FINAL REPORT

to

THE FLORIDA DEPARTMENT OF TRANSPORTATION
RESEARCH OFFICE

on Project

“Development and Calibration of Highway Safety Manual Equations for Florida Conditions”

FDOT Contract BDK77 977-06 (UF Project 00082013)

November 30, 2011

Transportation Research Center
The University of Florida

DISCLAIMER

METRIC CONVERSION CHART

U.S. UNITS TO METRIC (SI) UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

METRIC (SI) UNITS TO U.S. UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

Technical Report Documentation Page

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16. Abstract

The Highway Safety Manual (HSM) provides statistically-valid analytical tools and techniques for quantifying the potential effects on crashes as a result of decisions made in planning, design, operations, and maintenance. Implementation of the new techniques in the HSM will upgrade FDOT's safety analysis methods from descriptive methods to quantitative, predictive analyses. However, the base models for the HSM safety prediction methodologies were developed with data from specific highway agencies from different parts of the country. To apply these models to geographic regions in Florida and to account for changes in crash trends over time within the same geographic region, calibrations of these base models is required. This study provides these calibration factors the segment- and intersection- level safety performance functions from the HSM for Florida conditions or the years 2005 through 2008. The calibration factors provided in this report are to be used along with the appropriate SPFs for project-level safety analyses conducted in the state of Florida.

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EXECUTIVE SUMMARY

The Highway Safety Manual (HSM) provides statistically-valid analytical tools and techniques for quantifying the potential effects on crashes as a result of decisions made in planning, design, operations, and maintenance. The HSM tools and techniques provide reliable estimates of expected crash rates for specific roadway segments and intersections. Implementation of the new techniques in the HSM will upgrade FDOT's safety analysis methods from descriptive methods to quantitative, predictive analyses.

The base models for the HSM safety prediction methodologies were developed with data from specific highway agencies from different parts of the country. To apply these models to geographic regions in Florida and to account for changes in crash trends over time within the same geographic region, calibrations of these base models is required.

This study provides these calibration factors the segment- and intersection- level safety performance functions from the HSM for Florida conditions or the years 2005 through 2008. Tables E1 and E2 present a summary of these calibration factors by year and by facility type for the segment and intersection SPFs.

Table E1. Calibration Factors for Segment SPFs

Calibration Factor Time Frame		**Calibration Factors by Facility Type**						
		Rural Two-Lane Two-Way Roads	**Rural Multilane Highways**	**Urban and Suburban Arterials**				
		R2U	R4D	U2U	U32LT	U4U	U4D	U52LT
HSM SPF to be Calibrated		Eq. 10-6 Page 10-15	Eq. 11-9 Page 11-18	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20
Total Length of Roadway		2121.0	546.2	628.4	66.3	96.1	970.6	253.6
Average KABC Crashes/Year		947.8	576.5	924.0	122.3	329.5	2885.0	1005.3
Fatal and Injury Crashes (KABC)	2005	1.063	0.719	1.093	0.952	0.641	1.750	0.710
	2006	1.069	0.696	0.977	1.126	0.742	1.611	0.726
	2007	1.026	0.701	1.119	1.028	0.749	1.653	0.711
	2008	0.980	0.665	0.928	1.046	0.707	1.602	0.695
Fatal and Injury Crashes (KAB)[a]	2005	1.353	0.769					
	2006	1.372	0.752					
	2007	1.241	0.740					
	2008	1.217	0.688					

a: using the KABCO scale, these include only KAB crashes; crashes with severity level C (possible injury) are not included

Table E2. Calibration Factors for Intersection SPFs

Calibration Factor Time Frame		**Calibration Factors by Facility Type**					
		Rural Two-Lane Two-Way Roads			**Rural Multilane Highways**	**Urban and Suburban Arterials**	
		R2 3ST	R2 4ST	R2 4SG	RM 4SG	U 3SG	U 4SG
HSM SPF to be Calibrated		Eq. 10-8 Page 10-18	Eq. 10-9 Page 10-19	Eq. 10-10 Page 10-20	Eq. 10-11 Eq. 10-12 Page 11-21	Eq. 12-21, 12-24, 12-29, & 12-31	Eq. 12-21, 12-24, 12-29, & 12-31
Number of Intersections Used for Calibration		39	24	28	25	45	121
Average KABC Crashes/Year		26.8	21.6	43.8	48.2	107.4	736.8
Fatal and Injury Crashes KABC	2005	0.79	0.72	1.28	0.35	1.98	2.05
	2006	0.80	0.66	1.44	0.36	1.90	1.91
	2007	0.72	0.47	0.89	0.44	2.10	1.82
	2008	0.65	0.47	1.00	0.34	1.87	1.79
	2009	0.80	0.80	1.21	0.37	1.41	1.84
Fatal and Injury Crashes KAB[a]	2005	1.06	1.00	2.02	0.47		
	2006	1.05	0.89	1.91	0.54		
	2007	0.84	0.68	1.22	0.57		
	2008	0.58	0.54	1.40	0.40		
	2009	0.75	1.21	1.96	0.50		

The calibration factors provided in this report are to be used along with the appropriate SPFs for project-level safety analyses conducted in the state of Florida. Specifically, the expected crashes predicted by the SPF equations in the HSM are to be scaled by the appropriate calibration factors (and other crash modification factors as needed). The overall methodology is outlined in Part C of the HSM.

It is also useful to acknowledge that the intersection equations were calibrated using relatively smaller sample sizes and so caution must be administered in using these factors.

For segment-level analysis, district-level or population-group-level calibration factors may be used instead of the state-level factors if the localized factors were derived using adequate data. Similarly, population-group level calibration factors would also be more appropriate for segments in high-density urban counties as the state-wide factors are shown to underestimate the crash rates in these locations.

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CHAPTER 1
INTRODUCTION

The Highway Safety Manual (HSM), published by the American Association of State Highway and Transportation Officials (AASHTO), provides a set of tools and methodologies to give quantitative safety performance information for decision making (*1*). Part C of the HSM presents crash prediction methods to estimate the expected crash frequency at any roadway segment or intersection. These methods include safety performance functions (SPF), crash modification factors (CMF), and calibration factors (*C*).

SPFs are crash prediction equations (negative binomial regression models) that primarily relate crash frequencies to traffic volumes and are derived under "base" conditions for each roadway segment or intersection type. Base conditions include geometric attributes, such as lane width (base is 12 feet for rural segments) and skew angle (base is no skew angle for all intersections), road features such as lighting (base is unlit for all segments and intersections) and right-turn-on-red (base is permitted for urban signalized intersections), and geographic factors, such as grade (base is level for rural two-lane, two-way segments).

The crash frequency estimated at a given site (segment or intersection) using the SPF is then modified through the use of CMFs to account for differences between the base conditions and the conditions of the site being analyzed. If a feature of a site matches the base condition, the corresponding CMF is 1.0. If a site's characteristics offer an expected decrease in crashes, such as lighting (base condition is unlit), then the CMF would be less than 1.0. Conversely, if a site's features would result in an expected increase in crashes, such as the presence of on-street parking (base condition is no on-street parking), the CMF would be greater than 1.0.

The final adjustment made to the estimated crash frequency in the HSM crash prediction method is the application of the calibration factor, *C*. The calibration factor facilitates the transferability of the SPF from the data set from which it was developed to the local analysis area. While CMFs account for changes of specific roadway features from the base conditions of the SPF, the calibration factor accounts for any attributes that may cause a facility-wide difference in the level of crash frequency. Factors contributing to such differences include crash reporting thresholds, driver population, weather, animal populations, and other unforeseen elements.

The HSM provides the SPFs for several facility types and the CMFs for several roadway features and other attributes (*1*). The HSM also prescribes that the SPFs be calibrated to local conditions prior to applications for safety assessments. This calibration procedure is briefly outlined here.

Using the appropriate SPF from the HSM, estimate the crash frequency for each segment assuming base conditions, N_{spf}. Since segment SPFs typically have a negative-binomial structure, this step involves the calculation of the type:

$$N_{spf} = exp\,(a + b \times ln(AADT) + ln(Length)) \qquad \text{Equation 1.1}$$

where a and b are regression coefficients available from the HSM, $AADT$ is the annual average daily traffic volume on the segment, and $Length$ is the length of the segment. The structure for intersection SPFs is similar as they generally follow the form:

$$N_{spf} = exp\,(a + b \times ln(AADT_{maj}) + c \times ln(AADT_{\min})) \qquad \text{Equation 1.2}$$

where a, b, and c are regression coefficients given by the HSM, $AADT_{maj}$ is larger of the annual average daily traffic volumes of the two intersecting roads, and $AADT_{min}$ is the smaller of the two annual average daily traffic volumes.

Next, the CMFs are determined for each site to adjust for any deviations of site characteristics from the base conditions. These CMF values may be directly used from the HSM or derived using local data. It is also useful to note that, in some cases, CMF values depend on the facility-specific crash type distribution. For example, the CMF for lane width applies to run-off-the-road, head-on, and sideswipe crashes. Therefore, calculating this CMF requires data on the proportion of these specific crash types for the given facility. Data on "default" crash-type distributions may be used from the HSM, or this may be substituted for with locally-derived information. Once all the CMFs have been calculated, the estimated crash frequency for a given site can be determined as

$$N_{predicted(uncalibrated)} = N_{spf} \times (CMF_1 \times CMF_2 \times ... \times CMF_y) \qquad \text{Equation 1.3}$$

where CMF_y are the CMFs for the different segment attributes (such as lane width, and lighting).

