.83	0.17	4.97
SDIEGO	0.77	0.06	13.09
LA	1.39	0.08	18.11
NAP	0.80	0.17	4.79
RT_OS_WI	-0.05	0.005	-9.90
RT_IS_WI	0.05	0.007	7.00
YEAR07	-0.11	0.04	-2.57
YEAR08	-0.23	0.04	-5.48
YEAR09	-0.28	0.04	-6.29
YEAR10	-0.37	0.05	-7.96
Scale parameter for overdispersion	0.62	0.04	16.88
Log-likelihood at convergence	-15,714.839		
Number of observations	54,894		

Table 24. Rural Four-lane SPF 2 – Severe Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-3.96	0.28	-14.23
Logarithm of ADT	0.44	0.03	13.34
DES_SP	-0.03	0.003	-9.66
VEN	1.00	0.18	5.43
LA	1.12	0.16	7.11
MED_WI	0.005	0.0009	5.55
RT_OS_WI	-0.03	0.01	-3.17
MRN	1.06	0.15	7.28
SB	0.48	0.19	2.47
RT29	0.53	0.16	3.40
RT168	-0.33	0.17	-1.90
YEAR06	-0.20	0.08	-2.59
YEAR07	-0.18	0.08	-2.31
YEAR08	-0.19	0.08	-2.39
YEAR09	-0.41	0.08	-4.97
YEAR10	-0.36	0.08	-4.32
Scale parameter for overdispersion	0.58	0.09	6.45
Log-likelihood at convergence	-6,999.565		
Number of observations	54,894		

Table 25. Rural Four-lane SPF 2 – Fatal Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.10	0.30	-23.74
Logarithm of ADT	0.48	0.03	14.91
RT101	0.30	0.14	2.19
RT40	0.36	0.12	3.07
RT2	1.06	0.27	4.01
RT99	0.62	0.25	2.44
VEN	0.62	0.29	2.12
LAK	0.60	0.17	3.50
YEAR07	-0.18	0.09	-2.07
YEAR08	-0.26	0.09	-2.84
YEAR09	-0.27	0.09	-2.93
YEAR10	-0.49	0.10	-4.83
Scale parameter for overdispersion	N/A	N/A	N/A
Log-likelihood at convergence	-3,962.827		
Number of observations	54,894		

As seen in tables 21-25, the type 2 SPFs involve in addition to design speed, inside right shoulder width, outside right shoulder width and median width as geometric effects that are statistically significant. The maximum elasticities of inside and outside right shoulder widths are 0.05 to -0.30 indicating that the effects do not result in a greater than 1 percent change in any severity type due to a one percent change in the shoulder width. Median width similarly is inelastic with an effect of 0.14 percent change in severe injury collisions for a one percent change in median width.

Tables 26-30 show type 2 SPFs for rural four-lane-plus roadway segments.

Table 26. Rural Four-Plus-Lane SPF 2 – PDO Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-1.86	0.88	-2.13
Logarithm of ADT	0.34	0.08	4.23
RTLANES	0.30	0.04	7.51
LMEDHOV	1.91	0.34	5.59
MENOBARR	-1.03	0.12	-8.63
SHA	-0.99	0.20	-5.06
Scale parameter for overdispersion	1.49	0.12	12.56
Log-likelihood at convergence	-1,596.870		
Number of observations	1,320		

Table 27. Rural Four-Plus-Lane SPF 2 – Complaint of Pain Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-0.67	0.73	-1.93
Logarithm of ADT	0.10	0.07	1.39
LT_TR_WI	0.03	0.005	6.82
MENOBARR	-1.90	0.15	-12.43
SHA	-1.27	0.30	-4.29
YEAR05	0.25	0.16	1.77
Scale parameter for overdispersion	1.60	0.23	6.97
Log-likelihood at convergence	-821.529		
Number of observations	1,320		

Table 28. Rural Four-Plus-lane SPF 2 – Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-5.12	0.80	-6.42
Logarithm of ADT	0.46	0.08	5.89
LT_TR_WI	0.02	0.005	4.88
LMEDHOV	2.36	0.28	8.32
MENOBARR	-0.65	0.15	-4.30
Scale parameter for overdispersion	0.47	0.14	3.28
Log-likelihood at convergence	-628.742		
Number of observations	1,320		

Table 29. Rural Four-Plus-Lane SPF 2 – Severe Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-6.01	1.44	-4.18
Logarithm of ADT	0.46	0.14	3.33
LMEDHOV	2.67	0.42	6.35
MENOBARR	-0.50	0.29	-1.70
Scale parameter for overdispersion	N/A	N/A	N/A
Log-likelihood at convergence	-224.634		
Number of observations	1,320		

Table 30. Rural Four-Plus-Lane SPF 2 – Fatal Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-1.06	1.52	-1.70
Logarithm of ADT	-0.08	0.16	-1.49
RT10	2.08	0.53	3.96
YEAR06	-0.69	0.42	-1.83
YEAR07	-1.02	0.49	-2.11
YEAR09	-1.03	0.49	-2.12
YEAR10	-1.95	0.73	-2.66
Scale parameter for overdispersion	N/A	N/A	N/A
Log-likelihood at convergence	-148.407		
Number of observations	1,320		

As seen in tables 26-30, the geometric effects range from continuous effects such as right travel lanes to left travel width to dummy effects such as left median side HOV lane presence and non-barriered median. The elasticity of ADT is greatest on visible and severe injury outcomes with a value of 0.46 – yet, this value is substantially lower than typical ADT elasticities. The elasticity of left travel width is greatest for complain of pain outcomes, with a value of 1.03, which indicates this effect is elastic. This suggests that a 1% percent change in left traveled width will result in a 1.03 percent increase in complaint of pain collisions on four-plus-lane rural roadways. The right travel lanes variable is near elastic with respect to PDO collisions with a value of 0.89.

Tables 31-35 show type 2 SPFs for multilane undivided rural roadway segments.

Table 31. Rural Multilane Undivided SPF 2 –PDO Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-4.63	1.12	-4.12
Logarithm of ADT	0.77	0.17	4.39
DES_SP	-0.03	0.01	-2.07
Scale parameter for overdispersion	1.22	0.31	3.95
Log-likelihood at convergence	-329.793		
Number of observations	690		

Table 31 above shows the type 2 SPF for PDO collisions on multilane undivided rural roadway segments. While ADT has an elasticity of 0.77, the elasticity of design speed is -1.64 indicating an elastic effect of design speed on PDO collisions. This indicates as found in some earlier cases, that speed management is crucial for safety on rural multilane undivided roadways. More insight on severe outcomes is discussed in the following pages.

Table 32. Rural Multilane Undivided SPF 2 –Complaint of Pain Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-0.68	2.14	-0.32
Logarithm of ADT	0.19	0.26	0.74
DES_SP	-0.04	0.02	-2.08
YEAR06	-0.83	0.53	-1.55
Scale parameter for overdispersion	0.19	0.51	0.38
Log-likelihood at convergence	-154.254		
Number of observations	690		

Table 33. Rural Multilane Undivided SPF 2 –Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-16.14	4.01	-4.02
Logarithm of ADT	1.86	0.51	3.64
RT32	2.37	0.68	3.48
Scale parameter for overdispersion	2.03	1.22	1.87
Log-likelihood at convergence	-140.789		
Number of observations	690		

Table 34. Rural Multilane Undivided SPF 2 –Severe Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-6.18	4.68	-1.32
Logarithm of ADT	0.40	0.61	0.65
RT89	1.05	0.06	1.99
Scale parameter for overdispersion	N/A	N/A	N/A
Log-likelihood at convergence	-54.896		
Number of observations	690		

As the above tables show, design speed is the one geometric effect that is statistically significant, with an elasticity of -2.18. This is a substantial effect on complaint of pain outcomes, a pattern that appears to be repeated in several rural roadway segment categories. It is clear from the analysis of rural segments that complain of pain categories seem to be influenced by speed related effects significantly.

Table 35. Rural Multilane Undivided SPF 2 –Fatal Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-21.18	13.95	-1.52
Logarithm of ADT	1.98	1.76	1.12
RT36	1.60	1.42	1.13
YEAR09	1.62	1.42	1.14
Scale parameter for overdispersion	N/A	N/A	N/A
Log-likelihood at convergence	-12.107		
Number of observations	690		

It is also observed that ADT is very elastic in its effect on fatal collisions and visible collisions. This might be suggestive of substantive interactions between truck traffic and other vehicles; suggestive of interactions resulting to head on collision types since the roadway segments are undivided.

Tables 36-40 show the results of type 2 SPFs for two-lane urban roadway segments.

Table 36. Urban Two-lane SPF 2 –PDO Collision Counts.

Variable	Mean	Standard Errors	T-statistic
Constant	-5.61	0.20	-27.66
Logarithm of ADT	0.10	0.02	50.47
DES_SP	-0.03	0.001	-28.56
MEPAVE	-0.56	0.10	-5.48
RT111	-0.56	0.12	-4.65
RT138	0.51	0.09	5.77
RT184	1.23	0.13	9.23
RT129	0.84	0.11	7.82
STA	0.71	0.06	12.45
SLO	-0.46	0.06	-7.08
UNDIVIDE	-0.45	0.04	-10.06
YEAR07	-0.12	0.03	-3.60
YEAR08	-0.23	0.04	-6.30
YEAR09	-0.30	0.04	-8.41
YEAR10	-0.33	0.04	-8.39
Scale parameter for overdispersion	2.14	0.044	48.74
Log-likelihood at convergence	-25,177.736		
Number of observations	33,564		

Table 36 above shows results for two-lane urban SPFs for PDO collisions. As noticed in the table, the significant geometric effect is design speed, in addition to paved median which is a dummy effect. The elasticity of the design speed variable is -1.59 which indicates an elastic effect. Spatial effects due to route and county dummies are also significant. In addition, the undivided dummy shows a negative effect indicating that PDO collisions are expected to be lower than divided segments. All significant year dummies show a negative sign indicating that PDO crash frequencies are expected to be lower than years 2005 and 2006.

Table 37. Urban Two-lane SPF 2 – Complaint of Pain Collision Counts.

Variable	Mean	Standard Errors	T-statistic
Constant	-5.93	0.29	-20.23
Logarithm of ADT	0.93	0.03	31.62
DES_SP	-0.03	0.002	-16.98
MEPAVE	-0.58	0.14	-4.05
RT76	0.39	0.11	3.65
RT111	-0.68	0.20	-3.40
RT138	0.51	0.12	4.11
RT129	0.43	0.15	2.88
STA	0.80	0.08	10.44
SLO	-1.15	0.16	-7.31
UNDIVIDE	-0.65	0.06	-10.04
RT_OS_WI	-0.01	0.006	-2.26
YEAR06	-0.17	0.06	-2.82
YEAR07	-0.19	0.06	-3.25
YEAR08	-0.27	0.06	-4.35
YEAR09	-0.27	0.06	-4.40
YEAR10	-0.37	0.06	-5.70
Scale parameter for overdispersion	2.02	0.08	25.40
Log-likelihood at convergence	-13,004.452		
Number of observations	33,564		

Table 38. Urban Two-lane SPF 2 –Visible Injury Collision Counts.

Variable	Mean	Standard Errors	T-statistic
Constant	-3.19	0.28	-11.41
Logarithm of ADT	0.54	0.03	20.14
DES_SP	-0.02	0.002	-11.07
RT76	0.72	0.09	7.67
RT184	0.91	0.24	3.78
SLO	-0.90	0.16	-5.56
UNDIVIDE	-0.58	0.07	-8.36
RT_OS_WI	-0.04	0.006	-7.43
YEAR08	-0.20	0.05	-3.63
YEAR09	-0.33	0.06	-5.78
YEAR10	-0.27	0.06	-4.80
Scale parameter for overdispersion	1.02	0.06	16.17
Log-likelihood at convergence	-10,097.473		
Number of observations	33,564		

Table 39. Urban Two-lane SPF 2 –Severe Injury Collision Counts.

Variable	Mean	Standard Errors	T-statistic
Constant	-4.61	0.522	-8.87
Logarithm of ADT	0.55	0.05	10.60
DES_SP	-0.03	0.004	-6.94
RT76	1.11	0.14	7.80
RT129	0.66	0.24	2.79
STA	0.44	0.19	2.35
UNDIVIDE	-0.53	0.12	-4.45
RT_OS_WI	-0.04	0.01	-3.51
YEAR09	-0.17	0.09	-1.82
Scale parameter for overdispersion	1.61	0.21	7.68
Log-likelihood at convergence	-4,180.217		
Number of observations	33,564		

Table 40. Urban Two-lane SPF 2 –Fatal Injury Collision Counts.

Variable	Mean	Standard Errors	T-statistic
Constant	-6.87	0.66	-10.33
Logarithm of ADT	0.48	0.07	6.52
RT76	1.40	0.19	7.36
RT138	0.81	0.23	3.50
YEAR08	-0.37	0.14	-2.64
YEAR09	-0.27	0.14	-1.91
YEAR10	-0.46	0.15	-3.06
Scale parameter for overdispersion	1.09	0.35	3.08
Log-likelihood at convergence	-2,074.524		
Number of observations	33,564		

As seen in tables 37-40, with increasing severity of outcome, the variable outside right shoulder width appears to have a statistically significant role with a negative sign. Yet, this effect is not elastic, with a maximum of -0.22, while design speed continues to be elastic, with a value of -1.63 for severe injury collisions. In addition, the route dummies continue to have a statistically significant role spatially, with time dummies adding a temporal component, especially for years 2008-2010. What is important also to note is the significance of the overdispersion parameter for fatal injury collisions. The overdispersion parameter is 1.09, which indicates that the quadratic component involving the mean is substantial indicating heterogeneity due to unobserved effects in the urban environment. ADT has an elasticity of 0.93 for complaint of pain collisions as the maximum. This near elastic effect is suggestive of complaint of pain effects being an outcome from congestion related collisions such as rear ends or sideswipes.

Tables 41-45 shows the results for urban four-lane roadway segments.

Table 41. Urban Four-lane SPF 2 –PDO Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.77	0.13	-60.16
Logarithm of ADT	1.10	0.01	96.90
DES_SP	-0.02	0.0009	-20.00
RT15	-0.59	0.10	-5.69
RT210	-1.11	0.09	-11.90
RT2	-1.74	0.08	-21.26
RT135	1.88	0.10	18.27
RT13	1.02	0.08	12.30
RT99	-0.21	0.03	-7.47
RT101	-0.28	0.02	-11.10
LA	0.40	0.03	12.43
SON	0.33	0.03	9.78
ALA	-0.45	0.04	-11.62
YUB	-0.87	0.08	-10.70
MEBEAM	0.62	0.07	9.23
MESTRUC	-0.44	0.04	-10.94
MEDIT	-1.17	0.38	-3.09
MESGR	-0.68	0.06	-10.74
MEPAVE	-0.37	0.03	-14.46
MEST	-0.26	0.03	-8.37
MED_WI	-0.004	0.0004	-9.14
LTLANES	0.21	0.02	8.80
YEAR06	-0.12	0.02	-4.75
YEAR07	-0.17	0.02	-7.15
YEAR08	-0.28	0.02	-11.67
YEAR09	-0.31	0.02	-13.32
YEAR10	-0.30	0.02	-13.30
Scale parameter for overdispersion	1.173	0.02	77.82
Log-likelihood at convergence	-58,921.683		
Number of observations	43,104		

Table 41 shows that several geometric effects on the median side appear to be statistically significant in their impact on PDO collisions on urban four-lane roadway segments. Paved median, median guard rail beam presence, median structure presence, median ditch, as well as median stripes as dummies are significant, while median width as a continuous variable is also significant. This signifies the importance of median roadside treatment in four lane urban contexts. The effects are to decrease the crash frequencies of PDOs, with median width being -0.12 in elasticity. Design speed is significant and elastic with a value of -1.23. In addition, route, county and year dummies are significant.

Table 42. Urban Four-lane SPF 2 –Complaint of Pain Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-8.41	0.20	-43.08
Logarithm of ADT	1.14	0.02	65.77
DES_SP	-0.03	0.001	-27.25
METWTL	-0.12	0.06	-1.92
RT15	-0.56	0.11	-5.30
RT210	-0.91	0.11	-8.14
RT2	-1.20	0.12	-10.00
RT135	1.82	0.13	14.12
RT13	0.49	0.12	4.18
RT99	-0.30	0.04	-8.60
RT101	-0.57	0.03	-17.31
LA	0.37	0.04	8.56
SON	0.55	0.05	11.88
ALA	-0.18	0.06	-3.15
YUB	-0.53	0.11	-4.98
MECONCG	-0.33	0.06	-5.18
MEBEAM	0.63	0.08	7.62
MESTRUC	-0.47	0.06	-7.47
MESGR	-0.58	0.08	-7.59
MENPAVE	-0.43	0.05	-9.47
MEPAVE	-0.44	0.04	-9.89
MEST	-0.38	0.05	-7.31
MED_WI	-0.005	0.0006	-9.39
LTLANES	0.26	0.03	7.82
YEAR06	-0.10	0.03	-3.56
YEAR08	-0.17	0.03	-5.70
YEAR09	-0.19	0.03	-6.44
YEAR10	-0.14	0.03	-4.76
Scale parameter for overdispersion	1.19	0.02	48.54
Log-likelihood at convergence	-34,217.784		
Number of observations	43,104		

Similar to PDO collisions, median effects are significant in complaint of pain collisions as well, with several median dummies being negatively signed. Median width is not elastic with a value of -0.15, while left travel lanes is inelastic with a value of 0.47. Design speed is elastic with a value of -1.83 indicating that speed management is an issue for urban four lane roadways as well. The significance of route, county and yearly dummies continues to underscore the importance of spatial and temporal effects in terms of their heterogeneity. The temporal effects seem to indicate as previously seen in other type 2 SPFs that year 2005 frequencies are expected to be higher than subsequent years, 2006-2010. What is also noticeable is the significant value of the overdispersion parameter which indicates substantial residual heterogeneity even after accounting for a variety of geometric, spatial and temporal effects in the model. The ADT variable is elastic, which indicates congestion effects playing a substantial role.