After calculating the $N_{predicted(uncalibrated)}$ for each site in the calibration data set, the calibration factor, C is computed as the ratio of observed crashes across all chosen sites to the number of uncalibrated predicted crashes for the same selected sites during the same time period:

$$C = \frac{\sum_{all\ selected\ sites} observed\ crashes}{\sum_{all\ selected\ sites} N_{predicted(uncalibrated)}} \qquad \text{Equation 1.4}$$

The broad intent of this study is to develop the calibration factors for the segment- and intersection- level safety performance functions from the HSM for Florida conditions using the procedure described above.

It is useful to note that there is little documented empirical evidence on the calibration of HSM equations to specific jurisdictions. Arguably one of the main reasons is that the manual itself is very recent. Three major calibration studies are the efforts undertaken at Oregon State University, the University of Louisiana at Lafayette, and Brigham Young University (*2, 3, 4*). The most comprehensive of these three is the Oregon State University work, calibrating the HSM predictive models for Oregon (*2*). In the Oregon study, both segment and intersection SPFs for total crashes were calibrated, and the resulting calibration factors were found to be very low for most cases; this was attributed to the fact that Oregon relies on self-reporting for property damage only (PDO) crashes. Additionally, state-specific collision type distributions were examined, but found to not have an effect in Oregon. Finally, fatal and injury calibrations were investigated and recommended for use in safety analysis due to the low reporting of PDO crashes. In the study performed by the University of Louisiana at Lafayette, calibration factors were developed only for rural multilane highways in Louisiana (*3*). Performance measures for network screening were also addressed; however, uncalibrated crash prediction models were not part of the comparison. In the Brigham Young University research, the HSM was calibrated for rural two-lane, two-way roadway segments in Utah (*4*). The calibrated HSM SPFs were compared to new models developed for Utah, but the existing HSM SPFs without calibration were not evaluated.

The rest of this report is organized as follows. Chapter 2 focuses on the calibration of segment level SPFs. Chapter 3 focuses on the calibration of intersection level SPFs. In each of Chapters 2 and 3, the assembly of data required for calibrations and the calibration results are discussed in detail. Finally, Chapter 4 presents an overall summary of work and identifies the major conclusions. Supplemental material are provided in Appendices.

CHAPTER 2
CALIBRATION OF SEGMENT SPFS

This chapter describes the calibration of the segment SPFs for Florida Conditions. The segment level SPFs presented in the HSM are first listed and those calibrated in this study are identified (Section 2.1). Next, in Section 2.2, the site selection and data assembly procedure is discussed extensively. Section 2.3 gives the segment calibration results, and discusses the use of Florida-specific crash distributions compared to HSM crash distributions. The impacts of the assumptions made in order to carry out the segment calibration are examined in Section 2.4. Section 2.5 presents a comparison of the HSM crash estimation procedure for segments under calibrated and non-calibrated conditions in order to evaluate the benefits of calibration. Section 2.6 examines geographic segmentation in calibration, both by FDOT district division (Section 2.6.1) and by county level population density (Section 2.6.2). Finally, in Section 2.7, SPFs for two facility types are completely re-estimated using Florida data and these are compared to the corresponding calibrated HSM equations.

2.1 List of Segment SPFs

The HSM currently provides segment-level SPFs for three rural roadway types and five urban and suburban roadway types. The rural roadway types are: (1) Two-lane two-way undivided roads (R2U), (2) Four-lane undivided roads (R4U), and (3) Four-lane divided roads (R4D). The urban/suburban roadway types are: (1) Two-lane undivided segments (U2U), (2) Three-lane segments including a two-way left-turn lane (U32LT), (3) Four-lane undivided segments (U4U), (4) Four-lane divided segments (U4D), and (5) Five-lane segments including a two-way left-turn lane (U52LT). Each of the eight segment types has its own SPF, requiring an associated calibration factor to adjust the corresponding model to local conditions. Separate SPFs are generally provided for analyzing total crashes (includes crashes with property damage only) and only fatal and injury crashes.

Table 2.1 lists all the segment SPFs for rural facilities included in the HSM and identifies whether these are calibrated in this effort. The SPFs for total crashes were not calibrated as all property damage only (PDO) crashes are not fully recorded by the long-form crash reports used to populate Florida’s Crash Analysis Reporting (CAR) System. The equations for fatal and injury crashes were not calibrated for multilane undivided rural segments due to lack of adequate data.

Table 2.1 Rural HSM Segment SPFs by Facility Type and Severity Level

Facility Type	SPF	Calibrated for Florida
Total Crashes		
Two-Lane Two-Way	$N_{Total} = AADT \times L \times 365 \times 10^{-6} \times e^{(-0.312)}$	No[c]
Multilane Undivided	$N_{Total} = e^{(-9.653)} \times AADT^{1.176} \times L$	No[c]
Multilane Divided	$N_{Total} = e^{(-9.025)} \times AADT^{1.049} \times L$	No[c]
KABC Fatal and Injury Crashes[a]		
Two-Lane Two-Way	$N_{KABC} = N_{Total} \times 0.321$	Yes
Multilane Undivided	$N_{KABC} = e^{(-9.410)} \times AADT^{1.094} \times L$	No[d]
Multilane Divided	$N_{KABC} = e^{(-8.837)} \times AADT^{0.958} \times L$	Yes
KAB Fatal and Injury Crashes[b]		
Two-Lane Two-Way	$N_{KAB} = N_{Total} \times 0.176$	Yes
Multilane Undivided	$N_{KAB} = e^{(-8.577)} \times AADT^{0.938} \times L$	No[d]
Multilane Divided	$N_{KAB} = e^{(-8.505)} \times AADT^{0.874} \times L$	Yes

a: These include crashes with fatalities, incapacitating injuries, non-incapacitating injuries, and possible injuries.
b: These include crashes with fatalities, incapacitating injuries, and non-incapacitating injuries.
c: Not calibrated due to lack of complete PDO crash data in Florida.
d: Not calibrated due to insufficient mileage of this facility type in Florida.

Table 2.2 and Table 2.3 display the components of the HSM segment SPFs for the five urban and suburban arterial facility types. These urban and suburban arterial SPFs are each composed of five equations to estimate different types of crashes: (1) multiple-vehicle nondriveway, (2) single-vehicle, (3) multiple-vehicle driveway related, (4) vehicle-pedestrian, and (5) vehicle-bicycle. While each of these five equations is not calibrated individually, the sum of these five components forms the urban and suburban SPF which is calibrated to Florida conditions. The SPFs for total crashes given in Table 2.2 were not calibrated for the same reason that the total crash SPFs in Table 2.1 were not able to be calibrated: all property damage only (PDO) crashes are not fully recorded by the long-form crash reports used to populate Florida's Crash Analysis Reporting (CAR) System. Calibration was performed on the SPFs for the five facility types shown in Table 2.3.

Table 2.2 Urban and Suburban HSM Segment SPFs for Total Crashes

SPF Component by Facility Type	**SPF**
Two-Lane Undivided	
Multiple-Vehicle Nondriveway	$N_{Total,\ MV\text{-}ND} = e^{(-15.22)} \times AADT^{1.68} \times L$
Single-Vehicle	$N_{Total,\ SV} = e^{(-5.47)} \times AADT^{0.56} \times L$
Multiple-Vehicle Driveway-Related	$N_{Total,\ MV\text{-}D} = n_{driveways} \times 0.075 \times (AADT/15{,}000)^{1.000}$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$
Three-Lane (Including center TWLTL)	
Multiple-Vehicle Nondriveway	$N_{Total,\ MV\text{-}ND} = e^{(-12.40)} \times AADT^{1.41} \times L$
Single-Vehicle	$N_{Total,\ SV} = e^{(-5.74)} \times AADT^{0.54} \times L$
Multiple-Vehicle Driveway-Related	$N_{Total,\ MV\text{-}D} = n_{driveways} \times 0.048 \times (AADT/15{,}000)^{1.000}$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$
Multilane Undivided	
Multiple-Vehicle Nondriveway	$N_{Total,\ MV\text{-}ND} = e^{(-11.63)} \times AADT^{1.33} \times L$
Single-Vehicle	$N_{Total,\ SV} = e^{(-7.99)} \times AADT^{0.81} \times L$
Multiple-Vehicle Driveway-Related	$N_{Total,\ MV\text{-}D} = n_{driveways} \times 0.087 \times (AADT/15{,}000)^{1.172}$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$
Multilane Divided	
Multiple-Vehicle Nondriveway	$N_{Total,\ MV\text{-}ND} = e^{(-12.34)} \times AADT^{1.36} \times L$
Single-Vehicle	$N_{Total,\ SV} = e^{(-5.05)} \times AADT^{0.47} \times L$
Multiple-Vehicle Driveway-Related	$N_{Total,\ MV\text{-}D} = n_{driveways} \times 0.016 \times (AADT/15{,}000)^{1.106}$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$
Five-Lane (Including center TWLTL)	
Multiple-Vehicle Nondriveway	$N_{Total,\ MV\text{-}ND} = e^{(-9.70)} \times AADT^{1.17} \times L$
Single-Vehicle	$N_{Total,\ SV} = e^{(-4.82)} \times AADT^{0.54} \times L$
Multiple-Vehicle Driveway-Related	$N_{Total,\ MV\text{-}D} = n_{driveways} \times 0.079 \times (AADT/15{,}000)^{1.172}$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$

Table 2.3 Urban and Suburban HSM Segment SPFs for Fatal and Injury Crashes

SPF Component by Facility Type	**SPF**
Two-Lane Undivided	
Multiple-Vehicle Nondriveway	$N_{KABC,\ MV\text{-}ND} = e^{(-16.22)} \times AADT^{1.66} \times L$
Single-Vehicle	$N_{KABC,\ SV} = e^{(-3.96)} \times AADT^{0.23} \times L$
Multiple-Vehicle Driveway-Related	$N_{KABC,\ MV\text{-}D} = N_{Total,\ MV\text{-}D} \times 0.323$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$
Three-Lane (Including center TWLTL)	
Multiple-Vehicle Nondriveway	$N_{KABC,\ MV\text{-}ND} = e^{(-16.45)} \times AADT^{1.69} \times L$
Single-Vehicle	$N_{KABC,\ SV} = e^{(-6.37)} \times AADT^{0.47} \times L$
Multiple-Vehicle Driveway-Related	$N_{KABC,\ MV\text{-}D} = N_{Total,\ MV\text{-}D} \times 0.243$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$
Multilane Undivided	
Multiple-Vehicle Nondriveway	$N_{KABC,\ MV\text{-}ND} = e^{(-12.08)} \times AADT^{1.25} \times L$
Single-Vehicle	$N_{KABC,\ SV} = e^{(-7.37)} \times AADT^{0.61} \times L$
Multiple-Vehicle Driveway-Related	$N_{KABC,\ MV\text{-}D} = N_{Total,\ MV\text{-}D} \times 0.342$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$
Multilane Divided	
Multiple-Vehicle Nondriveway	$N_{KABC,\ MV\text{-}ND} = e^{(-12.76)} \times AADT^{1.28} \times L$
Single-Vehicle	$N_{KABC,\ SV} = e^{(-8.71)} \times AADT^{0.66} \times L$
Multiple-Vehicle Driveway-Related	$N_{KABC,\ MV\text{-}D} = N_{Total,\ MV\text{-}D} \times 0.284$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$
Five-Lane (Including center TWLTL)	
Multiple-Vehicle Nondriveway	$N_{KABC,\ MV\text{-}ND} = e^{(-10.47)} \times AADT^{1.12} \times L$
Single-Vehicle	$N_{KABC,\ SV} = e^{(-4.43)} \times AADT^{0.35} \times L$
Multiple-Vehicle Driveway-Related	$N_{KABC,\ MV\text{-}D} = N_{Total,\ MV\text{-}D} \times 0.269$
Vehicle-Pedestrian	$N_{Ped} = \Sigma N_{Total} \times \text{CMFs} \times PedFactor_{Table12.8}$
Vehicle-Bicycle	$N_{Bike} = \Sigma N_{Total} \times \text{CMFs} \times BikeFactor_{Table12.9}$

2.2 Site Selection and Data Assembly

The HSM calibration procedure requires two essential types of data: (1) roadway attributes and (2) crash data. Each of these was assembled for the years 2005 through 2008.

The roadway characteristic data were collected through the Florida Roadway Characteristics Inventory (RCI), which is maintained by the Florida Department of Transportation (FDOT). The RCI contains a wide variety of roadway data for all roads that are maintained by FDOT. End-of-year archived copies of the RCI were obtained for years 2005, 2006, 2007, and 2008. As the RCI includes roadway segments that are no longer in use, as well as segments that are not part of the state highway system (SHS), the "STATEXPT" variable was used to restrict segments to those identified as "Active on SHS." This qualification was made because inactive and non SHS roadways do not have complete crash and geometric data that is necessary for HSM calibration. The proportion of the RCI segments which qualify as active segments for this analysis is shown in Table 2.4.

Table 2.4 RCI Percent Share by Section Status

Section Status	% Share			
	2005	2006	2007	2008
'1' – Pending	1.2	1.2	1.1	0.7
'2' - Active on SHS	11.1	11.3	11.1	9.1
'4' – Inactive	1.4	1.9	2.5	5.2
'5' – Deleted	1.7	2.2	2.2	2
'7' - Active Exclusive	9	9.9	10.9	25.4
'9' - Active off the SHS	75.6	73.6	72.1	56.6
'17' - Active off Exclusive	-	-	-	0.9
Total	100	100	100	100

For each year, twenty-one segment attributes were extracted from the RCI, resulting in data collected on fifteen of the twenty-one roadway attributes identified in Table A-2 of Volume 2 of the HSM (page A-6). Table 2.5 is derived from Table A-2 of the HSM and shows the segment data elements that were collected from the RCI and elements for which default values were assumed.

The reader will note from Table 2.1 that the majority of the necessary roadway characteristics were obtained from the RCI. For the data elements that were not available through the RCI, recommended HSM default values were assumed. In the case of roadside fixed objects, object offset and density assumptions were taken so that the CMF was equal to 1.0. For urban driveway density and type, default values were used based on the data used in the development of the urban and suburban arterial SPFs (*5*). In addition to the roadway attributes required by the HSM for Part C analysis, data on bike lanes were also included as part of this research effort.

Table 2.5 Segment Data Elements Used in the Development of Florida Calibration Factors

Required Roadway Characteristics	**Data Availability by Facility Type**[a]							
	Rural Two-Lane Two-Way Roads	**Rural Multilane Highways**		**Urban and Suburban Arterials**				
	R2U	R4U	R4D	U2U	U32LT	U4U	U4D	U52LT
Number of Lanes	✓	✓	✓	✓	✓	✓	✓	✓
Functional Classification	✓	✓	✓	✓	✓	✓	✓	✓
AADT	✓	✓	✓	✓	✓	✓	✓	✓
Median Type	✓	✓	✓	✓	✓	✓	✓	✓
Surface Width	✓	✓	✓	✓	✓	✓	✓	✓
Shoulder Type	✓	✓	✓					
Shoulder Width	✓	✓	✓					
Horizontal Curve Location	✓							
Median Width			✓				✓	
Number of Luminaries	✓	✓	✓	✓	✓	✓	✓	✓
Speed Limit				✓	✓	✓	✓	✓
Type of Parking				✓	✓	✓	✓	✓
Grade	✗							
Centerline Rumble Strips	✗							
Roadside Hazard Rating	✗							
Side Slope		✗						
Driveway Density	✗			✗	✗	✗	✗	✗
Roadside Fixed Objects				✗	✗	✗	✗	✗
Automated Speed Enforcement	No automated speed enforcement was used in Florida during the study period							
Bike Lane[b]	✓	✓	✓	✓	✓	✓	✓	✓
Bike Slot[b]	✓	✓	✓	✓	✓	✓	✓	✓

a: Where ✓ denotes that the data element was extracted from the RCI and ✗ denotes that a default value was assumed.
b: Bike lane attributes are not required by the HSM, but were considered relevant for investigation in Florida.

For the roadway characteristics for which information were available through the RCI, Table 2.6 gives the RCI variable associated with each data element. In cases such as lighting, shoulder width, and shoulder type, multiple RCI variables were required for the creation of the corresponding HSM segment attribute.

In the case of lighting presence, the RCI contained information on the number of luminaries along a given segment. In order to convert this data into whether or not the segment was to be considered lit, two lights were subtracted from the segment total for each boarding intersection, and the remaining lights were required to have a density of at least 26.4 lights per mile (one light every 200 feet), in order to be designated as a lit segment.

Multiple shoulder type and shoulder width variables were used in the case of rural two-way two-lane roads, in the identification of composite shoulders (a combination of paved and turf shoulders) for the shoulder CMF. While the HSM gives CMF values for a composite shoulder that is half paved and half turf (the resulting CMF is halfway between the CMF for a paved shoulder and the CMF for a turf shoulder), composite shoulders not conforming to this ratio are not addressed. For the purposes of this calibration analysis, shoulders were determined to be composite if the ratio of paved shoulder width to total shoulder width (paved plus turf) was between one-third and two-thirds.

Table 2.6 RCI Variable Names Associated with HSM Required Roadway Characteristics

Required Roadway Characteristics	RCI Variable(s)
Number of Lanes	NOLANES
Functional Classification	FUNCLASS
AADT	SECTADT
Median Type	RDMEDIAN
Surface Width	SURWIDTH
Shoulder Type	SHLDTYPE, SHLDTYP2, SHLDTYP3
Shoulder Width	SLDWIDTH, SHLDWTH2, SHLDWTH3
Horizontal Curve Location	HRZPTINT
Median Width	MEDWIDTH
Number of Luminaries	NOHMSLUM, NOSTDLUM, NOLOCLUM, NOUDKLUM
Speed Limit	MAXSPEED
Type of Parking	TYPEPARK
Grade	N/A
Centerline Rumble Strips	N/A
Roadside Hazard Rating	N/A
Side Slope	N/A
Driveway Density	N/A
Roadside Fixed Objects	N/A
Automated Speed Enforcement	No automated speed enforcement was used in Florida during the study period
Bike Lane	BIKELNCD
Bike Slot	BIKSLTCD

The data in the RCI are in the form of database tables with each table representing an attribute. The rows in each table identify locations along the roadway where the corresponding attribute (such as number of lanes or shoulder width) changes value. As all attributes do not change value at the same locations, a segmenting procedure was developed to create homogenous roadway segments needed for the calibration procedure. This involves systematically splitting the roadway at points in which any of the attribute value changes (See Figure 1 for a schematic illustration of this procedure). As a result, the majority of Florida highways were divided into segments of less than half of a mile in rural locations and less than a quarter of a mile in urban locations. While the HSM does not establish a minimum segment length, the authors implemented a minimum of 0.10 miles for rural segments and 0.04 miles for urban segments; these lengths were the minimums used in the research efforts to develop the HSM SPFs (*5, 6, 7*). Segments shorter than these minimum thresholds were not used in the analysis.