Table 43. Urban Four-lane SPF 2 –Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.84	0.20	-39.44
Logarithm of ADT	0.88	0.02	48.82
DES_SP	-0.02	0.002	-10.53
RT2	-1.45	0.15	-9.69
RT99	-0.13	0.04	-3.66
RT101	-0.17	0.03	-5.32
LA	0.38	0.05	8.18
YUB	-0.89	0.14	-6.16
MEBEAM	0.64	0.08	8.12
MESTRUC	-0.19	0.07	-2.80
MESGR	-0.21	0.08	-2.63
MENPAVE	-0.16	0.04	-3.81
MEPAVE	-0.18	0.04	-4.76
MED_WI	-0.003	0.0006	-4.70
LTLANES	0.27	0.04	7.58
YEAR06	-0.07	0.03	-2.03
YEAR07	-0.25	0.04	-6.90
YEAR08	-0.33	0.04	-8.98
YEAR09	-0.36	0.04	-9.67
YEAR10	-0.42	0.04	-11.52
Scale parameter for overdispersion	0.58	0.02	28.06
Log-likelihood at convergence	-23,547.975		
Number of observations	43,104		

Table 44. Urban Four-lane SPF 2 –Severe Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.65	0.36	-21.28
Logarithm of ADT	0.72	0.03	20.61
DES_SP	-0.02	0.003	-7.05
SCR	0.54	0.11	4.94
HUM	0.52	0.16	3.17
YEAR05	0.11	0.06	1.96
YEAR09	-0.17	0.06	-2.78
YEAR10	-0.16	0.06	-2.66
Scale parameter for overdispersion	0.55	0.07	7.71
Log-likelihood at convergence	-8,401.243		
Number of observations	43,104		

Table 45. Urban Four-lane SPF 2 –Fatal Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.51	0.47	-16.13
Logarithm of ADT	0.54	0.04	12.07
MENPAVE	-0.14	0.07	-1.90
MEPAVE	-0.27	0.10	-2.70
YEAR08	-0.32	0.09	-3.60
YEAR09	-0.38	0.09	-4.30
YEAR10	-0.46	0.09	-4.89
Scale parameter for overdispersion	0.63	0.14	4.64
Log-likelihood at convergence	-4,522.402		
Number of observations	43,104		

As seen in tables 43-45, median effects continue to affect fatal injury collision propensities with paved and non-paved medians having a negative effect, while median width is inelastic with respect to visible injury collisions.

Tables 46-50 show results for type 2 SPFs for urban 5-6-7 lane roadway segments.

Table 46. Urban Five-Six-Seven-lane SPF 2 –PDO Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-8.04	0.11	-72.39
Logarithm of ADT	1.02	0.01	102.04
METWTL	-0.53	0.08	-6.27
RT261	-1.50	0.19	-7.73
RT15	-0.22	0.03	-7.19
RT92	0.53	0.07	7.80
RT29	0.98	0.09	10.86
LA	0.17	0.02	8.64
MESTRUC	-0.10	0.02	-4.45
FRE	0.35	0.04	8.48
MED_WI	-0.007	0.0003	-27.59
YEAR07	-0.07	0.02	-3.74
YEAR08	-0.22	0.02	-10.69
YEAR09	-0.28	0.02	-13.63
YEAR10	-0.26	0.02	-12.31
Scale parameter for overdispersion	0.82	0.01	69.24
Log-likelihood at convergence	-49,388.383		
Number of observations	25,590		

Table 47. Urban Five-Six-Seven-lane SPF 2 –Complaint of Pain Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.86	0.29	-20.23
Logarithm of ADT	1.10	0.02	70.94
DES_SP	-0.03	0.001	-24.26
METWTL	0.48	0.09	5.55
RT261	-1.37	0.32	-4.32
RT15	-0.21	0.04	-5.41
RT29	1.28	0.10	12.52
SOL	-0.35	0.08	-4.58
SF	-0.15	0.07	-2.30
MECONCG	-0.12	0.05	-2.64
MEST	-0.47	0.13	-3.56
MED_WI	-0.01	0.0004	-20.07
YEAR06	-0.06	0.03	-2.24
YEAR07	-0.07	0.03	-2.52
YEAR08	-0.21	0.03	-6.70
YEAR09	-0.22	0.03	-7.41
YEAR10	-0.20	0.03	-6.76
Scale parameter for overdispersion	0.69	0.02	45.34
Log-likelihood at convergence	-30,557.415		
Number of observations	25,590		

Table 48. Urban Five-Six-Seven-lane SPF 2 –Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.62	0.22	-35.39
Logarithm of ADT	0.92	0.02	45.71
DES_SP	-0.02	0.002	-9.41
FRE	0.26	0.06	4.72
LA	0.21	0.03	7.30
SOL	-0.25	0.09	-2.81
MENPAVE	-0.07	0.03	-2.16
MEPAVE	-0.14	0.04	-3.80
MEST	-0.49	0.14	-3.49
MED_WI	-0.01	0.001	-9.53
YEAR06	-0.08	0.03	-2.31
YEAR07	-0.18	0.03	-5.51
YEAR08	-0.25	0.03	-7.29
YEAR09	-0.34	0.03	-9.75
YEAR10	-0.33	0.03	-9.69
Scale parameter for overdispersion	0.38	0.02	25.12
Log-likelihood at convergence	-20,783.558		
Number of observations	25,590		

Table 49. Urban Five-Six-Seven-lane SPF 2 –Severe Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.76	0.46	-16.92
Logarithm of ADT	0.72	0.04	18.55
DES_SP	-0.01	0.004	-2.37
RT_OS_WI	-0.03	0.01	-4.76
FRE	0.44	0.09	5.08
YEAR08	-0.14	0.06	-2.57
YEAR09	-0.18	0.06	-3.18
YEAR10	-0.19	0.06	-3.33
Scale parameter for overdispersion	0.34	0.05	6.42
Log-likelihood at convergence	-7,325.192		
Number of observations	25,590		

Table 50. Urban Five-Six-Seven-lane SPF 2 –Fatal Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.83	0.69	-11.43
Logarithm of ADT	0.55	0.06	9.35
RT99	0.18	0.01	2.09
RT4	0.47	0.23	2.09
YEAR08	-0.17	0.08	-2.07
YEAR09	-0.19	0.08	-2.24
YEAR10	-0.37	0.09	-4.05
Scale parameter for overdispersion	N/A	N/A	N/A
Log-likelihood at convergence	-3,733.609		
Number of observations	25,590		

As tables 46-50 show, the median effects are the significant geometric effects in addition to design speed. Median effects are generally dummy in nature, including variables such as median turnouts, median striping, paved medians, medians with concrete barriers and glare screens as well as median width. However, median width is not elastic. Right outside shoulder width is significant for severe injury collisions, although it is not elastic. Design speed is the one geometric effect that is elastic, with respect to complaint of pain and visible injury collisions. The elasticity is as high as -2.02. Spatial dummies are not as pronounced in the urban 5-6-7 lane models as noticed in other type 2 SPFs indicating a greater level of design consistency and diminished spatial heterogeneity due to route or county effects. ADT is elastic for PDO and complaint of pain collision types. This emphasizes congestion effects and the need for active traffic management strategies to mitigate lower severity outcomes. Higher severity outcomes appear to be influenced primarily by median effects or time dummies. Tables 51-55 show the results of type 2 SPFs for urban eight-plus lane roadway segments.

Table 51. Urban Eight-Plus-Lane SPF 2 –PDO Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-11.72	0.26	-45.55
Logarithm of ADT	1.25	0.01	114.55
DES_SP	0.01	0.003	2.44
RT210	-0.53	0.04	-14.43
RT105	-0.21	0.04	-4.64
RT10	0.23	0.02	11.87
RT24	-0.21	0.03	-6.58
RT29	1.94	0.16	12.25
RT101	-0.10	0.02	-5.96
VEN	0.23	0.10	2.38
LA	0.25	0.01	21.93
SF	0.83	0.04	20.43
SCL	0.25	0.02	12.08
ALA	0.54	0.02	31.53
SAC	0.36	0.03	13.77
MESTRUC	-0.23	0.02	-11.23
MED_WI	-0.003	0.0002	-18.02
YEAR06	-0.01	0.02	-3.58
YEAR07	-0.10	0.02	-6.53
YEAR08	-0.22	0.02	-13.71
YEAR09	-0.26	0.02	-16.15
YEAR10	-0.24	0.02	-15.05
Scale parameter for overdispersion	0.64	0.01	96.58
Log-likelihood at convergence	-91,032.522		
Number of observations	34,170		

As table 51 shows, the significant geometric effects are design speed, median effects such as median structure and median width. The rest of the statistically significant effects are time dummies, spatial dummies related to routes and counties. ADT is elastic, while median width is not. Design speed is also inelastic with respect to PDO collisions on eight-plus-lane urban roadways. The inelasticity of geometric effects may indicate the majority of significant impact arises from flow related effects, which is confirmed by the elastic ADT variable.

Table 52. Urban Eight-Plus-lane SPF 2 –Complaint of Pain Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-12.04	0.19	-63.61
Logarithm of ADT	1.23	0.02	78.81
RT210	-0.40	0.04	-10.43
RT24	-0.34	0.06	-6.00
RT29	2.14	0.21	10.27
LA	0.07	0.01	5.26
SF	0.61	0.06	9.59
ALA	0.29	0.02	12.87
SAC	0.43	0.03	14.78
MESTRUC	-0.14	0.03	-4.55
MED_WI	-0.004	0.0003	-13.51
YEAR06	-0.07	0.02	-3.66
YEAR07	-0.09	0.02	-4.43
YEAR08	-0.18	0.02	-9.52
YEAR09	-0.19	0.02	-9.76
YEAR10	-0.14	0.02	-7.40
Scale parameter for overdispersion	0.49	0.01	62.42
Log-likelihood at convergence	-58,741.044		
Number of observations	34,170		

Table 53. Urban Eight-Plus-lane SPF 2 –Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-9.46	0.23	-41.22
Logarithm of ADT	0.97	0.02	49.84
RT24	-0.28	0.06	-4.26
RT29	1.19	0.31	3.88
RT_TR_WI	-0.004	0.001	-5.87
SJ	0.30	0.09	3.43
MRN	-0.45	0.07	-6.78
MED_WI	-0.003	0.0003	-10.84
SM	-0.38	0.04	-10.76
RT1	0.40	0.15	- 2.62
RT680	-0.41	0.05	-8.05
RT22	0.59	0.15	4.08
YEAR06	-0.09	0.02	-4.10
YEAR07	-0.18	0.02	-8.50
YEAR08	-0.26	0.02	-11.51
YEAR09	-0.32	0.02	-14.09
YEAR10	-0.29	0.02	-13.20
Scale parameter for overdispersion	0.29	0.01	33.42
Log-likelihood at convergence	-39,925.551		
Number of observations	34,170		

Table 54. Urban Eight-Plus-lane SPF 2 –Severe Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-9.24	0.51	-16.92
Logarithm of ADT	0.77	0.04	18.55
LA	-0.11	0.03	-3.62
SM	-0.54	0.08	-6.75
MED_WI	-0.003	0.001	-4.98
RT805	0.15	0.08	1.92
RT180	0.79	0.36	2.18
LT_OS_WI	0.02	0.008	2.50
RT_OS_WI	-0.02	0.01	-2.31
YEAR05	0.07	0.04	1.92
YEAR09	-0.08	0.04	-2.14
YEAR10	-0.18	0.04	-4.63
Scale parameter for overdispersion	0.22	0.03	7.06
Log-likelihood at convergence	-14,172.825		
Number of observations	34,170		

Table 55. Urban Eight-Plus-lane SPF 2 –Fatal Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.84	0.74	-10.58
Logarithm of ADT	0.55	0.06	8.97
RT710	0.64	0.16	3.93
RT4 RT10	0.35	0.07	5.08
SF	0.84	0.20	4.28
YEAR06	0.17	0.06	3.04
YEAR09	-0.23	0.07	-3.43
YEAR09	-0.37	0.07	-5.31
Scale parameter for overdispersion	0.13	0.07	1.97
Log-likelihood at convergence	-6,879.667		
Number of observations	34,170		

As tables 52-55 show, the variable design speed is absent in severe injury collision models, while outside shoulder widths are. They are however not elastic. Median effects such as median width are also inelastic, while, ADT is elastic for complaint of pain collisions and near elastic for visible injury collisions. Time dummies, route dummies and county dummies continue to play a significant role across the severity spectrum. The positive sign of the year 2005 dummy reinforces what has been noticed in other type 2 SPFs – that year 2005 is universally a more crash prone year across the severity spectrum for all SPF classes.

Tables 56-60 show results for urban multilane undivided roadway segments.

Table 56. Urban Multi-Lane Undivided SPF 2 –PDO Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-3.45	0.54	-6.38
Logarithm of ADT	0.65	0.05	13.96
RTLANES	0.77	0.09	8.70
DES_SP	-0.03	0.003	-11.45
RTRCL	-1.40	0.14	-9.96
TUL	1.35	0.20	6.68
RT138	-0.68	0.30	-2.25
YEAR08	-0.24	0.09	-2.75
YEAR10	-0.41	0.09	-4.51
Scale parameter for overdispersion	3.01	0.14	21.79
Log-likelihood at convergence	4,612.316		
Number of observations	5,064		

Table 57. Urban Multi-Lane Undivided SPF 2 –Complaint of Pain Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-8.95	0.88	-10.16
Logarithm of ADT	0.98	0.09	11.04
RTLANES	0.97	0.15	6.39
DES_SP	-0.02	0.004	-5.12
RTRCL	-1.37	0.18	-7.64
TUL	1.24	0.30	4.10
STA	1.24	0.39	3.21
RT108	-1.30	0.50	-2.58
YEAR10	-0.44	0.14	-3.11
Scale parameter for overdispersion	3.27	0.27	12.26
Log-likelihood at convergence	-2,382.162		
Number of observations	5,064		

As tables 56-60 show, the geometric effects that are statistically significant include right travel lanes, truck climbing lane dummy, and design speed. The right travel lanes variable is elastic with an elasticity of 1.90, while the design speed variable is also elastic with a value of -1.57 for PDO collisions. ADT is near elastic for complaint of pain collisions with a value of 0.98. Spatial dummies include both route and county effects which are however not as rich as some of the earlier type 2 SPFs. Time dummies include later year effects such as year 2008 and year

2010. The overdispersion parameter magnitude is significant indicating substantial residual heterogeneity due to unobserved effects.

Table 58. Urban Multi-Lane Undivided SPF 2 –Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-4.89	0.87	-5.65
Logarithm of ADT	0.56	0.09	6.19
RTRCL	-0.77	0.20	-3.84
SBT	1.35	0.44	3.03
YEAR08	-0.39	0.17	-2.30
YEAR09	-0.33	0.17	-1.97
YEAR10	-0.43	0.17	-2.53
Scale parameter for overdispersion	3.03	0.39	7.83
Log-likelihood at convergence	-1,626.679		
Number of observations	5,064		

Table 59. Urban Multi-Lane Undivided SPF 2 –Severe Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-4.40	1.40	-3.15
Logarithm of ADT	0.48	0.14	3.51
DES_SP	-0.03	0.009	-3.12
TUL	1.33	0.55	2.42
YEAR10	-0.67	0.31	-2.13
Scale parameter for overdispersion	1.39	0.88	1.89
Log-likelihood at convergence	-593.393		
Number of observations	5,064		

Table 60. Urban Multi-Lane Undivided SPF 2 –Fatal Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-8.14	1.78	-4.56
Logarithm of ADT	0.59	0.19	3.14
RIV	0.76	0.29	2.65
RT62	1.47	0.45	3.30
YEAR06	-0.89	0.47	-1.91
NEV	1.07	0.50	2.16
Scale parameter for overdispersion	N/A	N/A	N/A
Log-likelihood at convergence	-300.531		
Number of observations	5,064		

Tables 61-65 show the type 2 SPFs for urban multilane divided roadway segments.

Table 61. Urban Multi-Lane Divided SPF 2 –PDO Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-4.41	0.26	-17.17
Logarithm of ADT	0.84	0.03	31.49
RT_TR_WI	0.01	0.003	4.39
DES_SP	-0.02	0.002	-14.45
METWTL	-0.43	0.04	-10.33
MEPAVE	-0.47	0.04	-11.18
MENPAVE	-0.56	0.04	-2.25
MESTRUC	-1.09	0.14	-7.54
SCL	-0.65	0.06	-10.04
SBD	0.61	0.06	11.06
MER	-0.60	0.09	-6.59
IMP	-0.92	0.07	-13.44
RT18	-0.46	0.09	-5.22
YEAR06	-0.14	0.05	-2.95
YEAR07	-0.21	0.05	-4.70
YEAR08	-0.39	0.05	-7.79
YEAR09	-0.44	0.05	-8.88
YEAR10	-0.52	0.05	-11.16
Overdispersion	2.55	0.05	48.00
Log-likelihood at convergence	-19,626.609		
Number of observations	19,434		

Table 62. Urban Multi-Lane Undivided SPF 2 –Complaint of Pain Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-8.68	0.44	-19.62
Logarithm of ADT	1.09	0.04	25.44
LT_IS_WI	0.04	0.01	3.39
LTLANES	0.39	0.05	8.40
RT_IS_WI	-0.07	0.01	-5.31
DES_SP	-0.03	0.002	-13.57
METWTL	-0.37	0.06	-6.61
MENPAVE	-0.53	0.06	-9.15
MENOBARR	0.48	0.09	5.28
SCL	-0.85	0.08	-10.44
VEN	1.02	0.19	5.23
RIV	0.21	0.08	2.75
MER	-1.18	0.12	-9.84
IMP	-1.02	0.10	-10.17
RT33	-1.09	0.26	-4.10
RT18	-0.45	0.15	-3.09
RT74	0.54	0.11	4.84
YEAR08	-0.145	0.05	-2.89
YEAR09	-0.11	0.05	-2.13
YEAR10	-0.13	0.05	-2.38
Overdispersion	2.15	0.07	29.62
Log-likelihood at convergence	-12,203.616		
Number of observations	19,434		

Table 63. Urban Multi-Lane Undivided SPF 2 –Visible Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-6.61	0.46	-14.35
Logarithm of ADT	0.80	0.05	16.59
LTLANES	0.40	0.06	6.75
RT_IS_WI	-0.05	0.01	-4.58
DES_SP	-0.03	0.003	-8.75
METWTL	-0.20	0.07	-2.98
SCL	-0.48	0.09	-5.13
RIV	0.39	0.09	4.56
SBD	0.57	0.09	5.99
IMP	-0.69	0.12	-5.57
RT18	-0.59	0.19	-3.14
YEAR06	-0.21	0.08	-2.74
YEAR07	-0.43	0.08	-5.36
YEAR08	-0.41	0.08	-4.87
YEAR09	-0.49	0.08	-5.87
YEAR10	-0.53	0.08	-6.27
Scale parameter for overdispersion	1.71	0.11	15.20
Log-likelihood at convergence	-7,060.811		
Number of observations	19,434		

Table 64. Urban Multi-Lane Undivided SPF 2 –Severe Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-7.54	0.79	-9.51
Logarithm of ADT	0.67	0.09	7.81
LTLANES	0.33	0.10	3.19
DES_SP	-0.02	0.005	-4.39
SCL	-0.42	0.18	-2.38
Scale parameter for overdispersion	1.52	0.30	5.01
Log-likelihood at convergence	-2,187.033		
Number of observations	19,434		

As tables 61-65 show, the geometric effects that are statistically significant include left travel lanes, design speed, inside shoulder width, median type dummies and right travel width. Design speed is elastic, with a maximum of -1.62 for visible injury collisions, while left travel lanes is near elastic for visible injury collisions, with an elasticity of 0.84. Right outside shoulder width is significant in fatal injury collisions with a negative sign, but not elastic. ADT is elastic for complaint of pain collisions.