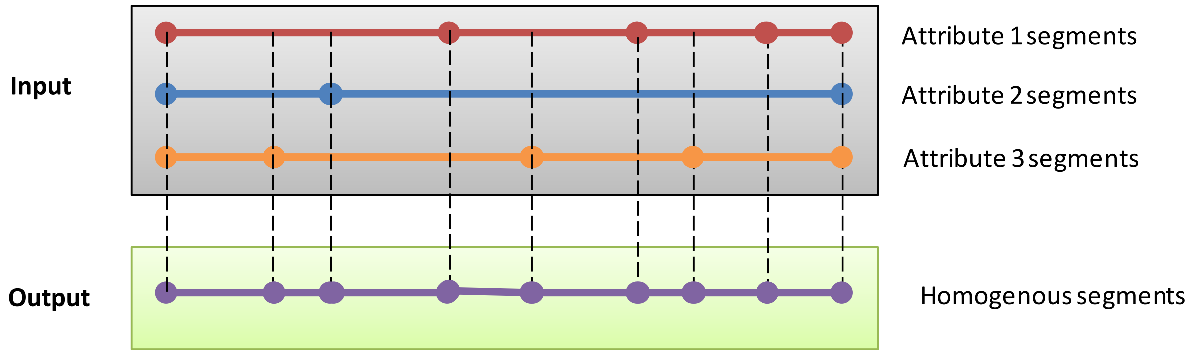

Figure 2.1 Creation of Homogeneous Segments from the Florida RCI

The segmentation procedure incorporated several consistency checks, including the removal of segments with missing and/or internally inconsistent attributes. It was ensured that segments do not include intersections, and curves were removed from the analysis. The entire segmentation procedure was automated using a Python script, and the output of this program was a set of homogenous roadway segments with all the necessary attributes required for calibration. Only segments that remained homogenous for all four years were retained for analysis in order to ensure consistency in year-to-year comparisons. See Appendix A for a detailed description of the segmentation procedure.

After the segments were identified, crashes were extracted from Florida's Crash Analysis Reporting System (CARS) for the 2005 through 2008 study period. The crashes identified as "occuring at an intersection" or "influenced by an intersection" in the crash reports were excluded. The remaining crashes were then assigned to roadway segments depending on their locations relative to the starting and ending mileposts of the segments.

Crash reporting in Florida is a three-tier system: long-form reports, short-form reports, and driver's reports (*8*). Long-form reports must be completed for any crashes involving injuries or fatalities, hazardous materials, government owned property, or the act of commiting a criminal offense; whereas, short-form reporting is used for property damage only crashes. Only crashes recorded using the long-form reports are included in the CARS database (*9*). Due to this limitation, only crashes with injuries or fatalities were included for analysis in this study, as the majority of the property damage only crashes are not readily available for analysis in Florida. Therefore, calibration factors developed in this study are for the fatal and injury crash SPFs and not for the total crash SPFs. The concentration on only fatal and injury crashes is not detrimental to statewide safety analysis due to the proven impact of crashes to be skewed heavily towards fatal and injury crashes (*10*).

Table 2.7 shows the number of segments, total mileage, and observed crashes for each year of the study period for the eight HSM segment types. Seven of the eight segment facility types met the recommended HSM values of at least 100 crashes on at least 30 to 50 segments. The SPFs for the rural four-lane undivided facility were not calibrated for the lack of adequate data.

Within the HSM crash esimation procedure for fatal and injury crashes on rural segments, the HSM offers two crash prediction equations, one for the KAB levels of severity and one for the KABC levels of severity. However, the urban and suburban procedure does not make this distinction, and single equations including only severity levels KABC are presented.

Table 2.7 Description of Segment Facility Types in Florida

Facility Attributes		**Segment Statistics by HSM Facility Types in Florida**							
		Rural Two-Lane Two-Way Roads	**Rural Multilane Highways**		**Urban and Suburban Arterials**				
		R2U	R4U	R4D	U2U	U32LT	U4U	U4D	U52LT
Total Number of Segments		4811	25	1351	5076	709	1251	7506	2868
Sum of Segment Lengths (mi.)		2121.0	4.6	546.2	628.4	66.3	96.1	970.6	253.6
Mean AADT	2005	5295	8164	15137	12179	15543	22849	28105	27889
	2006	5466	7972	15675	12472	15695	23128	28614	28123
	2007	5491	8784	15464	12511	15685	23256	28610	27877
	2008	5471	8348	15245	12390	15476	22470	28282	27699
Fatal and Injury Crashes	2005	951	0	587	962	112	298	3008	1024
	2006	982	2	589	881	134	348	2834	1029
	2007	948	4	584	1017	122	352	2916	998
	2008	906	4	546	836	121	320	2782	970
Fatal and Injury Crashes[a]	2005	664	0	386	-	-	-	-	-
	2006	691	2	390	-	-	-	-	-
	2007	629	3	378	-	-	-	-	-
	2008	617	3	347	-	-	-	-	-

a: Using the KABCO scale, these include only KAB crashes; crashes with severity level C (possible injury) are not included.

2.3 Segment Calibration Results

The calibration results are presented in this section. The complete set of calibration factors to be used in applying the HSM Part C predictive method to segments in Florida is given in Table 2.8. This calibration also includes the use of Florida-specific crash distributions for crash type on rural roads and nighttime crash distribution for rural and urban and suburban roads that were developed as a part of this research effort.

The yearly fluctuation of the calibration factors in Table 2.8 is apparent, including a significant decrease in crashes across six of the facility types in 2007 and 2008. Thus, yearly calibration factors strongly reflect the most recent trends in local crash history. The facility type with the greatest difference in expected crashes from the Washington State data from which the models were developed is the urban and suburban four-lane divided arterials. This segment type in Florida experiences sixty to seventy-five percent more crashes than similar segments in Washington State. With the exception of the urban and suburban four-lane divided arterials, three of the remaining facility types have calibration factors consistently lower than 1.0, and three roughly fluctuate near 1.0.

Table 2.8 Florida Segment Calibration Factors for Fatal and Injury Prediction Models

Calibration Factor Time Frame		**Calibration Factors by Facility Type**						
		Rural Two-Lane Two-Way Roads	**Rural Multilane Highways**	**Urban and Suburban Arterials**				
		R2U	R4D	U2U	U32LT	U4U	U4D	U52LT
HSM SPF that was Calibrated		Eq. 10-6	Eq. 11-9	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20	Eq. 12-10, 12-13, 12-16, 12-19, & 12-20
Fatal and Injury Crashes (KABC)	2005	1.063	0.719	1.093	0.952	0.641	1.750	0.710
	2006	1.069	0.696	0.977	1.126	0.742	1.611	0.726
	2007	1.026	0.701	1.119	1.028	0.749	1.653	0.711
	2008	0.980	0.665	0.928	1.046	0.707	1.602	0.695
	2005-2006	1.066	0.707	1.035	1.040	0.692	1.680	0.693
	2007-2008	1.005	0.683	1.025	1.038	0.729	1.628	0.669
Fatal and Injury Crashes (KAB)[a]	2005	1.353	0.769					
	2006	1.372	0.752					
	2007	1.241	0.740					
	2008	1.217	0.688					
	2005-2006	1.362	0.760					
	2007-2008	1.232	0.714					

a: Using the KABCO scale, these include only KAB crashes; crashes with severity level C (possible injury) are not included.

To accurately apply the CMFs in the crash prediction process, the researchers developed crash-type distributions for each facility type to replace the HSM default values. These crash-type distributions replace the values found in Table 10-4, Table 10-12, Table 11-6, Table 11-19, and Table 12-23 of Volume 2 of the HSM. The original HSM default crash distribution values and the corresponding Florida crash distributions are presented in Appendix B. Further, the procedure for generating these distributions is also described in Appendix B.

The percentage of relevant collisions for CMF applicability in Florida showed significant differences from the HSM default values. For rural facilities, the CMFs for lane width and shoulder width apply to run-off-the-road, head-on, and sideswipe crashes. By using HSM default values, these three crash types would be overestimated by twenty percent on two-lane two-way segments and twenty-five percent on multilane segments, as compared to the observed Florida crashes.

A comparison of the calibration factors for rural roads based on the origin of the collision type distribution is provided in Table 2.9. Urban and suburban roads are not included in Table 2.9 due to the fact that collision type distributions do not factor into any urban and suburban segment CMFs, thus they do not impact the calculated calibration factor. For Florida, the calibration factors with and without state-specific collision type distributions are similar due to the fact that many of the segments fit the base conditions of the SPF; therefore, the applicable CMF is 1.0, and the collision type distributions are not a part of the crash estimation procedure. For example, on rural multilane divided highways, only 3.4 percent of segments have a lane width CMF that is not equal to 1.0, and on rural two-lane two-way roads, 10.4 percent of segments have lane width and shoulder width CMFs that are not equal to 1.0. As a result, despite the difference in crashes affected by the lane width and shoulder width CMFs, the calibration factor was not significantly different when using the HSM default values versus the Florida derived values. This has also been observed by researchers in other states who have also developed state-specific collision type distributions for this purpose (*2*).

Table 2.9 Comparison of Calibration Factors Using HSM and Florida Collision Type Distributions

Collision Type Distribution	**Calibration Factor by Year and Collision Type Distribution**			
	2005	**2006**	**2007**	**2008**
Rural Two-Lane Two-Way Roads				
Calibration Factor with HSM Default Values	1.072	1.079	1.035	0.987
Calibration Factor with Florida Derived Values	1.063	1.069	1.026	0.980
Rural Multilane Divided Highways				
Calibration Factor with HSM Default Values	0.719	0.696	0.701	0.664
Calibration Factor with Florida Derived Values	0.719	0.696	0.701	0.665

In the context of urban and suburban four-lane divided segments in Florida, the presence of bike lanes can be expected to affect the safety of the facility. As a CMF to control for this feature was not readily available, this study explored simplified approaches to accommodate the effect of bike lanes. This is discussed in further detail in Appendix C.

2.4 Sensitivity Analysis

The most difficult and time intensive aspects of the HSM calibration procedure are data collection and data processing. Many prospective HSM users either do not have the necessary data readily available or do not have it organized in a fashion that is conducive to HSM analysis. In the available Florida data, there were two elements for both rural and urban facilities for which the authors had to assume values: driveway density and roadside hazard rating for rural segments and driveway density and roadside fixed object for urban segments. In order to examine the impacts of these assumptions on the HSM crash estimation procedure in Florida, a sensitivity analysis was performed.

In the sensitivity analysis, 2008 crash frequency was estimated for segments using the calibration factors from 2007 and the assumptions discussed in the “Site Selection and Data Collection” section (standard application of the HSM Part C predictive method for 2008). Next, the crash frequency was calculated again for each segment using the same calibration factors and varying the relevant assumptions by 50 percent and 200 percent. These two crash frequency estimations were compared to find the change in the number of predicted crashes due to the variations in the assumptions. An example of the results table is given in Table 2.10, which shows the average difference in predicted KABC fatal and injury crashes on rural two-lane two-way segments for varying driveway density and roadside hazard rating assumptions. The values are relative to crashes predicted under “default” conditions of 5 driveways per mile and roadside hazard rating of 3. Appendix D gives the complete results of the sensitivity analysis for each facility type in tables of similar structure to Table 2.10.

Table 2.10 Difference in Crashes per Mile by Varying Assumptions

Assumptions		**Difference in Crashes per Mile**					
Driveway Density (driveways/mi.)	**Roadside Hazard Rating**	**Minimum**	**5%**	**Mean**	**95%**	**Maximum**	**Standard Deviation**
5	3	-	-	-	-	-	-
5	1	-0.31	-0.14	-0.06	-0.02	0.00	-0.040
5	5	0.01	0.02	0.07	0.16	0.35	0.047
10	1	-0.31	-0.10	-0.02	0.00	0.00	0.039
10	3	0.00	0.02	0.04	0.05	0.07	0.010
10	5	0.01	0.05	0.11	0.21	0.35	0.051
2.5	1	-0.30	-0.14	-0.06	-0.02	0.00	0.040
2.5	3	0.00	0.00	0.00	0.00	0.03	0.002
2.5	5	0.01	0.02	0.07	0.16	0.37	0.047

As Table 2.10 shows, in the case of the driveway density and roadside hazard rating assumptions for rural two-lane two-way roads, varying the assumptions causes a small change in the predicted crashes per mile. Under the worst case scenario, where both driveway density and roadside hazard rating were increased, there were 0.11 more crashes per mile predicted, meaning that if real world conditions in Florida were twice what they were assumed to be in this research effort, then the developed calibration factor with the Part C predictive method would systematically under-predict crashes by an average of 0.11 crashes per mile.

For urban and suburban facility types, a similar procedure was carried out, varying the driveway density and roadside fixed object assumptions. Across the five segment types, the average worst case scenario experienced a difference of 1.11 crashes per mile. However, it is unlikely that any of these scenarios would be realized, as the doubling of driveway density assumptions resulted in average driveway densities of over 80 driveways per mile for some segment types. Segments are not expected to experience an average driveway density this high, as a previous study in Florida identified average driveway densities for U32LT and U52LT segment types to be 32.86 driveways per mile, less than the default values assumed for these segments in this research effort (*12*).

Overall, it appears that the predicted crash rates will not be substantially different even if the true values of attributes such as driveway density and roadside hazard rating were significantly different from the “default” values assumed in the development of the calibration factors. At the same time, this exercise assumes a constant value for each of these attributes across all segments. The impact when the value of factors such as driveway density and roadside hazard vary by segments still remains to be tested.

2.5 Calibration Benefit

The purpose of the calibration process is to adapt the HSM crash prediction models to reflect the conditions of the area in which they are to be implemented. This section seeks to identify the empirical benefits of calibration in Florida. The following procedure was employed.

First, for each of the seven segment types, the uncalibrated (or Base) SPFs from the HSM and other default values on crash type distributions were used to predict the crashes on all segments in 2008. The error in prediction of the uncalibrated model for each segment was calculated as the difference in the observed and predicted crashes.

Next, for each of the seven segment types, the calibrated (using 2007 data) SPFs from the HSM and other Florida-specific values on crash type distributions were used to predict the crashes on all segments in 2008. The error in prediction of the calibrated model for each segment was calculated as the difference in the observed and predicted crashes.

Results comparing the prediction errors from the uncalibrated and calibrated models are given in Table 2.11. The magnitude of the average prediction errors from calibrated models was lower than the corresponding values from the uncalibrated models for five of the seven facility types; the two exceptions being rural two-lane two-way segments and urban and suburban two-lane undivided segments. This means that the total number of crashes observed across all segments of a specific facility type is closer to the total crashes predicted by the calibrated model than the total crashes predicted by the uncalibrated model for five of the seven facility types.

However, the average absolute error improved with calibration only for three facility types. It is interesting to note that all the three facility types with reduced absolute error after calibration were those that had 2007 calibration factors of less than 1.0. This may be due in part to the increase of error on zero-crash segments that is caused by a calibration factor greater than 1.0 (Note that the SPFs will necessarily over-predict the crashes for segments observed to have 0 crashes as it cannot predict negative values, and the extent of this over-prediction from a calibrated model will be higher than an uncalibrated model if the calibration factor is greater than 1.0).

The most substantial benefit of calibration across all facility types is in the variance and range of the prediction errors. Calibrated models showed a smaller variance of mean absolute error and a smaller range of mean absolute error for five and six facility types, respectively. These improvements are important because they show that calibration does reduce the number of segments where crashes are severely under or over predicted.

It is also useful to note that similar trends were also seen when carrying out this prediction-comparison procedure for another pair of years (2005-2006). The results of the 2006 predictions based on 2005 calibrations are shown in Table 2.12.

It is useful to note that the approach of comparing predictions for a single year was dictated by data limitations. It would be more appropriate to make forecasts for multiple future years and compare the expected predicted crashes with the observed crashes over the longer time horizon. This would consistent with the approach of assessing the safety benefits of any roadway improvement project over its “life span”. Such a multi-year predictive analysis and validation is identified as a future step once data for a few more years are available.

Table 2.11 Base SPF versus Calibrated SPF Comparisons for 2008 Segment Crash Predictions

Facility Type	**Crash Prediction Error Statistics**							
	Mean Error		**Mean Absolute Error**		**Variance of Absolute Error**		**5% to 95% Range of Absolute Error**	
	Base SPF	**Calibrated SPF**	**Base SPF**	**Calibrated SPF**	**Base SPF**	**Calibrated SPF**	**Base SPF**	**Calibrated SPF**
R2U	0.003	0.009	0.275	0.278	0.157	0.155	0.910	0.908
R4U	0.204	0.022	0.568	0.478	0.434	0.326	1.639	1.553
U2U	0.013	0.034	0.267	0.281	0.148	0.149	0.881	0.873
U32LT	-0.008	-0.003	0.267	0.270	0.160	0.158	0.870	0.867
U4U	0.106	0.015	0.435	0.386	0.435	0.386	1.273	1.033
U4D	-0.140	0.020	0.425	0.483	0.377	0.327	1.644	1.501
U52LT	0.148	0.008	0.532	0.467	0.246	0.271	1.249	1.328

Table 2.12 Base SPF versus Calibrated SPF Comparisons for 2006 Segment Crash Predictions

Facility Type	**Goodness of Fit Measures**							
	Mean Error		**Mean Absolute Error**		**Variance of Mean Absolute Error**		**5% to 95% Range of Mean Absolute Error**	
	Base SPF	**Calibrated SPF**	**Base SPF**	**Calibrated SPF**	**Base SPF**	**Calibrated SPF**	**Base SPF**	**Calibrated SPF**
R2U	-0.015	-0.001	0.284	0.290	0.196	0.192	0.911	0.907
R4U	0.191	0.014	0.566	0.481	0.372	0.311	1.647	1.518
U2U	0.004	0.021	0.269	0.278	0.154	0.152	0.872	0.864
U32LT	-0.022	-0.029	0.289	0.284	0.176	0.179	0.862	0.868
U4U	0.097	-0.038	0.436	0.370	0.207	0.241	1.081	0.957
U4D	-0.144	0.033	0.436	0.500	0.459	0.402	1.634	1.503
U52LT	0.136	-0.008	0.546	0.484	0.293	0.335	1.291	1.404

2.6 Geographic Segmentation

Factors contributing to crash frequency could also vary across Florida due to a statewide diversity of driver demographics, weather patterns, and land usage. To examine the existence of such variations, the data were segmented (grouped) based on the location of the roadway within the state. The calibration process was repeated for each group and the local, group-specific calibration factors were compared to the overall, statewide calibration factors discussed earlier. If significant differences exist, this implies that it would be beneficial to utilize separate calibration factors in certain areas where driving conditions cause crash patterns to differ greatly.

The above procedure was carried out twice – first by segmenting the roadways by FDOT district (Section 2.6.1), and second by dividing them based on their respective county's population density (Section 2.6.2).

2.6.1 Segmentation by FDOT Districts

To illustrate any variations in crash-frequency across the districts, this process was first applied by grouping each roadway segment by county, and subsequently dividing the counties belonging to each of the FDOT's seven districts.