Table 65. Urban Multi-Lane Undivided SPF 2 –Fatal Injury Collision Counts.

Variable	Mean	Standard Error	T-statistic
Constant	-6.42	0.88	-7.31
Logarithm of ADT	0.48	0.08	5.70
RT_OS_WI	-0.05	0.02	-2.73
YEAR05	0.40	0.14	2.78
YEAR10	-0.57	0.21	-2.66
Scale parameter for overdispersion	N/A	N/A	N/A
Log-likelihood at convergence	-1,228.294		
Number of observations	19,434		

Intersection SPFs

Table 66 shows the type 1 SPFs for intersections, for all severity types and total crashes.

Table 66. Type 1 SPFs for Intersections for Total Crashes, Property Damage Only, Complaint of Pain, Visible Injury, Severe Injury and Fatal Collisions.*

Injury Type	α	β_1	β_2	θ
Total Crashes	-8.61	0.84	0.10	1.34
PDO	-8.91	0.85	0.058	1.63
Complaint of Pain	-11.70	0.97	0.16	1.55
Visible	-9.24	0.64	0.15	1.20
Severe	-8.20	0.43	0.09	1.49
Fatal	-8.38	0.44	-0.03	2.69

*All coefficients significant at 95% or better with the exception of cross street volume for severe and fatal injury

α *is coefficient for constant (intercept)*

β_1 *and* β_2 *are coefficients for ln(ADT) for mainline and cross street*

θ *is overdispersion parameter*

Tables 67-72 show the type 2 SPFs for total crashes, property damage only, complaint of pain, visible injury, severe injury and fatal collisions for intersection locations on the state network. As can be seen from the tables, the geometric effects are rich, with traffic control effects also being statistically significant in the estimation of mainline crashes at intersections. The significance of these findings is that intersection geometry contributes to several heterogeneous effects, considering that cross street geometry in our study is fairly limited in measurement. The significance of mainline geometry more so than what was found in roadway segment analysis emphasizes this point.

Table 67. Type 2 SPFs for Total Intersection Crashes.

```
Fitting constant-only model:

Iteration 0:   log likelihood = -159073.36
Iteration 1:   log likelihood = -153455.56
Iteration 2:   log likelihood = -152632.44
Iteration 3:   log likelihood = -152632.41
Iteration 4:   log likelihood = -152632.41

Fitting full model:

Iteration 0:   log likelihood = -140397.04
Iteration 1:   log likelihood = -132403.26
Iteration 2:   log likelihood = -131121.34
Iteration 3:   log likelihood = -131074.76
Iteration 4:   log likelihood = -131074.72
Iteration 5:   log likelihood = -131074.72

Negative binomial regression                      Number of obs   =     103169
                                                  LR chi2(49)     =   43115.37
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -131074.72                       Pseudo R2       =     0.1412
```

totalcrashes	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6133459	.0064782	94.68	0.000	.6006487	.626043
lncrossv	-.1410736	.0140817	-10.02	0.000	-.1686732	-.1134741
minltlanes	.1449676	.0255409	5.68	0.000	.0949083	.1950269
maxlt_os_wi	.0063704	.001255	5.08	0.000	.0039106	.0088302
minlt_tr_wi	-.0100624	.0019383	-5.19	0.000	-.0138614	-.0062633
minlt_is_wi	.0149978	.0031689	4.73	0.000	.0087869	.0212087
minrtlanes	-.0982446	.0271308	-3.62	0.000	-.15142	-.0450693
minrt_is_wi	-.0239234	.0033113	-7.22	0.000	-.0304133	-.0174334
minrt_tr_wi	.0070746	.0021124	3.35	0.001	.0029344	.0112147
minrt_os_wi	-.0167029	.0022861	-7.31	0.000	-.0211835	-.0122222
maxrt_os_wi	.0224313	.0023766	9.44	0.000	.0177732	.0270894
mindes_sp	.0021743	.0005332	4.08	0.000	.0011292	.0032194
divide	-.1024913	.017483	-5.86	0.000	-.1367574	-.0682253

Table 67 (Continued). Type 2 SPFs for Total Intersection Crashes.

lltr	.0743771	.0280154	2.65	0.008	.019468	.1292863
lauxl	.1796179	.0356457	5.04	0.000	.1097537	.2494821
rtrcl	-.1764438	.0512193	-3.44	0.001	-.2768318	-.0760559
rauxl	-.0952557	.0378629	-2.52	0.012	-.1694657	-.0210457
rmedhov	-.1126428	.0219937	-5.12	0.000	-.1557496	-.069536
mepave	.1236426	.0169987	7.27	0.000	.0903258	.1569595
menpave	-.0307839	.016837	-1.83	0.067	-.0637839	.0022161
mestruc	.0532624	.0195647	2.72	0.006	.0149162	.0916085
mecabl	.2781644	.0443702	6.27	0.000	.1912004	.3651285
megraill	.1858224	.0433621	4.29	0.000	.1008342	.2708106
meconcb	-.3140365	.0350575	-8.96	0.000	-.382748	-.245325
tint	-.393841	.0105309	-37.40	0.000	-.4144812	-.3732007
yint	-.2396012	.0238982	-10.03	0.000	-.2864408	-.1927616
fiveleg	-.1935039	.0459206	-4.21	0.000	-.2835066	-.1035013
offsetin	-.1596155	.0243562	-6.55	0.000	-.2073528	-.1118782
nocontrol	-.7572276	.02974	-25.46	0.000	-.815517	-.6989382
stopcross	-.3026414	.0208442	-14.52	0.000	-.3434952	-.2617875
fourstop	.1614093	.0606475	2.66	0.008	.0425424	.2802762
fourflxr	.4455516	.0806193	5.53	0.000	.2875406	.6035625
twophasepre	.3142496	.0353213	8.90	0.000	.2450212	.383478
multphasepre	.1881784	.0738758	2.55	0.011	.0433845	.3329723
multphasesemi	.1673245	.0586155	2.85	0.004	.0524402	.2822088
twophasefull	.5762345	.0357863	16.10	0.000	.5060947	.6463744
multphasefull	.3407056	.0260966	13.06	0.000	.2895572	.3918539
lightyes	.1039192	.0119127	8.72	0.000	.0805708	.1272677
mainltcurb	.2186175	.0170353	12.83	0.000	.1852288	.2520061
mainltpaint	.1661019	.0115275	14.41	0.000	.1435084	.1886954
mainrtpaint	.1725248	.0385924	4.47	0.000	.0968851	.2481644
intmastyes	.1711527	.0198221	8.63	0.000	.1323021	.2100033
intltno	-.1437601	.0179971	-7.99	0.000	-.1790337	-.1084865
intrtcurb	-.3614039	.1682024	-2.15	0.032	-.6910746	-.0317333
intrtno	-.1426633	.0164	-8.70	0.000	-.1748067	-.11052
intrtpaint	-.3177159	.0421229	-7.54	0.000	-.4002754	-.2351564
int2wyeslt	.2800226	.0241456	11.60	0.000	.2326981	.3273472
int2wpeaklt	.9137443	.1223196	7.47	0.000	.6740022	1.153486
int1way	.2755741	.0350238	7.87	0.000	.2069287	.3442196
_cons	-4.598094	.1196858	-38.42	0.000	-4.832674	-4.363515
/lnalpha	-.185688	.0113005			-.2078366	-.1635394
alpha	.8305327	.0093854			.8123398	.8491331

Likelihood-ratio test of alpha=0: chibar2(01) = 3.6e+04 Prob>=chibar2 = 0.000

As can be noticed in table 67, 48 statistically significant parameters were found to be associated with total intersection crashes on the mainline. These vary from minimum and maximum values for geometric variables such as number of lanes, to traveled width, shoulder width and design speed, to dummy effects involving divided highways, traffic signal phasing, mainline left turn treatments, intersection right turn treatments, type of unsignalized control as well as intersection mast arm treatments. It is evident from this substantive set of variables that type 2 SPFs at intersections show a high degree of complexity with respect to the multifaceted interactions that are being captured by the variables shown in table 67. What is important to note is the elastictics of the design speed and ADT variables substantially diminish with both being inelastic, while the dispersion parameter magnitude is less than unity. This shows that a rich type 2 SPF can capture heterogeneity much more effectively than a type 1 SPF, which has an overdispersion parameter of 1.34 in comparison. Tables 68-72 further underscore the significant change in the overdispersion parameters for PDO, complaint of pain, visible, severe and fatal collision types, compared to what the overdispersion parameters were in type 1 SPFs as shown previously in table 66.

Table 68. Type 2 SPFs for PDO Intersection Crashes.

```
Fitting constant-only model:

Iteration 0:   log likelihood = -122361.55
Iteration 1:   log likelihood = -120733.31
Iteration 2:   log likelihood = -116848.93
Iteration 3:   log likelihood =  -116848.8
Iteration 4:   log likelihood =  -116848.8

Fitting full model:

Iteration 0:   log likelihood = -107437.33
Iteration 1:   log likelihood = -101508.87
Iteration 2:   log likelihood = -100809.75
Iteration 3:   log likelihood = -100796.27
Iteration 4:   log likelihood = -100796.26

Negative binomial regression                      Number of obs   =     103169
                                                  LR chi2(46)     =   32105.07
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -100796.26                       Pseudo R2       =     0.1374
```

pdo	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6141739	.0079429	77.32	0.000	.5986061	.6297418
lncrossv	-.1923174	.0168308	-11.43	0.000	-.2253053	-.1593296
minltlanes	.1494973	.0304915	4.90	0.000	.0897351	.2092595
maxlt_os_wi	.011944	.0015031	7.95	0.000	.008998	.0148901
minlt_tr_wi	-.0093302	.0023073	-4.04	0.000	-.0138524	-.004808
minlt_is_wi	.0142216	.0038375	3.71	0.000	.0067002	.021743
minrtlanes	-.090343	.0325231	-2.78	0.005	-.1540872	-.0265988
minrt_is_wi	-.0255522	.0040323	-6.34	0.000	-.0334553	-.017649
minrt_tr_wi	.006776	.0025333	2.67	0.007	.0018109	.0117411
minrt_os_wi	-.0189988	.0026895	-7.06	0.000	-.0242702	-.0137274
maxrt_os_wi	.0251797	.0027862	9.04	0.000	.0197189	.0306405
mindes_sp	.0020932	.0006309	3.32	0.001	.0008567	.0033296
divide	-.186434	.0181802	-10.25	0.000	-.2220665	-.1508015
lltr	.0853727	.0333489	2.56	0.010	.0200101	.1507354

.

Table 69 (Continued). Type 2 SPFs for PDO Intersection Crashes.

lauxl	.1554248	.0359707	4.32	0.000	.0849235	.2259261
rtrcl	-.2176923	.0627255	-3.47	0.001	-.3406321	-.0947526
rmedhov	-.137207	.0264858	-5.18	0.000	-.1891181	-.0852958
mepave	.1839356	.0166152	11.07	0.000	.1513704	.2165008
mestruc	.0621697	.0228052	2.73	0.006	.0174723	.106867
mecabl	.2022338	.0532547	3.80	0.000	.0978564	.3066111
megraill	.2123886	.0521967	4.07	0.000	.1100849	.3146922
meconcb	-.3429574	.0425497	-8.06	0.000	-.4263532	-.2595615
tint	-.3805384	.0127146	-29.93	0.000	-.4054585	-.3556182
yint	-.2520886	.0295332	-8.54	0.000	-.3099727	-.1942045
fiveleg	-.1740362	.0543055	-3.20	0.001	-.2804731	-.0675993
offsetin	-.1711202	.0293872	-5.82	0.000	-.2287181	-.1135223
nocontrol	-.7911439	.0365998	-21.62	0.000	-.8628782	-.7194096
stopcross	-.2978276	.0248258	-12.00	0.000	-.3464854	-.2491699
fourstop	.2346009	.0713551	3.29	0.001	.0947476	.3744543
fourflxr	.4192227	.0952184	4.40	0.000	.232598	.6058475
twophasepre	.2229943	.0416725	5.35	0.000	.1413177	.3046709
multphasepre	.2857398	.0846399	3.38	0.001	.1198487	.451631
multphasesemi	.189653	.0680261	2.79	0.005	.0563243	.3229816
twophasefull	.5660321	.0415919	13.61	0.000	.4845135	.6475507
multphasefull	.3427682	.0307497	11.15	0.000	.2824999	.4030364
lightyes	.1636314	.0144546	11.32	0.000	.1353009	.1919619
mainltcurb	.1962509	.0203274	9.65	0.000	.1564099	.2360918
mainltpaint	.1615924	.013915	11.61	0.000	.1343195	.1888653
mainrtpaint	.24089	.0444192	5.42	0.000	.1538299	.3279501
intmastyes	.2101654	.0230193	9.13	0.000	.1650483	.2552825
intltno	-.1228423	.0210326	-5.84	0.000	-.1640654	-.0816193
intrtno	-.1125373	.0192135	-5.86	0.000	-.150195	-.0748796
intrtpaint	-.3140838	.0487665	-6.44	0.000	-.4096643	-.2185033
int2wyeslt	.2589066	.0289653	8.94	0.000	.2021356	.3156775
int2wpeaklt	.8782562	.1446935	6.07	0.000	.5946622	1.16185
int1way	.3164075	.0414933	7.63	0.000	.2350821	.3977329
_cons	-4.834925	.143479	-33.70	0.000	-5.116139	-4.553712
/lnalpha	.01517	.0134793			-.011249	.041589
alpha	1.015286	.0136854			.988814	1.042466

Likelihood-ratio test of alpha=0: chibar2(01) = 2.2e+04 Prob>=chibar2 = 0.000

Compared to an overdispersion parameter of 1.63 in type 1 SPF, we now observe a much reduced effect of magnitude 1.02, while the ADT effect is also reduced to 0.58 from 0.87. Similar trends are noticed in complaint of pain type 2 SPFs shown in table 69.

Table 69. Type 2 SPFs for Complaint of Pain Intersection Crashes.

```
Fitting constant-only model:

Iteration 0:   log likelihood = -75144.976
Iteration 1:   log likelihood = -72438.695
Iteration 2:   log likelihood = -72431.779
Iteration 3:   log likelihood = -72431.777

Fitting full model:

Iteration 0:   log likelihood = -65626.293
Iteration 1:   log likelihood = -62610.254
Iteration 2:   log likelihood = -60951.962
Iteration 3:   log likelihood = -60476.614
Iteration 4:   log likelihood = -60050.097
Iteration 5:   log likelihood = -59966.402
Iteration 6:   log likelihood = -59965.733
Iteration 7:   log likelihood = -59965.733

Negative binomial regression                      Number of obs   =     103169
                                                  LR chi2(38)     =   24932.09
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -59965.733                       Pseudo R2       =     0.1721
```

cp	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6969018	.0109922	63.40	0.000	.6753574	.7184462
lncrossv	-.0685087	.0207569	-3.30	0.001	-.1091914	-.027826
minltlanes	.1381937	.0390102	3.54	0.000	.0617352	.2146523
minlt_tr_wi	-.0101277	.0029383	-3.45	0.001	-.0158867	-.0043688
minlt_is_wi	.0101191	.0049959	2.03	0.043	.0003273	.0199109
minrtlanes	-.154319	.0415223	-3.72	0.000	-.2357012	-.0729368
minrt_is_wi	-.0149684	.0052036	-2.88	0.004	-.0251674	-.0047695
minrt_tr_wi	.0105026	.0032123	3.27	0.001	.0042066	.0167986
minrt_os_wi	-.0150735	.0032648	-4.62	0.000	-.0214724	-.0086747
maxrt_os_wi	.0198424	.0033764	5.88	0.000	.0132248	.0264599
lauxl	.1814086	.0451134	4.02	0.000	.092988	.2698292
rtrcl	-.2493348	.0850314	-2.93	0.003	-.4159932	-.0826763
mepave	.1047486	.0194067	5.40	0.000	.0667121	.1427851
mecabl	.4418082	.06247	7.07	0.000	.3193693	.5642472

Table 69 (Continued). Type 2 SPFs for Complaint of Pain Intersection Crashes.

megraill	.2752666	.0647142	4.25	0.000	.1484291	.4021042
meconcb	-.3612731	.0521133	-6.93	0.000	-.4634134	-.2591328
tint	-.4022606	.0163272	-24.64	0.000	-.4342613	-.3702598
yint	-.2669061	.0413932	-6.45	0.000	-.3480352	-.1857769
fiveleg	-.2002519	.06526	-3.07	0.002	-.3281592	-.0723446
offsetin	-.1302154	.0364058	-3.58	0.000	-.2015694	-.0588614
nocontrol	-.8680251	.0520365	-16.68	0.000	-.9700149	-.7660354
stopcross	-.3247392	.0305986	-10.61	0.000	-.3847114	-.2647669
fourstop	.1599182	.0925267	1.73	0.084	-.0214308	.3412672
fourflxr	.4493006	.1144009	3.93	0.000	.225079	.6735222
twophasepre	.4640733	.0460101	10.09	0.000	.3738951	.5542514
multphasesemi	.1754864	.075546	2.32	0.020	.027419	.3235538
twophasefull	.6645483	.0455029	14.60	0.000	.5753642	.7537323
multphasefull	.3974874	.0347511	11.44	0.000	.3293765	.4655983
lightyes	.1627164	.0200094	8.13	0.000	.1234987	.2019341
mainltcurb	.2367883	.0238284	9.94	0.000	.1900855	.2834911
mainltpaint	.1634462	.0179756	9.09	0.000	.1282147	.1986777
intmastyes	.1384372	.0250367	5.53	0.000	.0893663	.1875082
intltno	-.2025567	.0234244	-8.65	0.000	-.2484676	-.1566457
intrtno	-.1180648	.0220333	-5.36	0.000	-.1612493	-.0748804
intrtpaint	-.3415044	.0481419	-7.09	0.000	-.4358608	-.247148
int2wyeslt	.3041624	.036916	8.24	0.000	.2318083	.3765165
int2wpeaklt	.9713521	.1516534	6.41	0.000	.6741169	1.268587
int1way	.1997411	.0518485	3.85	0.000	.0981198	.3013623
_cons	-7.289073	.1765334	-41.29	0.000	-7.635072	-6.943074
/lnalpha	-.2550479	.0245489			-.3031629	-.2069329
alpha	.7748794	.0190225			.7384788	.8130742

Likelihood-ratio test of alpha=0: chibar2(01) = 4561.49 Prob>=chibar2 = 0.000

The complaint of pain overdispersion parameter is reduced in magnitude to 0.77 from 1.56, while the ADT parameter is reduced to 0.68 from 1.01. This suggests that an elastic variable such as ADT is now weakened in its statistical influence due to the inclusion of geometric effects to a degree that makes it substantially inelastic. What is also noteworthy is the substantial significance of traffic control type variables as well as certain types of intersection geometry such as T-intersections.