Table 2.13 shows the length of roadway available in the data for each district. For most facility types, it is obvious that sufficient mileage does not exist in each individual district to provide for statistically-significant results. The facility types with the maximum mileage at district level were rural two-lane undivided roads and urban four-lane divided arterials. The results for these two cases are discussed below. Those for each remaining facility type can be found in Appendix E.

Table 2.13 Lengths of Facility Type by District

District	**Lengths of Roadway Segments**						
	Rural Two-Lane Two-Way Roads	**Rural Multilane Highways**	**Urban and Suburban Arterials**				
	R2U	R4D	U2U	U32LT	U4U	U4D	U52LT
D1	419.76	109.55	88.39	10.52	9	177	23.7
D2	550.32	163.65	109.6	6.01	21	155	40.79
D3	660.28	69.73	114.1	10.69	15	136	43.48
D4	65.78	46.56	79.04	16.29	13	79.2	26.44
D5	269.96	124.77	107.3	11.26	14	268	77.78
D6	69.05	6.17	50.9	4.88	13	50.6	23.77
D7	85.81	25.74	79.1	6.59	12	105	17.6

In the Table 2.14, C_d / C_o denotes the ratio between the new district-wide calibration factor to the overall factor for the state of Florida. For instance, it can be deduced that for District 1 in 2005 ($C_d / C_o = 0.97$) the district calibration factor was three percent less than the overall. The following year however, District 1's district calibration factor was three percent greater.

The reader will note in every case except Districts 6 and 3, the average yearly variation (shown in the final column) is less than ten percent. However, the yearly values vary significantly. In District 6's case, the district factor is consistently greater than the overall factor, but in most cases, this relationship is not as consistent. From these results, it is not possible to predict whether the overall calibration factor over or underestimates crash frequency on rural two-lane roads in individual districts.

Table 2.14 Rural Two-Lane KABC District-Calibration

District	Average Crashes/Year	C_d / C_o				
		2005	2006	2007	2008	Avg.
D1	189.75	0.97	1.03	0.96	0.88	0.96
D2	209.25	0.94	1.01	1.01	1.19	1.04
D3	210.25	0.68	0.85	0.92	0.98	0.86
D4	30	1.15	1.00	0.78	0.75	0.92
D5	148.25	0.99	1.15	1.05	0.94	1.03
D6	89	1.23	1.32	1.15	1.27	1.24
D7	70.25	0.98	0.76	1.18	0.87	0.95

Table 2.15 shows the variation between the district and overall calibration factors for urban four-lane arterials. For Districts 1-4, the general trend is a smaller district factor, implying that the overall calibration factor tends to slightly overestimate the crash frequency for these districts. The opposite occurs for Districts 6 and 7.

The cause for these consistent trends in the data is unknown, since the relative location of the districts is not in itself a contributing factor to crash frequency. To develop a better understanding of why the overall calibration leads to overestimations in certain districts and underestimations in others, factors that directly contribute to traffic behavior should be considered.

Table 2.15 Urban Multilane Divided KABC District-Calibration

District	Average Crashes/Year	C_d / C_o				
		2005	2006	2007	2008	Avg.
D1	456.25	0.85	0.90	0.90	0.91	0.89
D2	387.25	0.86	0.87	0.99	0.92	0.91
D3	411	1.00	0.95	0.82	0.81	0.89
D4	158.75	0.97	0.88	0.82	0.97	0.91
D5	828.5	1.03	0.99	0.98	1.05	1.01
D6	221.75	1.10	1.20	1.24	1.12	1.17
D7	421.5	1.34	1.42	1.48	1.34	1.40

2.6.2 Segmentation by County Population Density

As a second segmenting factor, the counties were divided into four groups based on population density levels. Group 1 included Florida's six most populous counties (excluding Pinellas), from Broward (1,445 per sq. mile) to Duval (1,134 per sq. mile). Group 2 included the next ten, with Lee County as the most populous (788 per sq. mile) and Leon County as the most sparsely populated (413 per sq. mile) of the group. The next eighteen counties comprise Group 3 – these span from Hernando County (365 per sq. mile) to Santa Rosa County (150 per sq. mile). The fourth and final Group, consists of the remaining thirty-two, and includes Nassau County (113 per sq. mile) and Liberty County (Florida's least densely populated with merely 10 per sq. mile).

Pinellas – Florida's most densely populated county – is a major outlier, having more than twice the population density of the runner-up, Broward County. Since none of the available data is from Pinellas County, it was ignored for this study. Information on county population density was taken from the 2010 U.S. Census (*13*).

Table 2.16 shows the roadway mileage available in the data for each facility type and individual group number. Again, rural two-lane roads and urban multilane divided arterials are discussed below, while the results for each other facility type can be found in Appendix E.

Table 2.16 Lengths of Facility Type by Population Density Group Number

District	**Lengths of Roadway Segments**						
	Rural Two-Lane Two-Way Roads	**Rural Multilane Highways**	**Urban and Suburban Arterials**				
	R2U	R4D	U2U	U32LT	U4U	U4D	U52LT
G1	92.44	36.27	138.93	7.74	47.94	240.3	91.75
G2	215.15	80.77	202.62	24.79	26.96	272.1	80.55
G3	596.88	238.58	170.59	18.41	8.98	373.8	66.05
G4	1216.49	190.55	105.98	12.23	9.85	66.81	10.04

Table 2.17 shows the results of the population density segmentation for rural 2-lane roads. The obvious trend in the data is that the group-to-overall calibration factor ratio (C_g / C_o) consistently decreases with simultaneously with population density. For instance, note that the average ratio for Group 1 (the highest-density group) is 1.22, implying that its calibration factor is 22 percent greater than the overall factor. With each successive group, the average ratio decreases, until finally it reaches 0.94 for Group 4 (the lowest-density group).

Furthermore, this trend is clearly visible for each single year of the study, implying that the overall calibration factor consistently tends to underestimate crash frequency on rural 2-lane roads in more populated areas, while overestimating in those counties with less density.

Table 2.17 Rural 2 Lane KABC Population Density-Calibration

District	**Average Crashes/Year**	**C_g / C_o**				
		2005	**2006**	**2007**	**2008**	**Avg.**
G1	110.50	1.28	1.23	1.30	1.07	1.22
G2	129.75	1.06	1.11	1.21	1.05	1.11
G3	290.25	1.05	1.02	0.91	0.93	0.98
G4	416.25	0.89	0.91	0.94	1.02	0.94

Table 2.18 suggests that the same appears to be true for urban facility types. Again, the group-to-overall ratio decreases steadily with population density. Higher population counties (particularly those in the highest-density group) tend to experience more crashes than are accounted for by the statewide calibration factor.

The results for the remaining facility types (especially those for which a larger portion of data is available) appear to support the same trend (See Appendix E for details). The implication of these results is that it may be beneficial for higher-density areas to develop local or county-wide calibration factors, to avoid severely underestimating crash frequency.

Table 2.18 Urban 4 Lane Divided KABC Population Density-Calibration

District	**Average Crashes/Year**	**C_g / C_o**				
		2005	**2006**	**2007**	**2008**	**Avg.**
G1	1011.50	1.23	1.28	1.32	1.23	1.26
G2	768.00	0.98	0.96	0.88	1.04	0.96
G3	922.25	0.87	0.86	0.87	0.83	0.86
G4	126.25	0.82	0.77	0.91	0.79	0.82

2.7 Florida-Specific SPFs

While the HSM supplies SPFs and provides a methodology for calibrating those SPFs to local conditions, it also notes that development of SPFs for a local area is possible if sufficient data are available (*1*). Development of a local SPF may provide more accurate crash estimations than calibration due to the flexibility that model development allows. The calibration process results in a factor that is multiplied to the existing SPF; however, the coefficient on the AADT variable of the regression model remains the same. The lack of flexibility in this coefficient forces the assumption that the general shape of the relationship between crashes and volume is identical for both the SPF's base area and the local area. While this assumption may hold true, or at least be reasonably close, it is possible that the same factors that necessitate calibration may also affect this relationship. These factors include driver behavior, weather, animal populations, crash reporting thresholds, and local road conditions.

Florida-specific SPFs were developed in order to compare the crash estimation results of locally derived SPFs to calibrated SPFs. Two facility types (those with the maximum volume of data) were considered for SPF development and comparison with the calibration approach: (1) rural two-lane roads and (2) urban and suburban four-lane divided arterials. The same data used for the calibration (described in Section 2.2 and Section 2.3) were also used for SPF development. Further, in this case, 80 percent of the data points from all four years were used to generate a calibration factor based on the HSM methodology and a Florida-specific SPF, while 20 percent of the data was withheld for comparison of the two procedures. As previously discussed, PDO crash data was not available in Florida, as a result, the SPFs developed and this comparison were conducted using KABC severity crashes.

As expected, the computed calibration factor for each of the two facility types with 80 percent of the data was very similar to the four year average calibration factor previously calculated. The calibration factor for rural two-lane roads was 1.039, and the calibration factor for urban and suburban four-lane divided arterials was 1.657.

The SPFs were developed using negative binomial regression, taking the form shown in Equation 1.1 and repeated here:

$$N_{spf} = exp\,(a + b \times ln(AADT) + ln(Length)) \qquad \text{Equation 2.1}$$

where *a* and *b* are regression coefficients, *AADT* is the annual average daily traffic volume on the segment, and *Length* is the length of the segment in miles. The SPFs for Florida were developed using all available segments for each year, rather than base conditions only, such that the application of CMFs is not necessary for crash prediction.