Table 70 shows type 2 SPFs for visible injury collisions.

Table 70. Type 2 SPFs for Visible Injury Intersection Crashes.

```
Fitting constant-only model:

Iteration 0:   log likelihood = -44541.543
Iteration 1:   log likelihood = -44338.644
Iteration 2:   log likelihood = -44302.067
Iteration 3:   log likelihood = -44302.065

Fitting full model:

Iteration 0:   log likelihood = -41028.109
Iteration 1:   log likelihood = -40006.985
Iteration 2:   log likelihood = -39872.844
Iteration 3:   log likelihood = -39870.762
Iteration 4:   log likelihood =  -39870.76

Negative binomial regression                      Number of obs   =     103169
                                                  LR chi2(30)     =    8862.61
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -39870.76                        Pseudo R2       =     0.1000
```

visible	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.4811165	.0128773	37.36	0.000	.4558775	.5063556
lncrossv	-.0139969	.0271628	-0.52	0.606	-.0672349	.0392411
minlt_is_wi	.0253492	.0060602	4.18	0.000	.0134715	.037227
minrtlanes	-.0332552	.0097282	-3.42	0.001	-.052322	-.0141883
minrt_is_wi	-.0344473	.0063263	-5.45	0.000	-.0468466	-.022048
maxrt_os_wi	.0072089	.0028331	2.54	0.011	.0016561	.0127617
rtrcl	-.223947	.1076584	-2.08	0.038	-.4349537	-.0129403
mepave	.0567855	.0256727	2.21	0.027	.006468	.107103
mestruc	.079029	.033412	2.37	0.018	.0135426	.1445154
mecabl	.4462903	.0829818	5.38	0.000	.2836489	.6089316
meconcb	-.3765056	.0730442	-5.15	0.000	-.5196696	-.2333416
tint	-.3894692	.0211708	-18.40	0.000	-.4309632	-.3479751
yint	-.1885313	.0493677	-3.82	0.000	-.2852902	-.0917723
fiveleg	-.2671497	.0898061	-2.97	0.003	-.4431664	-.091133
offsetin	-.2089678	.0499651	-4.18	0.000	-.3068976	-.1110379
nocontrol	-.6386282	.0595975	-10.72	0.000	-.7554372	-.5218193
stopcross	-.2834667	.0376529	-7.53	0.000	-.3572651	-.2096683
fourflxr	.4737992	.1417368	3.34	0.001	.1960001	.7515983
twophasepre	.3566371	.0591772	6.03	0.000	.2406519	.4726224
twophasefull	.4609374	.0584016	7.89	0.000	.3464724	.5754024
multphasefull	.1883907	.0428886	4.39	0.000	.1043306	.2724507
lightyes	-.1111295	.025293	-4.39	0.000	-.1607028	-.0615561
mainltcurb	.2957137	.0316068	9.36	0.000	.2337654	.357662
mainltpaint	.1856983	.0233663	7.95	0.000	.1399011	.2314954
intmastyes	.1334435	.034078	3.92	0.000	.0666519	.2002352
intltno	-.1595968	.0318185	-5.02	0.000	-.2219599	-.0972337
intrtno	-.148049	.0294033	-5.04	0.000	-.2056784	-.0904196
intrtpaint	-.1833003	.063598	-2.88	0.004	-.3079501	-.0586506
int2wyeslt	.2521526	.0389716	6.47	0.000	.1757698	.3285355
int2wpeaklt	.9162631	.1860186	4.93	0.000	.5516734	1.280853
_cons	-6.029623	.2226231	-27.08	0.000	-6.465956	-5.59329
/lnalpha	-.3519959	.0498255			-.4496521	-.2543397
alpha	.703283	.0350414			.63785	.7754284

```
Likelihood-ratio test of alpha=0:  chibar2(01) =  731.63 Prob>=chibar2 = 0.000
```

As observed in table 70, the overdispersion parameter is reduced to 0.70 from 1.21, and the ADT parameter is reduced to 0.48 from 0.68. As expected, none of the variables are elastic even though they are statistically significant.

Table 71. Type 2 SPFs for Severe Injury Intersection Crashes.

```
Fitting constant-only model:

Iteration 0:   log likelihood = -14524.272
Iteration 1:   log likelihood =  -14515.77
Iteration 2:   log likelihood = -14513.255
Iteration 3:   log likelihood = -14513.248
Iteration 4:   log likelihood = -14513.248

Fitting full model:

Iteration 0:   log likelihood = -13969.336
Iteration 1:   log likelihood = -13894.467
Iteration 2:   log likelihood = -13894.075
Iteration 3:   log likelihood = -13894.073
Iteration 4:   log likelihood = -13894.073

Negative binomial regression                      Number of obs   =     103169
                                                  LR chi2(15)     =    1238.35
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -13894.073                       Pseudo R2       =     0.0427
```

severe	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.340603	.0239305	14.23	0.000	.2937001	.387506
lncrossv	.0304938	.0551994	0.55	0.581	-.0776951	.1386826
maxlt_os_wi	.014648	.0049763	2.94	0.003	.0048946	.0244014
mindes_sp	.0042404	.0016427	2.58	0.010	.0010209	.00746
rmedhov	-.2858256	.0872508	-3.28	0.001	-.456834	-.1148172
mepave	.0912087	.0443896	2.05	0.040	.0042067	.1782107
meconcb	-.4291794	.1529403	-2.81	0.005	-.7289369	-.1294218
tint	-.3809582	.0390626	-9.75	0.000	-.4575195	-.3043969
nocontrol	-.6215784	.0991876	-6.27	0.000	-.8159826	-.4271742
stopcross	-.3792195	.0537873	-7.05	0.000	-.4846406	-.2737983
lightyes	-.2891426	.048956	-5.91	0.000	-.3850946	-.1931905
mainltcurb	.2367462	.065936	3.59	0.000	.107514	.3659784
mainltpaint	.3079781	.0459114	6.71	0.000	.2179934	.3979629
intltno	-.2315491	.057629	-4.02	0.000	-.3444998	-.1185984
int2wyeslt	.2467394	.0814967	3.03	0.002	.0870087	.40647
_cons	-6.758554	.452891	-14.92	0.000	-7.646204	-5.870904
/lnalpha	.0990606	.158704			-.2119935	.4101146
alpha	1.104133	.1752303			.80897	1.50699

```
Likelihood-ratio test of alpha=0:  chibar2(01) =   68.17 Prob>=chibar2 = 0.000
```

Table 72. Type 2 SPFs for Fatal Injury Intersection Crashes.

```
Fitting constant-only model:

Iteration 0:   log likelihood = -6377.0159  (not concave)
Iteration 1:   log likelihood = -6370.5597
Iteration 2:   log likelihood = -6370.3674
Iteration 3:   log likelihood = -6370.3637
Iteration 4:   log likelihood = -6370.3637

Fitting full model:

Iteration 0:   log likelihood = -6159.6606
Iteration 1:   log likelihood = -6128.3786
Iteration 2:   log likelihood = -6128.2766
Iteration 3:   log likelihood = -6128.2766

Negative binomial regression                      Number of obs   =     103169
                                                  LR chi2(16)     =     484.17
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -6128.2766                       Pseudo R2       =     0.0380
```

fatal	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.3545113	.0389932	9.09	0.000	.278086	.4309365
lncrossv	-.0813442	.0913421	-0.89	0.373	-.2603714	.0976829
maxlt_os_wi	.0207059	.0082615	2.51	0.012	.0045136	.0368982
minlt_is_wi	.0465175	.0182558	2.55	0.011	.0107368	.0822982
minrt_is_wi	-.0687279	.0194798	-3.53	0.000	-.1069077	-.0305482
minrt_os_wi	.0201465	.0093033	2.17	0.030	.0019123	.0383806
rmedhov	-.2773468	.139755	-1.98	0.047	-.5512615	-.0034321
mepave	.1511551	.075169	2.01	0.044	.0038265	.2984837
mestruc	.335986	.0993914	3.38	0.001	.1411825	.5307895
tint	-.3680556	.0653458	-5.63	0.000	-.4961311	-.2399802
nocontrol	-.7226715	.1791701	-4.03	0.000	-1.073838	-.3715046
stopcross	-.2193669	.1022055	-2.15	0.032	-.4196861	-.0190477
lightyes	-.5251565	.0807689	-6.50	0.000	-.6834607	-.3668523
mainltcurb	.4535416	.1071657	4.23	0.000	.2435006	.6635825
mainltpaint	.4026722	.0742647	5.42	0.000	.257116	.5482284
intmastyes	.3843168	.108325	3.55	0.000	.1720037	.5966299
_cons	-7.012168	.6888448	-10.18	0.000	-8.362279	-5.662057
/lnalpha	.6722018	.2914538			.1009628	1.243441
alpha	1.958545	.5708254			1.106235	3.467524

```
Likelihood-ratio test of alpha=0:  chibar2(01) =   23.17 Prob>=chibar2 = 0.000
```

The fatal overdispersion parameter is reduced to 1.96 from 2.69 in type 1 specification, while the ADT parameter drops to 0.34 from 0.49. None of the continuous geometric variables such as inside shoulder widths are elastic although they are statistically significant.

Ramp and ramp metering SPFs

Tables 73 and 74 show type 1 SPFs for the ramp network and ramp metering subnetworks.

Table 73. Type 1 SPFs for Ramps for Total Crashes, Property Damage Only, Complaint of Pain, Visible Injury, Severe Injury and Fatal Collisions.*

Injury Type	α	β	θ
Total Crashes	-5.25	0.66	0.94
PDO	-5.71	0.67	1.02
Complaint of Pain	-6.55	0.63	1.24
Visible	-6.74	0.56	1.13
Severe	-8.11	0.51	1.90
Fatal	-9.99	0.59	2.57

*All coefficients significant at 95% or better

α *is coefficient for constant (intercept)*

β *is coefficient for* $ln(ADT)$

θ *is overdispersion parameter*

Table 74. Type 1 SPFs for Ramp Metered Locations for Total Crashes, Property Damage Only, Complaint of Pain, Visible Injury, Severe Injury and Fatal Collisions.*

Injury Type	α	β	θ
Total Crashes	-5.17	0.65	0.72
PDO	-5.85	0.68	0.79
Complaint of Pain	-6.75	0.65	0.86
Visible	-6.38	0.51	0.75
Severe	-7.64	0.44	
Fatal	-8.76	0.40	

*All coefficients significant at 95% or better

α *is coefficient for constant (intercept)*

β *is coefficient for* $ln(ADT)$

θ *is overdispersion parameter*

As can be seen in tables 73 and 74, the overdispersion parameters tend to vary substantially between the all-ramps network and the ramp metered subnetwork. In particular, the severe and fatal type 1 SPFs for the ramp metered subnetwork do not follow a negative binomial, instead, a Poisson model. This appears to show that heterogeneity in the ramp metered subnetwork is minimal, perhaps due to the traffic control effects from the metering. Tables 75-80 show type 2 SPFs for the entire ramp network, consisting of basic ramp functionality and ADT. Tables 81-86 on the other hand show type 2 SPFs for ramp metered subnetwork, which includes ramp geometry, and HOV information as well.

Table 75. Type 2 SPFs for Ramps for Total Crashes.

```
Negative binomial regression                      Number of obs   =      81959
                                                  LR chi2(3)      =   24705.04
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -130461.24                       Pseudo R2       =     0.0865
```

totalcrashes	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6488936	.0045199	143.57	0.000	.6400348	.6577523
OnRamp	.5028575	.1978103	2.54	0.011	.1151565	.8905586
OffRamp	.9324096	.1977938	4.71	0.000	.5447409	1.320078
_cons	-5.906301	.2010779	-29.37	0.000	-6.300406	-5.512196
/lnalpha	-.1190781	.0100086			-.1386945	-.0994617
alpha	.8877385	.008885			.8704939	.9053246

```
Likelihood-ratio test of alpha=0:  chibar2(01) = 5.0e+04 Prob>=chibar2 = 0.000
```

Table 76. Type 2 SPFs for Ramps for PDO Crashes.

```
Negative binomial regression                      Number of obs   =      81959
                                                  LR chi2(3)      =   20287.91
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -108638.38                       Pseudo R2       =     0.0854
```

PDO	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6562919	.0051439	127.59	0.000	.6462101	.6663738
OffRamp	.4048062	.0102274	39.58	0.000	.3847608	.4248515
OntoOff	-.5690243	.3447068	-1.65	0.099	-1.244637	.1065886
_cons	-5.849856	.0458855	-127.49	0.000	-5.93979	-5.759922
/lnalpha	-.0309775	.0116516			-.0538142	-.0081407
alpha	.9694974	.0112962			.9476081	.9918924

```
Likelihood-ratio test of alpha=0:  chibar2(01) = 3.2e+04 Prob>=chibar2 = 0.000
```

As tables 75 and 76 show, the ADT variable remains statistically significant while being inelastic. The off-ramp functionality appears to be very strong for PDO crash collisions.

Table 77. Type 2 SPFs for Ramps for Complaint of Pain Crashes.

```
Negative binomial regression                      Number of obs   =     81959
                                                  LR chi2(3)      =   9522.55
Dispersion     = mean                             Prob > chi2     =    0.0000
Log likelihood = -58172.753                       Pseudo R2       =    0.0757
```

CP	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6130114	.007551	81.18	0.000	.5982117	.627811
OnRamp	1.458803	.5923893	2.46	0.014	.2977417	2.619865
OffRamp	1.945977	.5923614	3.29	0.001	.7849695	3.106984
_cons	-8.129116	.5954194	-13.65	0.000	-9.296116	-6.962115
/lnalpha	.1302532	.0218749			.087379	.1731273
alpha	1.139117	.0249181			1.09131	1.189017

Likelihood-ratio test of alpha=0: chibar2(01) = 6038.86 Prob>=chibar2 = 0.000

Table 78. Type 2 SPFs for Ramps for Visible Injury Crashes.

```
Negative binomial regression                      Number of obs   =     81959
                                                  LR chi2(1)      =   4080.20
Dispersion     = mean                             Prob > chi2     =    0.0000
Log likelihood = -35168.179                       Pseudo R2       =    0.0548
```

Visible	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.5601032	.0096531	58.02	0.000	.5411833	.579023
_cons	-6.743783	.0871005	-77.43	0.000	-6.914496	-6.573069
/lnalpha	.1250341	.0415398			.0436177	.2064506
alpha	1.133187	.0470723			1.044583	1.229307

Likelihood-ratio test of alpha=0: chibar2(01) = 1448.69 Prob>=chibar2 = 0.000

As observed in table 78, the lack of geometric or non-ADT effects renders the visible injury type 2 SPF to be the same as the type 1 functional form. Complaint of pain however is influenced by both off and on ramp functionalities significantly.

Table 79. Type 2 SPFs for Ramps for Severe Injury Crashes.

```
Negative binomial regression                    Number of obs   =     81959
                                                LR chi2(2)      =    753.58
Dispersion     = mean                           Prob > chi2     =    0.0000
Log likelihood = -9209.2216                     Pseudo R2       =    0.0393
```

Severe	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.4721863	.0213066	22.16	0.000	.4304262	.5139464
OnRamp	13.51002	.192909	70.03	0.000	13.13192	13.88811
OffRamp	13.95382	.1942049	71.85	0.000	13.57318	14.33445
_cons	-21.54248	.	.	.	.	.
/lnalpha	.574361	.1619652			.2569151	.891807
alpha	1.775995	.2876494			1.292935	2.439534

```
Likelihood-ratio test of alpha=0:  chibar2(01) =   93.59 Prob>=chibar2 = 0.000
Warning: convergence not achieved
```

Table 80. Type 2 SPFs for Ramps for Fatal Injury Crashes.

```
Negative binomial regression                    Number of obs   =     81959
                                                LR chi2(2)      =    314.17
Dispersion     = mean                           Prob > chi2     =    0.0000
Log likelihood = -3530.3937                     Pseudo R2       =    0.0426
```

Fatal	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.566802	.0393387	14.41	0.000	.4896995	.6439045
OnRamp	14.02448	.36046	38.91	0.000	13.31799	14.73097
OffRamp	14.56547	.3628027	40.15	0.000	13.85439	15.27655
_cons	-24.15179	.	.	.	.	.
/lnalpha	.8866192	.3550369			.1907597	1.582479
alpha	2.426911	.8616429			1.210169	4.867005

```
Likelihood-ratio test of alpha=0:  chibar2(01) =   23.70 Prob>=chibar2 = 0.000
Warning: convergence not achieved
```

As noticed in tables 79 and 80, model convergence was not achieved for severe and fatal injury collisions. This is most likely due to sparsity of crash counts at numerous ramp sites, due to the severity issue in question. It would therefore be reasonable to use the visible injury SPF as the default type 2 SPF for severe and fatal injury collisions for all ramps.

Tables 81-86 show the type 2 SPFs for the ramp metered subnetwork.

Table 81. Type 2 SPFs for Ramp Metered Locations for Total Crashes.

Negative binomial regression		Number of obs	=	4900
		LR chi2(5)	=	1129.54
Dispersion	= mean	Prob > chi2	=	0.0000
Log likelihood = -8259.8383		Pseudo R2	=	0.0640

TotalCrashes	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6641019	.0258991	25.64	0.000	.6133406	.7148631
ofLanes	.3281783	.0330524	9.93	0.000	.2633967	.3929599
connector	-.6020613	.0490803	-12.27	0.000	-.6982569	-.5058656
coldist	-.5602787	.0958969	-5.84	0.000	-.748233	-.3723243
hovmeter	-.3144367	.0528187	-5.95	0.000	-.4179593	-.210914
_cons	-5.705457	.2166421	-26.34	0.000	-6.130068	-5.280846
/lnalpha	-.4653664	.0454081			-.5543646	-.3763682
alpha	.627905	.028512			.5744372	.6863496

Likelihood-ratio test of alpha=0: chibar2(01) = 1654.30 Prob>=chibar2 = 0.000

Table 81 shows the type 2 SPF for all total crashes for the ramp metered subnetwork. As is observed in the table, the number of lanes variable is the capacity related factor, while the connector, collector-distributor dummies capture the ramp geometry. The metered HOV dummy captures high occupancy effects. The number of lanes variable is not elastic, with an elasticity equal to 0.64. The ADT variable is also inelastic with an elasticity of 0.66.

Tables 82 and 83 show the type 2 SPFs for PDO and complaint of pain collisions for the ramp metered subnetwork. As can be seen in the tables, the statistical significance of the number of lanes and ramp geometry variables remains strong; however, the magnitudes are still in the inelastic range. The ADT variable continues to operate in the 0.70 elasticity range.

Table 82. Type 2 SPFs for Ramp Metered Locations for PDO Crashes.

```
Negative binomial regression                      Number of obs   =       4900
                                                  LR chi2(6)      =     981.19
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -6977.3948                       Pseudo R2       =     0.0657
```

PDO	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6983929	.029612	23.58	0.000	.6403544	.7564313
ofLanes	.3506135	.0371636	9.43	0.000	.2777741	.4234528
connector	-.5644273	.0565581	-9.98	0.000	-.6752791	-.4535754
coldist	-.4838733	.1065081	-4.54	0.000	-.6926253	-.2751213
loop	.0926589	.0467163	1.98	0.047	.0010966	.1842212
hovmeter	-.3084664	.0589081	-5.24	0.000	-.4239242	-.1930086
_cons	-6.441491	.2494287	-25.82	0.000	-6.930362	-5.95262
/lnalpha	-.4008168	.0536339			-.5059373	-.2956962
alpha	.6697728	.0359225			.6029402	.7440134

Likelihood-ratio test of alpha=0: chibar2(01) = 1032.71 Prob>=chibar2 = 0.000

Table 83. Type 2 SPFs for Ramp Metered Locations for Complaint of Pain Crashes.

```
Negative binomial regression                      Number of obs   =       4900
                                                  LR chi2(6)      =     424.63
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -3652.0258                       Pseudo R2       =     0.0549
```

CP	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.6911846	.0467713	14.78	0.000	.5995145	.7828547
ofLanes	.2336579	.0558695	4.18	0.000	.1241556	.3431601
connector	-.9019132	.0938358	-9.61	0.000	-1.085828	-.7179983
coldist	-.7202889	.1703086	-4.23	0.000	-1.054088	-.3864901
hook	-.2982828	.1312783	-2.27	0.023	-.5555834	-.0409821
hovmeter	-.2982878	.089538	-3.33	0.001	-.4737791	-.1227965
_cons	-7.313816	.3930371	-18.61	0.000	-8.084155	-6.543478
/lnalpha	-.2803495	.1137273			-.5032509	-.057448
alpha	.7555196	.0859232			.6045621	.9441709

Likelihood-ratio test of alpha=0: chibar2(01) = 152.75 Prob>=chibar2 = 0.000

Table 84. Type 2 SPFs for Ramp Metered Locations for Visible Injury Crashes.

```
Negative binomial regression                      Number of obs   =       4900
                                                  LR chi2(5)      =     144.53
Dispersion     = mean                             Prob > chi2     =     0.0000
Log likelihood = -2020.6507                       Pseudo R2       =     0.0345
```

Visible	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
lnadt	.4862228	.0635088	7.66	0.000	.3617479	.6106978
ofLanes	.3950526	.0788215	5.01	0.000	.2405653	.54954
connector	-.3332938	.1177001	-2.83	0.005	-.5639818	-.1026058
coldist	-.7095001	.2712138	-2.62	0.009	-1.241069	-.1779308
hovmeter	-.430329	.1308323	-3.29	0.001	-.6867555	-.1739025
_cons	-6.743953	.530995	-12.70	0.000	-7.784684	-5.703222
/lnalpha	-.7304997	.3443324			-1.405379	-.0556205
alpha	.4816682	.165854			.2452741	.945898

Likelihood-ratio test of alpha=0: chibar2(01) = 12.31 Prob>=chibar2 = 0.000

Table 85. Type 2 SPFs for Ramp Metered Locations for Severe Injury Crashes.

```
Poisson regression                                Number of obs   =       4900
                                                  LR chi2(4)      =      30.24
                                                  Prob > chi2     =     0.0000
Log likelihood = -508.35183                       Pseudo R2       =     0.0289
```

Severe	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
lnadt	.3154588	.1374426	2.30	0.022	.0460763	.5848414
ofLanes	.3199715	.1911302	1.67	0.094	-.0546368	.6945798
hook	1.170044	.2650076	4.42	0.000	.6506386	1.689449
hovmeter	-.794243	.3797733	-2.09	0.036	-1.538585	-.049901
_cons	-7.102819	1.147123	-6.19	0.000	-9.351139	-4.854499

Table 86. Type 2 SPFs for Ramp Metered Locations for Fatal Injury Crashes.

```
Poisson regression                          Number of obs   =       6080
                                            LR chi2(1)      =       3.11
                                            Prob > chi2     =     0.0778
Log likelihood = -203.58165                 Pseudo R2       =     0.0076
```

Fatal	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnadt	.4042716	.2396838	1.69	0.092	-.0655001	.8740432
_cons	-8.760081	2.136095	-4.10	0.000	-12.94675	-4.573412

As can be noticed in tables 85 and 86, type 2 SPFs for severe and fatal injuries follow the Poisson model. The fatal injury SPF is the same as the type 1 SPF with no geometric or traffic control effects found to be statistically significant.

Model Transferability and Predictions

Three issues are relevant for post-estimation evaluation of the type 2 SPFs: Model checking via specification search, parameter stability via structural change tests, and predictive effectiveness via out of sample tests.

Specification: Several factors affect specification searches. Functional forms are usually tested in the safety community via cumulative residual plots. However, this method has significant limitations. It assumes apriori that the model contains numerous continuous variables, whose functional forms can be tested alternatively. In the current set of models that have been developed for this study, a majority of the variables are dummy types. Second, CURE plots do not address the issue of omitted variable bias. Omitted variable bias can arise when a variable that should be in the model is excluded, and the excluded variable share correlations with included variables in the model. When unobserved effects are significant in the models, the potential for omitted variable bias is non trivial and the CURE plot approach does not resolve the problem. It is important to note that including irrelevant variables in the models in order to enrich type 2 SPFs will cause inefficiency in the parameter estimates. Another issue that is significant in a multi-year panel of crash data such as the one used in this study is the effect of time. It has been noted repeatedly in several of the type 2 SPFs that year dummies are significant. In fact, years 2006-2010 appear to be negatively signed. This shows that year 2005 is a significant threshold for structural change. Further, when such time dummies are evaluated in concert with spatial dummies such as route and county dummies, the evaluation of type 2 SPFs in terms of model transferability becomes complex. In order to proceed step by step to evaluate whether model transferability is possible, we evaluate six year models (2005-2010) against a two year model (2011-2012) to see if parameters are stable and transferable. We then evaluate the predictive effectiveness using methods involving changes in outcomes, and measures of effectiveness such as root mean square, mean squared error and mean absolute percentage error.

Figure 17 shows the conceptual basis of parameter stability via structural change tests.

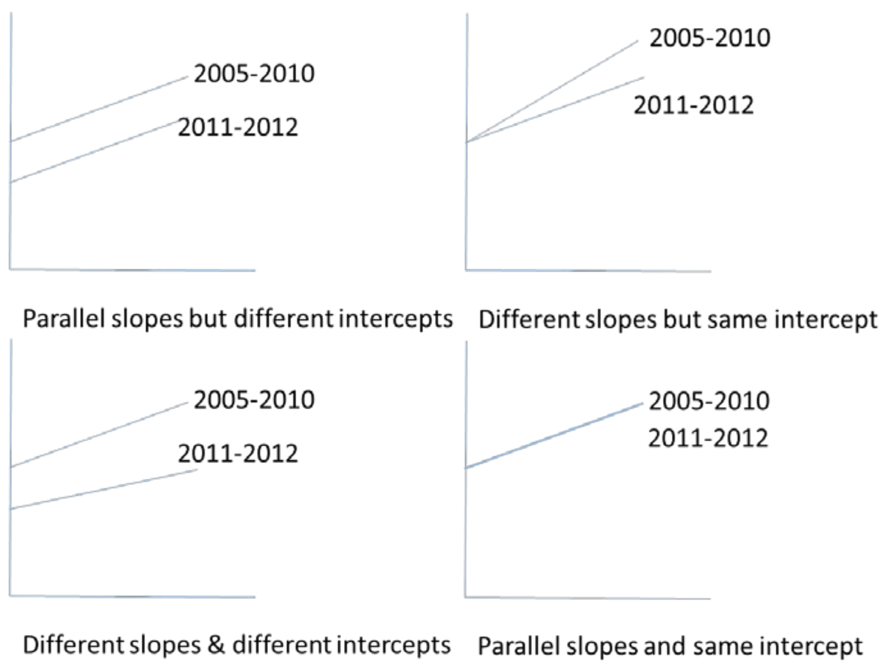


Figure 17. Concepts of parameter stability.

As figure 17 shows, the year 2005-2010 and 2011-2012 models have slopes (non intercept coefficients) that remain stable in the top left scenario. The intercepts are however statistically dissimilar. In the top right scenario, the intercepts are same, but the slopes are statistically dissimilar. This is a rare scenario, since unobserved effects are usually significant. In the bottom right scenario, the slopes and intercepts are statistically similar, which would imply a model developed on 2005-2010 data is completely transferable to 2011-2012. The bottom left scenario is one where neither the intercept nor the slope is transferable. This is a common occurrence in models with limited specifications and where unobserved effects are significant. Omitted variable effects can amplify the likelihood of this scenario.

To test if the models are transferable, we use likelihood based ratio tests. In this type of testing, a fully specified model is estimated on a 2005-2010 dataset, and an independent model with same exact specification is estimated on a 2011-2012 dataset. Then, a pooled model is estimated using the combined 2005-2012 dataset. The likelihood ratio evaluating the difference in likelihoods between the pooled model and the sum of the independent likelihoods is computed according to the following formula: $LR = -(LL_{pooled} - LL_{2005-2010} - LL_{2011-2012}) \sim \chi^2$. The LR statistic is chi-squared distributed with k degrees of freedom where k is the number of parameters being evaluated for a given model. If the computed chi-squared exceeds the chi-squared value for 99% confidence, then, this will indicate that the models are not transferable. This test does not indicate which parameters are not transferable, it indicates if the model as a whole is transferable.

Architecture of the LR test: Since we have 10 SPF classes, and two data periods (2005-2010 versus 2011-2012), we need to estimate a pooled model and two unrestricted models, involving six injury classes including total, PDO, complaint of pain, visible, severe and fatal types. Thus, we have 18 models to be evaluated for each SPF class, resulting in a total of 180 LR tests.

Tables 87-92 shows the results of completed transferability tests.

Table 87. Rural 2-Lane Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Rural 2-lane	Total crashes	-13,664.1610	-4,015.9599	-17,710.4993	60.7567 (10)	23.209	No
	PDO	-8,930.2250	-2,774.9197	-11,716.9971	23.7048 (11)	24.725	Yes
	Complaint of Pain	-4,145.2708	-1,066.0194	-5,230.5145	38.4485 (10)	23.209	No
	Visible	-5,125.4062	-1,292.8470	-6,452.2480	67.9896 (13)	27.688	No
	Severe	-2,577.6148	-631.4126	-3,231.6818	45.3088 (8)	20.090	No
	Fatal	-3,743.5954	-989.8000	-4,748.5378	30.2849 (5)	15.086	No

As table 87 shows, with the exception of PDO type 2 SPFs, none of the other SPFs are transferable at the 99% confidence level. The computed LRs exceed the threshold values. Table 88 shows LR tests for rural 4-lane roadways, and it will be noted that the degree to which the computed LRs exceed the threshold values is far greater than that seen in table 87. This shows that the effect of unobservable is greater in rural 4-lane roadway datasets, and specification searches need to incorporate alignment data to reduce the effect of unobservables. Tables 89 and 90 on the other hand show conformant results for rural 4-plus-lane and rural multilane undivided datasets, where all models appear transferable at the 99% confidence level. Clearly, the heterogeneity in four-lane rural datasets appears to indicate a need for richer specifications, and to a lesser degree in rural two-lane datasets as well. The LR conformity of rural multilane undivided models is very strong, and it can be said that the parameter transferability in these type 2 SPFs as well as the rural 4-plus-lane models is supported.

Table 88. Rural 4-Lane Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Rural 4-lane	Total crashes	-45,699.9296	-13,130.7370	-58,973.2750	285.217 (22)	40.289	No
	PDO	-33,934.4651	-10,191.3363	-44,171.3646	91.127 (17)	33.409	No
	Complaint of Pain	-15,728.3478	-3,853.6889	-19,661.6226	159.172 (22)	40.289	No
	Visible	-15,760.6671	-3,842.0416	-19,715.0042	224.591 (14)	29.141	No
	Severe	-7,015.6723	-1,632.8321	-8,692.4872	87.966 (13)	27.688	No
	Fatal	-3,976.0095	-1,080.5945	-5,071.2675	29.327 (11)	24.725	No

Table 89. Rural 4-Plus-Lane Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Rural 4-lane+	Total crashes	-1,952.5706	-608.4628	-2,563.5468	5.0268 (7)	18.475	Yes
	PDO	-1,596.8697	-511.3818	-2,111.4473	6.3918 (7)	18.475	Yes
	Complaint of Pain	-822.383	-248.0513	-1,073.4913	6.1136 (6)	16.812	Yes
	Visible	-628.7422	-173.0790	-809.5890	16.5359 (6)	16.812	Yes
	Severe	-224.5139	-56.5311	-284.9014	7.7128 (5)	15.086	Yes
	Fatal	-156.6279	-17.6786	-180.7079	12.8029 (4)	13.277	Yes

Table 90. Rural Multi-Lane Undivided Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Rural multi-lane undivided	Total crashes	-456.9856	-125.2096	-585.7976	7.2048 (5)	15.086	Yes
	PDO	-332.5129	-95.7896	-431.6370	6.669 (4)	13.277	Yes
	Complaint of Pain	-158.3293	-32.2450	-193.5053	5.862 (4)	13.277	Yes
	Visible	-140.7889	-33.3066	-174.7423	1.294 (4)	13.277	Yes
	Severe	-55.9319	-18.2916	-74.4744	0.502 (3)	11.345	Yes
	Fatal	-13.1250	-9.0283	-23.3062	2.306 (3)	11.345	Yes

Tables 91-96 show LR tests for urban roadways. As seen in the tables, the urban 2-lane, urban 4-lane type 2 SPF and 5-6-7-lane type 2 are not transferable.

Table 91. Urban Two-Lane Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Urban 2-lane	Total crashes	-33,385.0459	-9,186.1428	-42,679.7243	217.071 (26)	45.642	No
	PDO	-25,220.1403	-7,124.7801	-32,394.2816	98.722 (12)	26.217	No
	Complaint of Pain	-13,021.8657	-3,205.8793	-16,284.7527	114.016 (13)	27.688	No
	Visible	-10,121.9253	-2,347.5005	-12,537.0472	135.243 (9)	21.666	No
	Severe	-4,181.9138	-997.9119	-5,200.2836	40.916 (9)	21.666	No
	Fatal	-2,104.4312	-578.7360	-2,692.1899	18.045 (5)	15.086	No

Table 92. Urban Four-Lane Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Urban 4-lane	Total crashes	-71,386.815	-21,302.093	-92,855.500	333.185 (41)	64.950	No
	PDO	-59,022.401	-18,102.652	-77,196.922	143.737 (24)	42.980	No
	Complaint of Pain	-34,245.727	-9,226.452	-46,797.426	301.656 (24)	42.980	No
	Visible	-23,657.406	-5,951.664	-29,792.503	366.866 (15)	30.578	No
	Severe	-8,412.667	-2,131.363	-10,580.435	72.810 (6)	16.812	No
	Fatal	-4,544.059	-1,207.019	-5,765.071	27.988 (5)	15.086	No

Table 93. Urban Five-Six-Seven-Lane Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Urban 567-lane	Total crashes	-57,576.4424	-17,360.2688	-75,091.5974	309.5723 (16)	32.000	No
	PDO	-49,500.0096	-15,064.6861	-64,654.0828	178.7743 (13)	27.688	No
	Complaint of Pain	-30,599.1225	-8,707.1146	-39,454.2323	295.9904 (14)	29.141	No
	Visible	-20,858.3952	-5,371.7097	-26,440.3498	420.4898 (12)	26.217	No
	Severe	-7,332.6969	-1,797.7764	-9,180.9979	101.0492 (8)	20.090	No
	Fatal	-3,743.5954	-989.8000	-4,748.5378	30.2849 (6)	16.812	No

Table 94. Urban Eight-Plus-Lane Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Urban 8+lane	Total crashes	-104,537.448	-31,878.033	-133,936.800	-4,957.361 (22)	40.289	Yes
	PDO	-91,206.809	-28,918.755	-120,214.959	178.792 (18)	34.805	No
	Complaint of Pain	-58,806.475	-17,420.954	-76,515.482	576.113 (12)	26.217	No
	Visible	-40,076.127	-10,778.084	-51,291.185	873.947 (13)	27.688	No
	Severe	-14,190.365	-37,78.948	-18,038.467	138.309 (10)	23.209	No
	Fatal	-6,910.729	-1,920.355	-8,848.216	34.266 (6)	16.812	No

Table 95. Urban Multi-Lane Undivided Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Urban multilane undivided	Total crashes	-5,900.454	-1,501.294	-7,433.833	64.171 (10)	23.209	No
	PDO	-4,621.383	-1,152.592	-5,798.798	49.645 (8)	20.090	No
	Complaint of Pain	-2,386.941	-534.881	-2,940.582	37.521 (9)	21.666	No
	Visible	-1,631.950	-358.688	-2,002.959	24.642 (5)	15.086	No
	Severe	-579.953	-121.538	-710.157	17.331 (9)	21.666	Yes
	Fatal	-301.391	-98.496	-404.255	8.736 (6)	16.812	Yes

Table 96. Urban Multi-Lane Divided Transferability Test by Severity.

SPF Class	Model	2005-2010 Log-L	2011-2012 Log-L	2005-2012 Log-L	LL-Ratio (Degrees of freedom)	99% Chi-Squared	2005-10 Model Transferable to 2011-2012?
Urban multilane divided	Total crashes	-25,444.032	-68,83.470	-32,434.473	213.942 (16)	32.000	No
	PDO	-19,685.438	-5,363.828	-25,119.110	139.688 (14)	29.141	No
	Complaint of Pain	-12,209.096	-2,915.073	-15,220.436	192.534 (19)	36.191	No
	Visible	-7,089.176	-1,629.127	-8,768.452	100.298 (12)	26.217	No
	Severe	-2,187.033	-598.620	-2,792.876	14.446 (6)	16.812	Yes
	Fatal	-1,237.860	-347.819	-1,590.157	8.957 (3)	11.345	Yes

Tables 97-98 show the out of sample prediction tests using estimated type 2 SPF predictions (from 2005-2010) of 2011 data.

Table 97. Prediction Measures of Effectiveness for 2011 Out of Estimation Sample Predictions by Rural SPF Class.