The model coefficients developed for the Florida-specific SPFs, as well as comparisons to the HSM SPF model coefficients, are given in Table 2.19. While the model form for the SPFs for rural two-lane roads are the same for the Florida SPF and the HSM SPF, the Florida and HSM urban four-lane divided arterial SPFs do not have identical model forms. The HSM SPFs for urban arterials consist of independent estimations of multivehicle non-driveway crashes, single vehicle crashes, and multivehicle driveway related crashes (*1*). Of these three components, multivehicle non-driveway crashes make-up an average of 84 percent of the total crashes. The prediction model for multivehicle non-driveway is also the same model form as shown in Equation 2.1. Therefore, the model coefficients for multivehicle non-driveway crash estimation are shown in Table 2.19 for coefficient comparison to the Florida SPF, although the comparison is not as direct as for the rural two-lane roads.

Table 2.19 Florida and HSM Model Coefficients for Fatal and Injury (KABC) Crashes

Facility Type	**a**	**b**	**Overdispersion Parameter**	**Calibration Factor**
Florida Rural Two-Lane	-9.012	0.964	0.549	N/A
HSM Rural Two-Lane	-9.364	1.000	0.236	1.039
Florida Urban Four-Lane Divided	-11.010	1.185	0.807	N/A
HSM Urban Four-Lane Divided Non-Driveway	-12.760	1.280	1.310	1.657[1]

1: This calibration factor is for urban four-lane divided fatal and injury crashes, not specific to non-driveway crashes.

After calculating calibration factors and developing Florida-specific SPFs based on the aforementioned randomly selected 80 percent of the data, the two crash estimation procedures were applied to the remaining 20 percent of the data. The error was then calculated based on the difference between the number of crashes observed on a given site and the number of crashes predicted. Table 2.20 displays the error statistics for the HSM calibration and Florida-specific SPF methods of crash estimation.

Table 2.20 Florida SPF and Calibrated HSM SPF Error Statistics

Facility Type		Average Error	Variance of Error	5% Error	95% Error	Average Absolute Error	Variance of Absolute Error	5% Absolute Error	95% Absolute Error
Rural Two-Lane	Florida SPF	0.008	0.218	-0.897	0.464	0.276	0.142	0.030	0.925
	Calibrated HSM	0.005	0.218	-0.899	0.457	0.274	0.143	0.029	0.925
Urban Four-Lane Divided	Florida SPF	0.023	0.649	-1.442	0.850	0.508	0.391	0.082	1.638
	Calibrated HSM	0.004	0.639	-1.486	0.798	0.500	0.388	0.079	1.605

Based on Table 2.20, there is not a system-wide improvement in the accuracy of (average) crash prediction through the development of state-specific SPFs relative to the use of the calibrated HSM equations. Several factors could contribute to this result. In the case of the rural 2-lane facility, the state-level equation closely mirrors the HSM equation (as was also evidenced by the calibration factor being very close to 1). Thus, for this facility type, Florida might be reasonably similar to the areas used to develop the corresponding HSM equation. In the case of the urban facility examined, the HSM has separate equations by crash type whereas the Florida equation does not vary by crash type. Finally, although 20 percent of the data points were withheld for testing the application of the model, these still come from the same years for which the model and the calibration factor were developed. Any true potential benefits to developing Florida-specific SPFs would be seen when using the SPF to estimate crashes in future years. Further analysis is needed when more years of data are available in order to test this possibility.

CHAPTER 3
CALIBRATION OF INTERSECTION SPFS

This chapter describes the calibration of the intersection SPFs for Florida Conditions. The intersection level SPFs presented in the HSM are first listed and those calibrated in this study are identified (Section 3.1). Next, in Section 3.2, the site selection and data assembly procedure is discussed extensively. Finally, in Section 3.3, the calibration results are presented and discussed.

Unlike in the case of Segment SPF calibration, geographic segmentations, sensitivity analysis, and predictive analyses were not undertaken due to the significantly small sizes of the estimation samples.

3.1 List of Intersection SPFs

The first version of the HSM provides intersection-level SPFs for three intersection types on rural two-lane two-way roads, three intersection types on rural multilane roads, and four intersection types on urban and suburban arterials. The rural two-lane two-way intersection types are: (1) three-leg stop controlled (R2 3ST), (2) four-leg stop controlled (R2 4ST), and (3) four-leg signalized (R2 4SG). The rural multilane intersection types are: (1) three-leg stop controlled (RM 3ST), (2) four-leg stop controlled (RM 4ST), and (3) four-leg signalized (RM 4SG). The urban and suburban arterial intersection types are: (1) three-leg stop controlled (U 3ST), (2) four-leg stop controlled (U 4ST), (3) three-leg signalized (U 3SG), and (4) four-leg signalized (U 4SG).

The HSM procedure for intersection crash prediction is very similar to that of roadway segments, since each facility type requires a specific SPF which calculates the crash frequency for base conditions. Additionally, separate SPFs are generally provided for analyzing total crashes (includes crashes with property damage only) and only fatal and injury crashes. A very limited sample size of intersections was available for this study. As such, not every facility type had a large enough sample size for a calibration factor to be calculated. Additionally, similarly to the segment calibration, the SPFs for total crashes were not calibrated, as all PDO crashes are not fully recorded by the long-form crash reports used to populate Florida's CAR System. Table 3.1 provides a reference to all rural intersection SPF equations relevant to this chapter, and a notation as to whether or not it could be calibrated.

Table 3.1 Rural HSM Intersection SPFs by Facility Type and Severity Level

Facility Type by Crash Severity Level	SPF	Calibrated for Florida
Total Crashes		
Rural Two-Lane Three-Leg Stop-Controlled	$N_{Total} = AADT_{maj}^{0.79} \times AADT_{min}^{0.49} \times e^{(-9.86)}$	No[a]
Rural Two-Lane Four-Leg Stop-Controlled	$N_{Total} = AADT_{maj}^{0.60} \times AADT_{min}^{0.61} \times e^{(-8.56)}$	No[a]
Rural Two-Lane Four-Leg Signalized	$N_{Total} = AADT_{maj}^{0.60} \times AADT_{min}^{0.20} \times e^{(-5.13)}$	No[a]
Rural Multilane Three-Leg Stop-Controlled	$N_{Total} = AADT_{maj}^{1.204} \times AADT_{min}^{0.236} \times e^{(-12.526)}$	No[a]
Rural Multilane Four-Leg Stop-Controlled	$N_{Total} = AADT_{maj}^{0.848} \times AADT_{min}^{0.448} \times e^{(-10.008)}$	No[a]
Rural Multilane Four-Leg Signalized	$N_{Total} = AADT_{maj}^{0.722} \times AADT_{min}^{0.337} \times e^{(-7.182)}$	No[a]
KABC Fatal and Injury Crashes		
Rural Two-Lane Three-Leg Stop-Controlled	$N_{KABC} = N_{Total} \times 0.415$	Yes
Rural Two-Lane Four-Leg Stop-Controlled	$N_{KABC} = N_{Total} \times 0.431$	Yes
Rural Two-Lane Four-Leg Signalized	$N_{KABC} = N_{Total} \times 0.340$	Yes
Rural Multilane Three-Leg Stop-Controlled	$N_{KABC} = AADT_{maj}^{1.107} \times AADT_{min}^{0.272} \times e^{(-12.664)}$	No[b]
Rural Multilane Four-Leg Stop-Controlled	$N_{KABC} = AADT_{maj}^{0.888} \times AADT_{min}^{0.525} \times e^{(-11.554)}$	No[b]
Rural Multilane Four-Leg Signalized	$N_{KABC} = AADT_{maj}^{0.638} \times AADT_{min}^{0.232} \times e^{(-6.393)}$	Yes
KAB Fatal and Injury Crashes		
Rural Two-Lane Three-Leg Stop-Controlled	$N_{KAB} = N_{Total} \times 0.223$	Yes
Rural Two-Lane Four-Leg Stop-Controlled	$N_{KAB} = N_{Total} \times 0.223$	Yes
Rural Two-Lane Four-Leg Signalized	$N_{KAB} = N_{Total} \times 0.135$	Yes
Rural Multilane Three-Leg Stop-Controlled	$N_{KAB} = AADT_{maj}^{1.013} \times AADT_{min}^{0.228} \times e^{(-11.989)}$	No[b]
Rural Multilane Four-Leg Stop-Controlled	$N_{KAB} = AADT_{maj}^{0.828} \times AADT_{min}^{0.412} \times e^{(-10.734)}$	No[b]
Rural Multilane Four-Leg Signalized	$N_{KAB} = \mathrm{AADT}_{\mathrm{total}}^{1.279} \times e^{(-12.011)}$	Yes

a : SPFs were not calibrated due to poor data quality of PDO crashes.
b: SPFs were not calibrated due to insufficient data.

Table 3.2 and Table 3.3 display the components of the HSM intersection SPFs for the four urban and suburban facility types. These urban and suburban SPFs are each composed of four equations to estimate different types of intersection crashes: (1) multiple-vehicle, (2) single-vehicle, (3) vehicle-pedestrian, and (4) vehicle-bicycle. While each of these four equations are not calibrated individually, the sum of these four components forms the urban and suburban SPF which is calibrated to Florida conditions. Table 3.2 gives the SPF components for total crashes at the four urban and suburban intersection facility types; none of these SPFs could be calibrated due to the aforementioned issue of poor data quality for PDO crashes. Table 3.3 provides the SPF components for fatal and injury crashes on urban and suburban intersections. From the four potential facility types, there was sufficient data to develop calibration factors for three-leg and four-leg signalized intersections.