		Type 1 SPF			Type 2 SPF		
SPF Class	Outcome	MAD	MAPE	RMSE	MAD	MAPE	RMSE
2-Lane	Total	0.363	182.926	0.814	0.329	182.538	0.618
	PDO	0.196	191.448	0.241	0.187	191.345	0.205
	CPAIN	0.082	198.104	0.061	0.078	197.975	0.055
	VISIBLE	0.112	197.173	0.102	0.105	197.068	0.090
	SEVERE	0.048	199.393	0.032	0.046	199.277	0.030
	FATALITY	0.017	199.877	0.009	0.017	199.846	0.009
4-Lane	Total	0.649	172.971	4.608	0.588	172.142	4.948
	PDO	0.415	181.954	1.862	0.386	181.432	2.346
	CPAIN	0.146	194.641	0.193	0.143	194.278	0.262
	VISIBLE	0.147	194.472	0.171	0.141	194.165	0.153
	SEVERE	0.050	199.040	0.033	0.049	195.778	0.032
	FATALITY	0.026	199.571	0.015	0.026	196.674	0.015
4+Lane	Total	4.065	161.718	85.321	1.867	151.317	22.727
	PDO	2.844	167.015	43.561	1.270	159.198	8.196
	CPAIN	0.785	183.312	0.933	0.431	181.822	0.863
	VISIBLE	0.253	184.062	0.259	0.256	183.679	0.269
	SEVERE	0.061	198.471	0.037	0.060	198.255	0.037
	FATALITY	0.018	199.893	0.009	0.018	193.519	0.009
Multi-Lane Undivided	Total	0.351	173.436	0.315	0.350	173.862	0.308
	PDO	0.256	184.542	0.172	0.252	184.553	0.173
	CPAIN	0.072	199.312	0.038	0.070	199.363	0.036
	VISIBLE	0.085	197.832	0.049	0.077	196.931	0.041
	SEVERE	0.065	199.260	0.051	0.064	173.093	0.051
	FATALITY	0.033	199.619	0.017	0.032	159.564	0.017

The measures of effectiveness are useful due to their particular implications in terms of predictive capability out of sample. Mean absolute deviation is meaningful when cost of forecast error is proportional to the absolute size of the error. Mean absolute percent error is meaningful when cost of error is related to percent than numerical size of error. Mean squared error (and root mean squared error) are meaningful in a quadratic loss function manner – they tend to weight large errors heavily compared to small errors.

By these definitions, type 2 SPFs are comparatively better than type 1 SPFs in both 2011 and 2012 out of sample predictions.

Table 98. Prediction Measures of Effectiveness for 2011 Out of Estimation Sample Predictions by Urban SPF Class.

		Type 1 SPF			Type 2 SPF		
SPF Class	Outcome	MAD	MAPE	RMSE	MAD	MAPE	RMSE
	Total	0.985	171.631	50.621	0.834	170.642	29.606
	PDO	0.612	181.724	17.342	0.527	181.090	10.138
2-Lane	CPAIN	0.241	193.626	1.888	0.221	193.587	1.273
	VISIBLE	0.156	195.733	0.531	0.143	195.575	0.237
	SEVERE	0.058	199.063	0.067	0.055	198.936	0.047
	FATALITY	0.019	199.857	0.014	0.019	196.172	0.014
	Total	2.787	144.272	54.395	2.279	140.669	47.924
	PDO	1.806	154.505	22.103	1.544	151.902	19.133
4-Lane	CPAIN	0.649	175.235	2.480	0.592	174.282	2.778
	VISIBLE	0.305	184.334	0.478	0.304	182.942	0.518
	SEVERE	0.088	197.244	0.061	0.088	197.275	0.061
	FATALITY	0.036	199.465	0.021	0.036	199.467	0.021
	Total	4.545	117.315	148.094	4.072	115.691	117.590
	PDO	3.089	128.563	68.133	2.563	128.995	47.504
5,6,&7-Lane	CPAIN	1.225	153.713	8.739	1.129	152.579	7.567
	VISIBLE	0.502	171.079	1.267	0.485	170.840	1.082
	SEVERE	0.129	193.943	0.100	0.128	193.020	0.098
	FATALITY	0.062	198.606	0.043	0.058	178.374	0.045
	Total	7.608	89.172	219.397	7.250	87.956	201.322
	PDO	5.599	98.499	120.225	5.403	97.552	113.398
8+Lane	CPAIN	1.885	119.225	13.269	1.836	118.994	12.484
	VISIBLE	0.767	143.822	1.659	0.754	143.634	1.586
	SEVERE	0.228	189.159	0.182	0.227	189.161	0.181
	FATALITY	0.086	197.857	0.051	0.086	197.835	0.051
	Total	1.641	163.951	16.488	1.304	162.028	9.058
	PDO	1.009	176.216	5.859	0.833	175.002	3.616
Multi-Lane	CPAIN	0.492	187.118	1.831	0.378	186.024	0.740
Divided	VISIBLE	0.179	194.777	0.202	0.170	194.774	0.167
	SEVERE	0.045	199.283	0.027	0.045	199.313	0.026
	FATALITY	0.023	199.710	0.013	0.023	199.711	0.013

Tables 99 and 100 show the out of sample prediction measures of effectiveness for year 2012 datasets. The patterns observed are similar to the ones shown in tables 97-98.

Table 99. Prediction Measures of Effectiveness for 2012 Out of Estimation Sample Predictions by Rural SPF Class.

		Type 1 SPF			Type 2 SPF		
SPF Class	Outcome	MAD	MAPE	RMSE	MAD	MAPE	RMSE
2-Lane	Total	0.285	186.925	0.441	0.267	186.733	0.354
	PDO	0.203	191.965	0.241	0.189	192.088	0.201
	CPAIN	0.047	199.404	0.029	0.045	198.859	0.028
	VISIBLE	0.054	198.937	0.032	0.051	195.333	0.029
	SEVERE	0.021	199.853	0.011	0.021	199.793	0.011
	FATALITY	0.018	199.903	0.010	0.018	199.900	0.010
4-Lane	Total	0.516	176.828	2.393	0.491	176.226	3.992
	PDO	0.395	182.517	1.350	0.380	182.208	2.525
	CPAIN	0.083	197.774	0.077	0.082	197.532	0.092
	VISIBLE	0.082	197.833	0.066	0.080	197.713	0.062
	SEVERE	0.032	199.534	0.019	0.032	199.499	0.019
	FATALITY	0.025	199.608	0.013	0.024	199.557	0.013
4+Lane	Total	4.33	160.640	100.284	2.031	146.475	53.929
	PDO	3.079	162.567	52.214	1.421	153.194	35.471
	CPAIN	0.870	193.412	3.741	8.202	189.027	147.548
	VISIBLE	0.189	194.583	0.382	0.163	188.799	0.223
	SEVERE	0.073	197.798	0.042	0.074	197.778	0.043
	FATALITY	0.018	199.880	0.009	0.017	193.499	0.009
Multi-Lane Undivided	Total	0.331	182.687	0.392	0.335	183.086	0.397
	PDO	0.243	188.133	0.201	0.244	188.134	0.201
	CPAIN	0.064	198.945	0.033	0.063	198.847	0.032
	VISIBLE	0.080	199.331	0.075	0.080	188.848	0.075
	SEVERE	0.095	197.876	0.134	0.036	187.786	0.026
	FATALITY	0.017	199.233	0.034	0.024	198.763	0.029

Table 100. Prediction Measures of Effectiveness for 2012 Out of Estimation Sample Predictions by Urban SPF Class.

		Type 1 SPF			Type 2 SPF		
SPF Class	Outcome	MAD	MAPE	RMSE	MAD	MAPE	RMSE
2-Lane	Total	0.772	176.881	28.989	0.652	175.569	15.568
	PDO	0.562	182.440	13.759	0.492	181.999	7.912
	CPAIN	0.125	197.061	0.449	0.117	197.110	0.269
	VISIBLE	0.086	197.962	0.179	0.083	197.936	0.099
	SEVERE	0.027	199.740	0.023	0.026	199.727	0.018
	FATALITY	0.023	199.727	0.019	0.023	199.720	0.017
4-Lane	Total	2.158	147.628	32.391	1.794	144.563	28.128
	PDO	1.643	154.587	18.288	1.407	152.043	16.056
	CPAIN	0.383	184.471	0.862	0.365	184.289	0.943
	VISIBLE	0.189	191.143	0.196	0.189	189.874	0.211
	SEVERE	0.057	198.667	0.035	0.057	198.685	0.035
	FATALITY	0.039	199.253	0.022	0.038	199.214	0.022
5,6,& 7-Lane	Total	3.713	121.092	98.097	3.413	119.816	80.938
	PDO	2.871	127.901	59.537	2.730	127.264	55.711
	CPAIN	0.728	168.154	2.894	0.683	167.410	2.440
	VISIBLE	0.350	181.174	0.633	0.344	181.085	0.579
	SEVERE	0.092	196.763	0.064	0.093	196.807	0.064
	FATALITY	0.053	198.857	0.032	0.052	198.791	0.032
8+Lane	Total	6.401	91.771	155.451	6.228	90.730	157.301
	PDO	5.311	97.281	106.661	5.189	96.332	111.583
	CPAIN	1.174	136.208	4.755	1.152	136.266	4.540
	VISIBLE	0.515	163.924	0.746	0.509	163.973	0.736
	SEVERE	0.143	195.246	0.102	0.143	194.696	0.102
	FATALITY	0.084	197.864	0.053	0.083	197.837	0.052
Multi-Lane Divided	Total	1.203	169.296	8.162	0.999	167.366	5.963
	PDO	0.883	178.470	4.382	0.761	177.261	3.349
	CPAIN	0.248	193.240	0.357	0.217	187.978	0.283
	VISIBLE	0.109	197.396	0.098	0.104	197.327	0.088
	SEVERE	0.032	199.632	0.017	0.032	199.658	0.017
	FATALITY	0.016	199.873	0.009	0.016	199.874	0.009
Multi-Lane Undivided	Total	0.944	174.736	6.700	0.799	174.132	4.267
	PDO	0.692	181.997	3.595	0.580	176.802	2.123
	CPAIN	0.192	197.738	0.242	0.178	197.814	0.205
	VISIBLE	0.082	198.982	0.062	0.081	174.681	0.061
	SEVERE	0.016	199.886	0.008	0.016	170.016	0.008
	FATALITY	0.026	199.840	0.013	0.024	162.126	0.013

Conclusions and Recommendations

An evaluation of the type 1 and type 2 SPFs for roadway segments indicates that segment length based on homogeneous geometry results in a large proportion of segments under the length of 0.1 mile. This implies that network screening should be conducted at the 0.1-mile interval, instead of at higher intervals. It is also our finding that re-defining segment lengths to minimize sensitivity to network screening outcomes from Safety Analyst is a complex decision making process, since it affects model building in a cyclical fashion. When models are built on the assumption of homogeneous geometry, and network screening dictates that only a subset of geometry be used for segment definitions, then, the variable definition process in the model building stage (especially for type 2 SPFs) becomes complicated, due to some variables being homogeneous and some being weighted values or values with ranges. This can induce heteroskedasticity and therefore bias the inference on standard errors in the model.

It was also determined that roadway segment models suffer from omitted variable effects due to the absence of alignment data. Alignment data can have substantial interactions with capacity variables and therefore, can help capture heterogeneities that otherwise are subsumed in the overdispersion parameter. As a result, the elasticities of the variables included in the models without alignment information can be over-estimated. For example, design speed was found to be a significant and elastic effect in several of the type 2 SPF models. Design speed may be a proxy for alignment effects, since design speed is used in the implementation of horizontal and vertical curvature on roadway segments. Future work is therefore required in detail to collect and assemble alignment geometry to provide for further resolution in the type 2 SPFs. This information can have substantial policy implications due to the fact that design speed is implicated by their absence.

An evaluation of intersection SPFs indicated that roadway geometry and traffic control have substantial impacts on intersection crash propensities on the mainline. This study did not use cross street crash data since that was not available; it can be inferred therefore, that the complexity of the mainline-cross street crash phenomena is only partly understood through the type 2 SPFs developed in this study. The fact that a rich set of variables was derived on the basis of mainline crash information indicates that more complex models can provide richer insight into the correlative aspects of mainline and cross street crash patterns. This in turn would shed light on the relative importance of road geometry and traffic control and help enhance intersection design policy issues with respect to safety.

An evaluation of the ramp network indicated that ramp configuration is not available – the length of ramps in particular, the geometry of the ramps in addition and the availability of ramp alignment information. Such information is highly valuable for thorough ramp analysis because it will allow for a comparative analysis of which ramps can benefit from ramp metering from an integrated operations-safety standpoint. An evaluation of the ramp metered subnetwork confirms this expectation since the heterogeneity parameter in the ramp metered subnetwork appears to be significantly subdued due to ramp metering operational effects.

Model transferability tests conducted on roadway datasets appear to indicate that unobserved effects remain in the models. In spite of these unobserved effects, the predictive effectiveness shown by type 2 SPFs compared to Type 1 SPFs is significant.

Table 101. Model Transferability with Varying Panels of Years.

SPF Class	Outcome	Rural			Urban		
		2006-2010 Model Transferable?	2007-10 Model Transferable?	2008-2010 Model Transferable	2006-2010 Model Transferable?	2007-10 Model Transferable?	2008-2010 Model Transferable
	Total	No	No	No	No	No	No
	PDO	Yes	No	No	No	No	No
2-Lane	CPAIN	No	No	No	No	No	No
	VISIBLE	No	No	No	No	No	No
	SEVERE	No	No	No	No	No	Yes
	FATALITY	No	Yes	Yes	No	No	No
	Total	No	No	No	No	No	No
	PDO	No	No	No	No	No	Yes
4-Lane	CPAIN	No	No	No	No	No	No
	VISIBLE	No	No	No	No	No	No
	SEVERE	No	No	No	No	No	No
	FATALITY	No	Yes	Yes	No	No	Yes
	Total	Yes	Yes	Yes			
	PDO	Yes	Yes	Yes			
4+Lane	CPAIN	Yes	Yes	Yes			
	VISIBLE	Yes	Yes	Yes			
	SEVERE	Yes	Yes	Yes			
	FATALITY	Yes	Yes	Yes			
	Total	Yes	Yes	Yes	No	No	No
	PDO	Yes	Yes	Yes	No	No	No
Multi-Lane	CPAIN	Yes	Yes	Yes	No	No	Yes
Undivided	VISIBLE	Yes	Yes	Yes	No	Yes	Yes
	SEVERE	Yes	Yes	Yes	Yes	Yes	Yes
	FATALITY	Yes	Yes	Yes	Yes	Yes	Yes
	Total				No	No	No
	PDO				No	No	No
5,6,7-Lane	CPAIN				No	No	No
	VISIBLE				No	No	No
	SEVERE				No	No	No
	FATALITY				No	No	Yes
	Total				Yes	No	No
	PDO				No	No	Yes
8-Lane	CPAIN				No	No	No
	VISIBLE				No	No	No
	SEVERE				No	No	No
	FATALITY				No	Yes	Yes
	Total				No	No	No
	PDO				No	No	No
Multi-Lane	CPAIN				No	No	No
Divided	VISIBLE				No	No	No
	SEVERE				Yes	Yes	Yes
	FATALITY				Yes	Yes	Yes

Environmental data is very challenging to collect on a statewide level, especially when one wishes to collect pavement level information. Economic effects at the SPF class level or route level are pose enormous data collection challenges. While it can be theorized that economic effects can influence driving exposure, as well as trip making behavior (for example, making more discretionary trips out of the home such as recreational and entertainment related), measuring aggregate manifestations of such effects at the route level or even district level is close to impossible. These unobserved effects can remain for several years. In the absence of environmental and economic data, consistent alignment information will mitigate the unobserved effects considerably, especially in terms of horizontal and vertical curvature information. In urban environments especially, alignment information can be critical due to the more frequent interactions between traffic flow and roadway geometry. Table 101 further emphasizes this point through the illustration of the longitudinal change in the likelihood ratio tests. In summary, on the basis of both transferability and predictive measures of effectiveness, it can be said that Type 2 SPFs offer far more effective decision making bases for identifying high collision concentrations than Type 1 SPFs.

All-Districts: Urban Multilane Divided SPF 2 – Total Fatalities

Poisson Regression	
Maximum Likelihood Estimates	
Model estimated: May 13, 2014 at 08:53:03PM.	
Dependent variable	TOTALFA
Weighting variable	None
Number of observations	2150
Iterations completed	9
Log likelihood function	-240.6025
Number of parameters	5
Info. Criterion: AIC =	.22847
Finite Sample: AIC =	.22848
Info. Criterion: BIC =	.24166
Info. Criterion:HQIC =	.23329
Restricted log likelihood	-306.0353
McFadden Pseudo R-squared	.2138082
Chi squared	130.8657
Degrees of freedom	4
Prob[ChiSqd > value] =	.0000000

```
Poisson Regression
Chi- squared =  2814.73811  RsqP=  -.0330
G  - squared =   359.91715  RsqD=   .2666
Overdispersion tests: g=mu(i)  :  1.123
Overdispersion tests: g=mu(i)^2:   .127
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Constant	-5.58618212	2.12473325	-2.629	.0086	
LOGADT	.39291266	.20367457	1.929	.0537	9.95892811
LOGLN	1.00000000	......(Fixed Parameter).......			
RT_OS_WI	-.09408215	.03809214	-2.470	.0135	7.39674419
RT123	1.34717687	.71969758	1.872	.0612	.04511628
RT62	.72464395	.40231558	1.801	.0717	.03953488

All-Districts: Urban Multilane Divided SPF 2 – Total Injuries

Normal exit from iterations. Exit status=0.

Negative Binomial Regression	
Maximum Likelihood Estimates	
Model estimated: May 13, 2014 at 08:59:14PM.	
Dependent variable	TOTALIN
Weighting variable	None
Number of observations	2150
Iterations completed	32
Log likelihood function	-3146.733
Number of parameters	22
Info. Criterion: AIC =	2.94766
Finite Sample: AIC =	2.94788
Info. Criterion: BIC =	3.00571
Info. Criterion:HQIC =	2.96890
Restricted log likelihood	-4225.331
McFadden Pseudo R-squared	.2552694
Chi squared	2157.196
Degrees of freedom	1
Prob[ChiSqd > value] =	.0000000
NegBin form 2; Psi(i) = theta	

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Constant	-6.68984854	.82381284	-8.121	.0000	
LOGADT	1.01634728	.07207555	14.101	.0000	9.95892811
LOGLN	1.00000000	......(Fixed Parameter)......			
LTLANES	.20432446	.10121756	2.019	.0435	2.15767442
LT_IS_WI	.09608650	.02378363	4.040	.0001	2.11302326
RT_IS_WI	-.10379896	.03037566	-3.417	.0006	2.14883721
DES_SP	-.03244610	.00409757	-7.918	.0000	55.0162791
METWTL	-.53981933	.11529251	-4.682	.0000	.18418605
MEPAVE	-.35452651	.10720673	-3.307	.0009	.26000000
MENPAVE	-.36426485	.13165506	-2.767	.0057	.27255814
MESTRUC	-1.72971530	.64801248	-2.669	.0076	.07906977
MEBRAIL	1.50259509	.59192446	2.538	.0111	.08139535
MENOBARR	.38884648	.19103362	2.035	.0418	.84558140
SCL	-.82829526	.15009363	-5.519	.0000	.07581395
VEN	1.17072277	.38958826	3.005	.0027	.03302326
RIV	-.42661215	.15390131	-2.772	.0056	.09488372
SBD	.51618293	.13935782	3.704	.0002	.08976744
MER	-.64612442	.25543134	-2.530	.0114	.04279070
IMP	-.65401482	.14402290	-4.541	.0000	.10790698
RT33	-1.61030294	.47997442	-3.355	.0008	.03116279
RT18	-.76625480	.22433629	-3.416	.0006	.02976744
RT74	.96118513	.21153978	4.544	.0000	.03860465
	Dispersion parameter for count data model				
Alpha	1.50340641	.08624217	17.432	.0000	

All-Districts: Urban Multilane Divided SPF 2 – Total Noninjuries

```
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Negative Binomial Regression                |
| Maximum Likelihood Estimates                |
| Model estimated: May 13, 2014 at 09:04:18PM.|
| Dependent variable              TOTALNI     |
| Weighting variable                 None     |
| Number of observations             2146     |
| Iterations completed                 32     |
| Log likelihood function       -3124.392     |
| Number of parameters                 22     |
| Info. Criterion: AIC =          2.93233     |
|   Finite Sample: AIC =          2.93255     |
| Info. Criterion: BIC =          2.99047     |
| Info. Criterion:HQIC =          2.95360     |
| Restricted log likelihood     -4196.906     |
| McFadden Pseudo R-squared       .2555487    |
| Chi squared                    2145.028     |
| Degrees of freedom                    1     |
| Prob[ChiSqd > value] =         .0000000     |
| NegBin form 2; Psi(i) = theta               |
+---------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable| Coefficient   | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 Constant|   -6.79627324      .82258213     -8.262   .0000
 LOGADT  |    1.02895535      .07202110     14.287   .0000   9.95899822
 LOGLN   |    1.00000000   ......(Fixed Parameter).......
 LTLANES |     .20462452      .10120727      2.022   .0432   2.15796831
 LT_IS_WI|     .09641763      .02366126      4.075   .0000   2.11230196
 RT_IS_WI|   -.10679965       .03037240     -3.516   .0004   2.14818267
 DES_SP  |   -.03300736       .00410671     -8.037   .0000   55.0046598
 METWTL  |   -.56033415       .11610620     -4.826   .0000    .18406337
 MEPAVE  |   -.35904379       .10732198     -3.345   .0008    .26048462
 MENPAVE |   -.35551370       .13249084     -2.683   .0073    .27213420
 MESTRUC |  -1.73799328       .64923643     -2.677   .0074    .07921715
 MEBRAIL |   1.52499364       .59278596      2.573   .0101    .08154706
 MENOBARR|    .39115749       .19130100      2.045   .0409    .84529357
 SCL     |   -.83362501       .15089729     -5.524   .0000    .07548928
 VEN     |   1.17648188       .38777743      3.034   .0024    .03308481
 RIV     |   -.43128692       .15536964     -2.776   .0055    .09506058
 SBD     |    .52663510       .13920890      3.783   .0002    .08946878
 MER     |   -.63376536       .25557518     -2.480   .0131    .04287046
 IMP     |   -.63901699       .14447489     -4.423   .0000    .10764212
 RT33    |  -1.59965413       .47976875     -3.334   .0009    .03122088
 RT18    |   -.73493626       .22809227     -3.222   .0013    .02935694
 RT74    |    .96888080       .21469348      4.513   .0000    .03867661
---------+Dispersion parameter for count data model
 Alpha   |   1.51171645       .08710103     17.356   .0000
```

All-Districts: Urban Four-lane SPF 1 – Total Noninjuries

```
Normal exit:   6 iterations. Status=0, F=    8887.590

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALNI
Log likelihood function        -8887.59015
Restricted log likelihood     -12115.03303
Chi squared [   1 d.f.]        6454.88577
Significance level                  .00000
McFadden Pseudo R-squared         .2663998
Estimation based on N =    5863, K =    3
Inf.Cr.AIC  =  17781.2 AIC/N =     3.033
Model estimated: Jul 21, 2014, 18:13:54
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model                  Logl ChiSquared[df]
Poisson(b=0)    -20163.13  ********* [**]
Poisson         -12115.03   16096.2 [ 2]
Negative Bin.    -8887.59    6454.9 [ 1]
--------+--------------------------------------------------------------------
        |                Standard            Prob.       95% Confidence
 TOTALNI|  Coefficient      Error        z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -5.59710***      .34997   -15.99  .0000    -6.28302  -4.91117
  LOGADT|     .72815***      .03333    21.85  .0000      .66283    .79347
   LOGLN|        1.0    .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|    1.67035***      .05288    31.59  .0000     1.56671   1.77400
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Four-lane SPF 1 – Total Fatalities

```
Normal exit:   6 iterations. Status=0, F=    756.7721

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALFA
Log likelihood function         -756.77208
Restricted log likelihood       -766.04851
Chi squared [   1 d.f.]           18.55285
Significance level                  .00002
McFadden Pseudo R-squared         .0121094
Estimation based on N =   5877, K =   3
Inf.Cr.AIC  =   1519.5 AIC/N =      .259
Model estimated: Jul 21, 2014, 18:15:31
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model                   Logl ChiSquared[df]
Poisson(b=0)       -979.39  ********* [**]
Poisson            -766.05      426.7 [ 2]
Negative Bin.      -756.77       18.6 [ 1]
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
 TOTALFA|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -7.55897***     1.14533   -6.60  .0000    -9.80378  -5.31416
  LOGADT|     .50705***      .10836    4.68  .0000      .29468    .71942
   LOGLN|      1.0    .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|    1.30775***      .31649    4.13  .0000      .68744   1.92806
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Four-lane SPF 1 – Total Injuries

```
Normal exit:   7 iterations. Status=0, F=    8954.284

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable               TOTALIN
Log likelihood function      -8954.28375
Restricted log likelihood   -12228.81810
Chi squared [   1 d.f.]       6549.06871
Significance level                .00000
McFadden Pseudo R-squared       .2677719
Estimation based on N =   5877, K =    3
Inf.Cr.AIC  =  17914.6 AIC/N =     3.048
Model estimated: Jul 21, 2014, 18:15:47
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model               Logl ChiSquared[df]
Poisson(b=0)   -20465.82  ********* [**]
Poisson        -12228.82   16474.0 [ 2]
Negative Bin.   -8954.28    6549.1 [ 1]
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
 TOTALIN|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -5.52897***     .34819   -15.88  .0000    -6.21142  -4.84653
  LOGADT|     .72264***     .03316    21.79  .0000      .65765    .78763
   LOGLN|      1.0     .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|    1.66884***     .05253    31.77  .0000     1.56587   1.77180
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Four-lane SPF 2 – Total Fatalities

```
--------------------------------------------------------------------------------
Poisson Regression
Dependent variable                 TOTALFA
Log likelihood function         -646.94541
Restricted log likelihood       -906.28645
Chi squared [    8 d.f.]         518.68208
Significance level                  .00000
McFadden Pseudo R-squared         .2861579
Estimation based on N =    5877, K =     9
Inf.Cr.AIC  =    1311.9 AIC/N =       .224
Model estimated: Jul 22, 2014, 13:22:58
Chi- squared =   3649.17361  RsqP=  .5395
G  - squared =    932.18635  RsqD=  .3575
Overdispersion tests: g=mu(i)  :     .833
Overdispersion tests: g=mu(i)^2:   2.217
--------+-----------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
 TOTALFA|  Coefficient       Error       z    |z|>Z*         Interval
--------+-----------------------------------------------------------------------
Constant|   -9.11754***     1.23206    -7.40  .0000   -11.53234  -6.70275
  LOGADT|    .65215***      .11867     5.50  .0000      .41957    .88474
   LOGLN|     1.0     .....(Fixed Parameter).....
LT_OS_WI|    .08417***      .03249     2.59  .0096      .02049    .14786
 RTLANES|   -.53424***      .18649    -2.86  .0042     -.89975   -.16874
      LA|    .75654***      .26179     2.89  .0039      .24344   1.26965
     STA|    .97214***      .36607     2.66  .0079      .25466   1.68962
  SDIEGO|    .71512***      .27603     2.59  .0096      .17410   1.25613
   RT395|   1.98305***      .38401     5.16  .0000     1.23041   2.73569
    RT12|    .91391***      .32190     2.84  .0045      .28300   1.54483
--------+-----------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
--------------------------------------------------------------------------------
```

All-Districts: Urban Four-lane SPF 2 – Total Injuries

```
Normal exit:  34 iterations. Status=0, F=    8662.635
-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable              TOTALIN
Log likelihood function     -8662.63453
Restricted log likelihood  -10991.75057
Chi squared [   1 d.f.]      4658.23208
Significance level               .00000
McFadden Pseudo R-squared      .2118967
Estimation based on N =   5877, K =  27
Inf.Cr.AIC  =  17379.3 AIC/N =    2.957
Model estimated: Jul 22, 2014, 04:04:12
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model              Logl ChiSquared[df]
Poisson(b=0)   -20465.82  ********* [**]
Poisson        -10991.75   18948.1 [26]
Negative Bin.   -8662.63    4658.2 [ 1]
-----------------------------------------------------------------------------
```

TOTALIN	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
Constant	-6.56045***	.42718	-15.36	.0000	-7.39771	-5.72318
LOGADT	.99310***	.03831	25.92	.0000	.91802	1.06819
LOGLN	1.0	.....(Fixed Parameter).....				
DES_SP	-.02752***	.00264	-10.41	.0000	-.03271	-.02234
METWTL	-.35301***	.12916	-2.73	.0063	-.60616	-.09987
RT15	-.53568***	.18915	-2.83	.0046	-.90640	-.16495
RT210	-.50410**	.22970	-2.19	.0282	-.95430	-.05390
RT105	.55057**	.25897	2.13	.0335	.04301	1.05813
RT2	-1.44332***	.24710	-5.84	.0000	-1.92762	-.95901
RT135	1.10340*	.56363	1.96	.0503	-.00129	2.20809
RT13	.86037***	.26940	3.19	.0014	.33236	1.38838
RT99	-.23920***	.06148	-3.89	.0001	-.35970	-.11871
RT101	-.56434***	.06644	-8.49	.0000	-.69457	-.43411
LA	.39219***	.08636	4.54	.0000	.22293	.56144
SON	.40660***	.09321	4.36	.0000	.22391	.58928
ALA	-.70414***	.12584	-5.60	.0000	-.95078	-.45750
YUB	-.73144***	.24136	-3.03	.0024	-1.20450	-.25838
MECONCG	-.49184***	.13223	-3.72	.0002	-.75100	-.23267
MEBEAM	.71217***	.16853	4.23	.0000	.38186	1.04248
MESTRUC	-.66431***	.11414	-5.82	.0000	-.88802	-.44060
MEDIT	-1.96983**	.78866	-2.50	.0125	-3.51557	-.42409
MESGR	-.74715***	.17316	-4.31	.0000	-1.08654	-.40777
MENPAVE	-.54051***	.09144	-5.91	.0000	-.71972	-.36129
MEPAVE	-.59115***	.08839	-6.69	.0000	-.76438	-.41791
MEST	-.35398***	.10306	-3.43	.0006	-.55597	-.15200
MED_WI	-.00651***	.00115	-5.64	.0000	-.00877	-.00425
LTLANES	.34827***	.06935	5.02	.0000	.21234	.48420
	Dispersion parameter for count data model					
Alpha	1.28092***	.04329	29.59	.0000	1.19608	1.36577

All-Districts: Urban Four-lane SPF 2 – Total Noninjuries

```
Normal exit:  34 iterations. Status=0, F=    8596.369
-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                TOTALNI
Log likelihood function       -8596.36938
Restricted log likelihood    -10888.80273
Chi squared [   1 d.f.]        4584.86671
Significance level                 .00000
McFadden Pseudo R-squared        .2105313
Estimation based on N =   5863, K =   27
Inf.Cr.AIC  =  17246.7 AIC/N =    2.942
Model estimated: Jul 22, 2014, 04:05:24
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin
Model               Logl ChiSquared[df]
Poisson(b=0)   -20163.13  ******** [**]
Poisson        -10888.80   18548.7 [26]
Negative Bin.   -8596.37    4584.9 [ 1]
```

TOTALNI	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
Constant	-6.59800***	.42836	-15.40	.0000	-7.43757	-5.75842
LOGADT	1.00071***	.03851	25.99	.0000	.92523	1.07619
LOGLN	1.0	.....(Fixed Parameter).....				
DES_SP	-.02845***	.00266	-10.70	.0000	-.03367	-.02324
METWTL	-.36681***	.12965	-2.83	.0047	-.62092	-.11270
RT15	-.55556***	.18826	-2.95	.0032	-.92455	-.18658
RT210	-.47269**	.23630	-2.00	.0455	-.93584	-.00954
RT105	.57536**	.25924	2.22	.0265	.06726	1.08347
RT2	-1.40317***	.24734	-5.67	.0000	-1.88794	-.91841
RT135	1.11166**	.56401	1.97	.0487	.00621	2.21711
RT13	.87752***	.26960	3.25	.0011	.34911	1.40593
RT99	-.24479***	.06189	-3.96	.0001	-.36610	-.12348
RT101	-.55982***	.06654	-8.41	.0000	-.69023	-.42941
LA	.36427***	.08757	4.16	.0000	.19264	.53590
SON	.40940***	.09301	4.40	.0000	.22711	.59169
ALA	-.70664***	.12573	-5.62	.0000	-.95307	-.46020
YUB	-.72551***	.24100	-3.01	.0026	-1.19786	-.25316
MECONCG	-.47797***	.13341	-3.58	.0003	-.73945	-.21650
MEBEAM	.71961***	.16879	4.26	.0000	.38878	1.05044
MESTRUC	-.65673***	.11399	-5.76	.0000	-.88014	-.43332
MEDIT	-1.95985**	.78722	-2.49	.0128	-3.50278	-.41692
MESGR	-.77110***	.17232	-4.47	.0000	-1.10883	-.43337
MENPAVE	-.54013***	.09120	-5.92	.0000	-.71888	-.36139
MEPAVE	-.59374***	.08826	-6.73	.0000	-.76674	-.42075
MEST	-.36092***	.10307	-3.50	.0005	-.56294	-.15890
MED_WI	-.00637***	.00116	-5.50	.0000	-.00864	-.00410
LTLANES	.34916***	.06993	4.99	.0000	.21211	.48621
	Dispersion parameter for count data model					
Alpha	1.27978***	.04345	29.45	.0000	1.19461	1.36495

All-Districts: Urban Five, Six, and Seven-lane SPF 1 – Total Noninjuries

```
Normal exit:   8 iterations. Status=0, F=    7185.647

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALNI
Log likelihood function     -7185.64728
Restricted log likelihood  -10077.93490
Chi squared [   1 d.f.]      5784.57523
Significance level               .00000
McFadden Pseudo R-squared      .2869921
Estimation based on N =    4053, K =   3
Inf.Cr.AIC  =  14377.3 AIC/N =     3.547
Model estimated: Jul 22, 2014, 14:59:14
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model               Logl ChiSquared[df]
Poisson(b=0)   -20626.43  ********* [**]
Poisson        -10077.93   21097.0 [ 2]
Negative Bin.   -7185.65    5784.6 [ 1]
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
 TOTALNI|  Coefficient     Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -7.05513***      .32979   -21.39  .0000    -7.70151  -6.40876
  LOGADT|     .86631***      .02911    29.76  .0000      .80925    .92338
   LOGLN|      1.0     .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|    1.29028***      .04731    27.27  .0000     1.19755   1.38301
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Five, Six, and Seven-lane SPF 1 – Total Fatalities

```
Normal exit:   7 iterations. Status=0, F=    573.6857

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALFA
Log likelihood function         -573.68573
Restricted log likelihood       -582.37093
Chi squared [   1 d.f.]           17.37040
Significance level                  .00003
McFadden Pseudo R-squared         .0149135
Estimation based on N =    4065, K =    3
Inf.Cr.AIC  =   1153.4 AIC/N =       .284
Model estimated: Jul 22, 2014, 14:59:26
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model                 Logl ChiSquared[df]
Poisson(b=0)     -710.47  ******** [**]
Poisson          -582.37     256.2 [ 2]
Negative Bin.    -573.69      17.4 [ 1]
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
 TOTALFA|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|    -9.40974***     2.20034    -4.28  .0000   -13.72232  -5.09715
  LOGADT|      .67428***      .19238     3.50  .0005      .29722   1.05134
   LOGLN|       1.0     .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|     1.80900***      .46702     3.87  .0001      .89366   2.72434
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Five, Six, and Seven-lane SPF 1 – Total Injuries

```
Normal exit:   8 iterations. Status=0, F=    7225.873

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                TOTALIN
Log likelihood function       -7225.87305
Restricted log likelihood    -10128.09519
Chi squared [   1 d.f.]        5804.44428
Significance level                 .00000
McFadden Pseudo R-squared        .2865516
Estimation based on N =    4065, K =    3
Inf.Cr.AIC  =  14457.7 AIC/N =     3.557
Model estimated: Jul 22, 2014, 14:59:39
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model              Logl ChiSquared[df]
Poisson(b=0)   -20823.00   ******** [**]
Poisson        -10128.10    21389.8 [ 2]
Negative Bin.   -7225.87     5804.4 [ 1]
--------+--------------------------------------------------------------------
        |                 Standard            Prob.       95% Confidence
 TOTALIN|  Coefficient      Error       z    |z|>Z*          Interval
--------+--------------------------------------------------------------------
Constant|   -7.08546***     .32885   -21.55  .0000    -7.73000  -6.44093
  LOGADT|     .86949***     .02904    29.95  .0000      .81259    .92640
   LOGLN|      1.0     .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|    1.28285***     .04694    27.33  .0000     1.19086   1.37484
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------

|-> negbin;lhs=pdo;rhs=one,logadt,logln;rst=a1,a2,1,a3$

-----------------------------------------------------------------------------
```

All-Districts: Urban Five, Six, and Seven-lane SPF 2 – Total Noninjuries

```
Normal exit:  34 iterations. Status=0, F=    7025.832

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALNI
Log likelihood function        -7025.83202
Restricted log likelihood      -9269.03317
Chi squared [   1 d.f.]         4486.40229
Significance level                  .00000
McFadden Pseudo R-squared         .2420103
Estimation based on N =    4053, K =  25
Inf.Cr.AIC  =  14101.7 AIC/N =    3.479
Model estimated: Jul 22, 2014, 19:01:22
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model                Logl ChiSquared[df]
Poisson(b=0)   -20626.43  ******** [**]
Poisson         -9269.03    22714.8 [24]
Negative Bin.   -7025.83     4486.4 [ 1]
--------+--------------------------------------------------------------------
        |                  Standard            Prob.       95% Confidence
 TOTALNI|  Coefficient       Error       z    |z|>Z*          Interval
--------+--------------------------------------------------------------------
Constant|   -7.33725***      .40952   -17.92  .0000    -8.13988   -6.53461
  LOGADT|    1.02473***      .03954    25.92  .0000      .94723    1.10223
   LOGLN|      1.0   .....(Fixed Parameter).....
  DES_SP|    -.01854***      .00368    -5.04  .0000     -.02574    -.01133
 LNOSPEC|    -.19950***      .05571    -3.58  .0003     -.30870    -.09031
      SF|     .54909***      .15568     3.53  .0004      .24395     .85422
     SCL|    -.19391**       .09225    -2.10  .0356     -.37472    -.01309
     SLO|    -.70670**       .35549    -1.99  .0468    -1.40344    -.00995
    MEST|   -1.41225***      .47394    -2.98  .0029    -2.34115    -.48335
  MED_WI|    -.00519***      .00080    -6.47  .0000     -.00677    -.00362
    RLTR|     .33623***      .11779     2.85  .0043      .10537     .56709
     PLA|    -.78199***      .22703    -3.44  .0006    -1.22697    -.33701
     SUT|    1.03660**       .40256     2.57  .0100      .24759    1.82562
     FRE|     .59995***      .10458     5.74  .0000      .39498     .80492
      LA|     .28544***      .06489     4.40  .0000      .15826     .41262
    RT65|    1.40387***      .28656     4.90  .0000      .84222    1.96551
    RT44|    2.50060***      .46883     5.33  .0000     1.58171    3.41948
    RT24|    -.71925***      .23814    -3.02  .0025    -1.18600    -.25250
    RT14|    -.46928***      .14471    -3.24  .0012     -.75291    -.18564
   RT178|    1.04453***      .25126     4.16  .0000      .55207    1.53700
    RT23|     .90750**       .38512     2.36  .0185      .15268    1.66232
    RT71|    -.77670**       .35962    -2.16  .0308    -1.48154    -.07185
   RT215|     .60925***      .11561     5.27  .0000      .38265     .83585
   RT905|   -1.50059***      .50570    -2.97  .0030    -2.49174    -.50944
   RT261|   -1.05529**       .47353    -2.23  .0258    -1.98340    -.12718
        |Dispersion parameter for count data model
   Alpha|    1.06987***      .04250    25.17  .0000      .98657    1.15317
--------+--------------------------------------------------------------------
```

All-Districts: Urban Five, Six, and Seven-lane SPF 2 – Total Fatalities

```
-----------------------------------------------------------------------------
Poisson Regression
Dependent variable                 TOTALFA
Log likelihood function         -566.77928
Restricted log likelihood       -710.47424
Chi squared [   7 d.f.]          287.38991
Significance level                  .00000
McFadden Pseudo R-squared         .2022522
Estimation based on N =    4065, K =     8
Inf.Cr.AIC  =    1149.6 AIC/N =       .283
Model estimated: Jul 22, 2014, 19:46:45
Chi- squared =   5929.82023  RsqP=-.0339
G  - squared =    837.36395  RsqD= .2555
Overdispersion tests: g=mu(i)   :   1.635
Overdispersion tests: g=mu(i)^2:    2.825
--------+--------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
 TOTALFA|  Coefficient      Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -12.4793***    2.06290   -6.05  .0000    -16.5226    -8.4361
  LOGADT|     .91639***     .17767    5.16  .0000      .56815    1.26462
   LOGLN|      1.0     .....(Fixed Parameter).....
   RT905|    1.69025**      .73298    2.31  .0211      .25362    3.12687
   RT125|    1.46769***     .50864    2.89  .0039      .47076    2.46462
    RT67|    2.39967***     .71861    3.34  .0008      .99122    3.80813
    RT35|    2.88251***    1.03836    2.78  .0055      .84736    4.91766
    RT99|     .92942***     .19648    4.73  .0000      .54433    1.31452
 MEOTHER|    1.63655***     .58526    2.80  .0052      .48946    2.78363
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Five, Six, and Seven-lane SPF 2 – Total Injuries

```
Normal exit:  34 iterations. Status=0, F=    7066.124

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALIN
Log likelihood function        -7066.12367
Restricted log likelihood      -9320.62993
Chi squared [    1 d.f.]        4509.01252
Significance level                  .00000
McFadden Pseudo R-squared         .2418835
Estimation based on N =    4065, K =   25
Inf.Cr.AIC  =  14182.2 AIC/N =     3.489
Model estimated: Jul 22, 2014, 19:00:14
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model                  Logl ChiSquared[df]
Poisson(b=0)   -20823.00  ********* [**]
Poisson         -9320.63   23004.7 [24]
Negative Bin.   -7066.12    4509.0 [ 1]
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
 TOTALIN|  Coefficient     Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -7.35298***     .40765   -18.04  .0000    -8.15195  -6.55400
  LOGADT|    1.02460***     .03938    26.02  .0000      .94741   1.10179
   LOCLN|        1.0    .....(Fixed Parameter).....
  DES_SP|    -.01815***     .00366    -4.95  .0000     -.02533   -.01096
 LNOSPEC|    -.19725***     .05545    -3.56  .0004     -.30592   -.08858
      SF|     .51891***     .15151     3.42  .0006      .22195    .81587
     SCL|    -.19812**      .09182    -2.16  .0310     -.37809   -.01815
     SLO|    -.71633**      .35479    -2.02  .0435    -1.41171   -.02096
    MEST|   -1.39761***     .47043    -2.97  .0030    -2.31964   -.47557
  MED_WI|    -.00525***     .00080    -6.57  .0000     -.00681   -.00368
    RLTR|     .33048***     .11755     2.81  .0049      .10009    .56087
     PLA|    -.79058***     .22231    -3.56  .0004    -1.22630   -.35485
     SUT|    1.03633***     .40134     2.58  .0098      .24971   1.82296
     FRE|     .59670***     .10442     5.71  .0000      .39204    .80136
      LA|     .28305***     .06473     4.37  .0000      .15617    .40992
    RT65|    1.40493***     .28253     4.97  .0000      .85117   1.95868
    RT44|    2.49299***     .46730     5.33  .0000     1.57710   3.40889
    RT24|    -.72776***     .23738    -3.07  .0022    -1.19302   -.26250
    RT14|    -.46949***     .14453    -3.25  .0012     -.75276   -.18622
   RT170|    1.03459***     .25065     4.13  .0000      .54332   1.52586
    RT23|     .90067**      .38329     2.35  .0188      .14943   1.65191
    RT71|    -.78429**      .35839    -2.19  .0286    -1.48672   -.08187
   RT215|     .61726***     .11539     5.35  .0000      .39109    .84343
   RT905|   -1.44218***     .45648    -3.16  .0016    -2.33686   -.54749
   RT261|   -1.06458**      .47270    -2.25  .0243    -1.99105   -.13811
        |Dispersion parameter for count data model
   Alpha|    1.06389***     .04215    25.24  .0000      .98129   1.14650
--------+--------------------------------------------------------------------
```

All-Districts: Urban Eight Plus-lane SPF 1 – Total Noninjuries

```
Normal exit:  16 iterations. Status=0, F=    13093.87

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALNI
Log likelihood function    -13093.86812
Restricted log likelihood  -17716.97840
Chi squared [   1 d.f.]      9246.22055
Significance level               .00000
McFadden Pseudo R-squared      .2609424
Estimation based on N =   5693, K =   3
Inf.Cr.AIC  =  26193.7 AIC/N =    4.601
Model estimated: Jul 23, 2014, 02:02:11
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model               Logl ChiSquared[df]
Poisson(b=0)   -39988.00  ******** [**]
Poisson        -17716.98   44542.0 [ 2]
Negative Bin.  -13093.87    9246.2 [ 1]
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
 TOTALNI|  Coefficient       Error        z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -11.6713***      .34352   -33.98  .0000    -12.3446  -10.9980
  LOGADT|    1.24437***      .02844    43.75  .0000     1.18862   1.30011
   LOGLN|        1.0    .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|     .72218***      .01991    36.28  .0000      .68316    .76120
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Eight Plus-lane SPF 1 – Total Fatalities

```
Normal exit:   8 iterations. Status=0, F=    1015.373

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                TOTALFA
Log likelihood function       -1015.37284
Restricted log likelihood     -1025.59524
Chi squared [   1 d.f.]          20.44481
Significance level                 .00001
McFadden Pseudo R-squared        .0099673
Estimation based on N =    5700, K =    3
Inf.Cr.AIC  =    2036.7 AIC/N =      .357
Model estimated: Jul 23, 2014, 02:02:27
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model                Logl ChiSquared[df]
Poisson(b=0)     -1225.49  ********* [**]
Poisson          -1025.60      399.8 [ 2]
Negative Bin.    -1015.37       20.4 [ 1]
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
 TOTALFA|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -9.04140***     2.22603    -4.06  .0000   -13.40434   -4.67847
  LOGADT|     .63202***      .18364     3.44  .0006      .27208     .99195
   LOGLN|      1.0    .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|    1.33563***      .37143     3.60  .0003      .60765    2.06362
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Eight Plus-lane SPF 1 – Total Injuries

```
Normal exit:  16 iterations. Status=0, F=    13138.61

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable               TOTALIN
Log likelihood function    -13138.60918
Restricted log likelihood  -17764.69028
Chi squared [   1 d.f.]      9252.16220
Significance level               .00000
McFadden Pseudo R-squared      .2604088
Estimation based on N =   5700, K =   3
Inf.Cr.AIC  =  26283.2 AIC/N =    4.611
Model estimated: Jul 23, 2014, 02:02:46
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model              Logl ChiSquared[df]
Poisson(b=0)   -40257.04  ******** [**]
Poisson        -17764.69   44984.7 [ 2]
Negative Bin.  -13138.61    9252.2 [ 1]
--------+--------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
 TOTALIN|  Coefficient      Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -11.6276***     .34287   -33.91  .0000    -12.2996  -10.9556
  LOGADT|    1.24139***     .02839    43.73  .0000     1.18575   1.29703
   LOGLN|        1.0    .....(Fixed Parameter).....
        |Dispersion parameter for count data model
   Alpha|     .71819***     .01972    36.42  .0000      .67955    .75684
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Eight Plus-lane SPF 2 – Total Fatalities

```
-----------------------------------------------------------------------------
Poisson Regression
Dependent variable                 TOTALFA
Log likelihood function         -973.47059
Restricted log likelihood      -1204.48431
Chi squared [  10 d.f.]          462.02745
Significance level                  .00000
McFadden Pseudo R-squared         .1917947
Estimation based on N =    5693, K =   11
Inf.Cr.AIC  =   1968.9 AIC/N =        .346
Model estimated: Jul 23, 2014, 18:34:05
Chi- squared =   6321.78433  RsqP=  .1637
G  - squared =   1425.10517  RsqD=  .2448
Overdispersion tests: g=mu(i)  :   2.912
Overdispersion tests: g=mu(i)^2:   1.885
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
 TOTALFA|  Coefficient     Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
Constant|   -11.9631***   2.45858    -4.87  .0000    -16.7819    -7.1444
  LOGADT|     .86849***    .19794     4.39  .0000      .48052    1.25645
   LOGLN|      1.0      .....(Fixed Parameter).....
    RT99|    1.23512**     .51257     2.41  .0160      .23050    2.23973
    RT15|     .44218**     .20955     2.11  .0348      .03147     .85289
   RT710|     .75332**     .36457     2.07  .0388      .03877    1.46787
   RT405|    -.75905**     .33361    -2.28  .0229    -1.41291    -.10518
    RT22|    2.08494***    .71480     2.92  .0035      .68395    3.48594
    RT10|     .51157***    .17753     2.88  .0040      .16362     .85952
      SF|    1.00860**     .41879     2.41  .0160      .18779    1.82942
 RNOSPEC|     .28160**     .13953     2.02  .0436      .00813     .55506
RT_IS_WI|    -.03618**     .01750    -2.07  .0387     -.07047    -.00189
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
-----------------------------------------------------------------------------
```

All-Districts: Urban Eight Plus-lane SPF 2 – Total Noninjuries

```
Normal exit:  38 iterations. Status=0, F=    12913.23

-----------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALNI
Log likelihood function        -12913.23166
Restricted log likelihood      -16854.05428
Chi squared [   1 d.f.]         7881.64523
Significance level                  .00000
McFadden Pseudo R-squared         .2338205
Estimation based on N =    5693, K =   30
Inf.Cr.AIC  =  25886.5 AIC/N =     4.547
Model estimated: Jul 23, 2014, 03:29:30
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model               Logl ChiSquared[df]
Poisson(b=0)   -39988.00  ********* [**]
Poisson        -16854.05   46267.9 [29]
Negative Bin.  -12913.23    7881.6 [ 1]
```

TOTALNI	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
Constant	-11.5163***	.46426	-24.81	.0000	-12.4262	-10.6063
LOGADT	1.23988***	.03821	32.45	.0000	1.16499	1.31478
LOGLN	1.0	.....(Fixed Parameter).....				
FRE	.62320**	.24588	2.53	.0113	.14128	1.10512
RT210	-.28744***	.09244	-3.11	.0019	-.46861	-.10626
RT280	-.29829***	.08153	-3.66	.0003	-.45808	-.13850
RT24	-.47476***	.13301	-3.57	.0004	-.73544	-.21407
RT29	2.63456***	.34479	7.64	.0000	1.95878	3.31034
LA	.08906***	.03244	2.75	.0060	.02548	.15265
SF	.61673***	.17131	3.60	.0003	.28096	.95249
SAC	.49017***	.06389	7.67	.0000	.36494	.61539
RIV	.19593***	.07096	2.76	.0058	.05685	.33501
MED_WI	-.00469***	.00067	-7.02	.0000	-.00600	-.00338
LAUXL	.14673***	.04909	2.99	.0028	.05051	.24296
LTOLL	.93852***	.28339	3.31	.0009	.38310	1.49395
RMEDHOV	-.16831***	.03577	-4.71	.0000	-.23842	-.09820
MEOTHER	.54996***	.14128	3.89	.0001	.27305	.82687
MECABLG	-.84813**	.41269	-2.06	.0399	-1.65698	-.03927
MEBRAIL	-.44140***	.06611	-6.68	.0000	-.57097	-.31183
MEGRAILL	-.33599**	.16099	-2.09	.0369	-.65151	-.02046
MECONCR	-.54357***	.19064	-2.85	.0044	-.91722	-.16993
MECONCB	.20216***	.06400	3.16	.0016	.07672	.32759
RT14	.56236***	.13155	4.27	.0000	.30453	.82018
SCL	.33092***	.07030	4.71	.0000	.19314	.46871
SJ	.55938***	.15981	3.50	.0005	.24617	.87260
RT980	.67325***	.24337	2.77	.0057	.19624	1.15025

All-Districts: Urban Eight Plus-lane SPF 2 – Total Noninjuries(contd)

RT680	-.33337***	.10234	-3.26	.0011	-.53395	-.13279
RT22	.92760**	.42236	2.20	.0281	.09980	1.75541
RT110	.23600***	.07323	3.22	.0013	.09247	.37954
RT215	.40984***	.15636	2.62	.0088	.10337	.71631
	Dispersion parameter for count data model					
Alpha	.65274***	.01866	34.98	.0000	.61617	.68932

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.

All-Districts: Urban Eight Plus-lane SPF 2 – Total Injuries

```
Normal exit:  38 iterations. Status=0, F=    12956.00

--------------------------------------------------------------------------
Negative Binomial Regression
Dependent variable                 TOTALIN
Log likelihood function    -12956.00500
Restricted log likelihood  -16896.66614
Chi squared [   1 d.f.]      7881.32228
Significance level              .00000
McFadden Pseudo R-squared      .2332212
Estimation based on N =   5700, K =  30
Inf.Cr.AIC  =  25972.0 AIC/N =    4.556
Model estimated: Jul 23, 2014, 03:27:31
NegBin form 2; Psi(i) = theta
Tests of Model Restrictions on Neg.Bin.
Model                Logl  ChiSquared[df]
Poisson(b=0)   -40257.04   ******** [**]
Poisson        -16896.67    46720.8 [29]
Negative Bin.  -12956.00     7881.3 [ 1]
--------+-----------------------------------------------------------------
```

TOTALIN	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
Constant	-11.4539***	.46309	-24.73	.0000	-12.3616	-10.5463
LOGADT	1.23543***	.03812	32.41	.0000	1.16072	1.31013
LOGLN	1.0	.....(Fixed Parameter).....				
FRE	.61287**	.24464	2.51	.0122	.13338	1.09236
RT210	-.29061***	.09188	-3.16	.0016	-.47069	-.11053
RT280	-.30765***	.08043	-3.83	.0001	-.46529	-.15001
RT24	-.48381***	.13284	-3.64	.0003	-.74417	-.22346
RT29	2.62033***	.34318	7.64	.0000	1.94771	3.29294
LA	.09176***	.03239	2.83	.0046	.02828	.15523
SF	.63691***	.16550	3.85	.0001	.31253	.96129
SAC	.48779***	.06366	7.66	.0000	.36300	.61257
RIV	.20670***	.07047	2.93	.0034	.06858	.34482
MED_WI	-.00470***	.00067	-7.05	.0000	-.00601	-.00339
LAUXL	.14555***	.04875	2.99	.0028	.04999	.24110
LTOLL	.92235***	.28080	3.28	.0010	.37200	1.47270
RMEDHOV	-.17261***	.03564	-4.84	.0000	-.24247	-.10275
MEOTHER	.56139***	.13739	4.09	.0000	.29212	.83067
MECABLG	-.83568**	.39765	-2.10	.0356	-1.61506	-.05630
MEBRAIL	-.42951***	.06619	-6.49	.0000	-.55925	-.29978
MEGRAILL	-.36115**	.15447	-2.34	.0194	-.66390	-.05840
MECONCR	-.54399***	.18914	-2.88	.0040	-.91471	-.17327
MECONCB	.20458***	.06344	3.22	.0013	.08024	.32892
RT14	.55250***	.13130	4.21	.0000	.29514	.80985
SCL	.33485***	.06988	4.79	.0000	.19789	.47180
SJ	.56365***	.16049	3.51	.0004	.24909	.87821
RT980	.66363***	.24209	2.74	.0061	.18915	1.13811

All-Districts: Urban Eight Plus-lane SPF 2 – Total Injuries(contd)

```
  RT680|    -.33421***      .10179    -3.28  .0010     -.53372   -.13470
   RT22|     .94784**       .44908     2.11  .0348      .06766   1.82802
  RT110|     .23604***      .07262     3.25  .0012      .09371    .37837
  RT215|     .37948**       .15317     2.48  .0132      .07928    .67969
       |Dispersion parameter for count data model
  Alpha|     .64836***      .01850    35.04  .0000      .61209    .68463
-------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
----------------------------------------------------------------------------
```