Table 3.2 Urban and Suburban HSM Intersection SPFs for Total Crashes

SPF Component by Facility Type	**SPF**
Three-Leg Stop Controlled[a]	
Multiple-Vehicle	$N_{Total, MV} = AADT_{maj}^{1.11} \times AADT_{min}^{0.41} \times e^{(-13.36)}$
Single-Vehicle	$N_{Total, SV} = AADT_{maj}^{0.16} \times AADT_{min}^{0.51} \times e^{(-6.81)}$
Vehicle-Pedestrian	$N_{Ped} = (N_{Total, MV} + N_{Total, SV}) \times 0.021$
Vehicle-Bicycle	$N_{Bike} = (N_{Total, MV} + N_{Total, SV}) \times 0.016$
Three-Leg Signalized[a]	
Multiple-Vehicle	$N_{Total, MV} = AADT_{maj}^{1.11} \times AADT_{min}^{0.26} \times e^{(-12.13)}$
Single-Vehicle	$N_{Total, SV} = AADT_{maj}^{0.42} \times AADT_{min}^{0.40} \times e^{(-9.02)}$
Vehicle-Pedestrian	$N_{Ped} = AADT_{total}^{0.05} \times (AADT_{min}/AADT_{maj})^{0.24} \times PedVol^{0.41} \times n_{lanesx}^{0.09} \times e^{(-6.60)}$
Vehicle-Bicycle	$N_{Bike} = (N_{Total, MV} + N_{Total, SV}) \times 0.011$
Four-Leg Stop Controlled[a]	
Multiple-Vehicle	$N_{Total, MV} = AADT_{maj}^{0.82} \times AADT_{min}^{0.25} \times e^{(-8.90)}$
Single-Vehicle	$N_{Total, SV} = AADT_{maj}^{0.33} \times AADT_{min}^{0.12} \times e^{(-5.33)}$
Vehicle-Pedestrian	$N_{Ped} = (N_{Total, MV} + N_{Total, SV}) \times 0.022$
Vehicle-Bicycle	$N_{Bike} = (N_{Total, MV} + N_{Total, SV}) \times 0.018$
Four-Leg Signalized[a]	
Multiple-Vehicle	$N_{Total, MV} = AADT_{maj}^{1.07} \times AADT_{min}^{0.23} \times e^{(-10.99)}$
Single-Vehicle	$N_{Total, SV} = AADT_{maj}^{0.68} \times AADT_{min}^{0.27} \times e^{(-10.21)}$
Vehicle-Pedestrian	$N_{Ped} = AADT_{total}^{0.40} \times (AADT_{min}/AADT_{maj})^{0.26} \times PedVol^{0.45} \times n_{lanesx}^{0.04} \times e^{(-9.53)}$
Vehicle-Bicycle	$N_{Bike} = (N_{Total, MV} + N_{Total, SV}) \times 0.015$

a: SPFs were not calibrated due to poor data quality of PDO crashes.

Table 3.3 Urban and Suburban HSM Intersection SPFs for Fatal and Injury Crashes

SPF Component by Facility Type	SPF
Three-Leg Stop Controlled[a]	
Multiple-Vehicle	$N_{KABC, MV} = AADT_{maj}^{1.16} \times AADT_{min}^{0.30} \times e^{(-14.01)}$
Single-Vehicle	$N_{KABC, SV} = N_{Total, SV} \times 0.31$
Vehicle-Pedestrian	$N_{Ped} = (N_{Total, MV} + N_{Total, SV}) \times 0.021$
Vehicle-Bicycle	$N_{Bike} = (N_{Total, MV} + N_{Total, SV}) \times 0.016$
Three-Leg Signalized	
Multiple-Vehicle	$N_{KABC, MV} = AADT_{maj}^{1.02} \times AADT_{min}^{0.17} \times e^{(-11.58)}$
Single-Vehicle	$N_{KABC, SV} = AADT_{maj}^{0.27} \times AADT_{min}^{0.51} \times e^{(-9.75)}$
Vehicle-Pedestrian	$N_{Ped} = AADT_{total}^{0.05} \times (AADT_{min}/AADT_{maj})^{0.24} \times PedVol^{0.41} \times n_{lanesx}^{0.09} \times e^{(-6.60)}$
Vehicle-Bicycle	$N_{Bike} = (N_{Total, MV} + N_{Total, SV}) \times 0.011$
Four-Leg Stop Controlled[a]	
Multiple-Vehicle	$N_{KABC, MV} = AADT_{maj}^{0.93} \times AADT_{min}^{0.28} \times e^{(-11.13)}$
Single-Vehicle	$N_{KABC, SV} = N_{Total, SV} \times 0.28$
Vehicle-Pedestrian	$N_{Ped} = (N_{Total, MV} + N_{Total, SV}) \times 0.022$
Vehicle-Bicycle	$N_{Bike} = (N_{Total, MV} + N_{Total, SV}) \times 0.018$
Four-Leg Signalized	
Multiple-Vehicle	$N_{KABC, MV} = AADT_{maj}^{1.18} \times AADT_{min}^{0.22} \times e^{(-13.14)}$
Single-Vehicle	$N_{KABC, SV} = AADT_{maj}^{0.43} \times AADT_{min}^{0.29} \times e^{(-9.25)}$
Vehicle-Pedestrian	$N_{Ped} = AADT_{total}^{0.40} \times (AADT_{min}/AADT_{maj})^{0.26} \times PedVol^{0.45} \times n_{lanesx}^{0.04} \times e^{(-9.53)}$
Vehicle-Bicycle	$N_{Bike} = (N_{Total, MV} + N_{Total, SV}) \times 0.015$

a: SPFs were not calibrated due to insufficient data.

3.2 Site Selection and Data Assembly

The HSM intersection calibration procedure requires two essential types of data: (1) intersection characteristics and (2) crash data.

To begin, a listing of all intersections in Florida was obtained from the Safety Engineering Section of the Florida Department of Transportation Safety Office. This list was then restricted to include only the facility types identified in the HSM. Additionally, only intersections of two state roads were retained for analysis, as AADT and crash data were not available for non-state roads.

In order to collect the necessary crash data corresponding with the identified intersections, crashes were compiled from the same source as the segment crashes, from Florida's CAR System. Crashes that occurred either "at an intersection" or "influenced by an intersection," were extracted for use in intersection calibration factor development. Crashes were assigned to the appropriate intersection based on the unique node identifier of each intersection.

In order to collect the intersection characteristic data several sources were used. First, intersection attributes were collected through the RCI, including geographic coordinates, number of approaches, AADT for each intersecting road, and intersection control. Remaining characteristics that were required for crash modification factors, but not directly available in the database were found online using satellite images (Google Maps) based on the coordinates supplied by the RCI (*14*). Additional details on the data collection procedure can be found in Appendix G. Table 3.4 shows the necessary data for intersection SPF calibration and how these data were obtained for Florida intersections.

Table 3.4 Intersection Data Elements Used in the Development of Florida Calibration Factors

Required Intersection Characteristics	**Data Availability by Facility Type**[a]					
	Rural Two-Lane Two-Way Roads			**Rural Multilane Highways**	**Urban and Suburban Arterials**	
	R2 3ST	R2 4ST	R2 4SG	RM 4SG	U 3SG	U 4SG
Number of Lanes	✓-R	✓-R	✓-R	✓-R	✓-R	✓-R
AADT	✓-R	✓-R	✓-R	✓-R	✓-R	✓-R
Geographic Coordinates	✓-R	✓-R	✓-R	✓-R	✓-R	✓-R
Number of Legs	✓-R	✓-R	✓-R	✓-R	✓-R	✓-R
Control Type	✓-R	✓-R	✓-R	✓-R	✓-R	✓-R
Intersection Skew Angle	✓-G	✓-G	✓-G			
Intersection Left-Turn Lanes	✓-G	✓-G	✓-G		✓-G	✓-G
Intersection Right-Turn Lanes	✓-G	✓-G	✓-G		✓-G	✓-G
Lighting	✓-G	✓-G	✓-G		✓-G	✓-G
Right-Turn-On-Red					✓-G	✓-G
Left-Turn Signal Phasing					✓-G[b]	✓-G[b]
Red-Light Cameras					✓-G	✓-G
Bus Stops (1000 ft)					✓-G	✓-G
Schools (1000 ft)					✓-G	✓-G
Alcohol Sales Establishments (1000 ft)					✓-G[b]	✓-G[b]
Pedestrian Activity Level					✗	✗
Max. Pedestrian Lanes Crossed					✓-G	✓-G

a: Where ✓-R denotes that the data element was extracted from the RCI, ✓-G the element that was found using Google Maps satellite images (See Appendix G), and ✗ HSM default values were assumed.
b: Assumptions made based on Google Maps satellite images.

Table 3.5 shows the intersection count, AADT, and crash count for each intersection type that was evaluated in this study. The intersection crash data were available for five years: 2005 through 2009. However, intersection characteristics were recorded as of currently available satellite images, from 2010 in most cases. The reader will note that urban four-leg signalized intersections comprised a significantly large portion of the data. The urban and suburban four-leg signalized intersection was the only intersection facility type where a random sample of the available intersections were used for calibration; for each other intersection facility type, all available intersections were used for calibration.

Similarly to segments, rural facility types were evaluated for KABC crashes (fatal-and-injury crashes, including possible injuries) and KAB crashes (which disregard possible injuries), as dictated by the HSM. However, the procedures for urban facilities do not distinguish between the two classifications, so they were not evaluated for KAB conditions.

Table 3.5 Description of Segment Facility Types in Florida

Facility Attributes		**Segment Statistics by HSM Facility Types in Florida**					
		Rural Two-Lane Two-Way Roads			**Rural Multilane Highways**	**Urban and Suburban Arterials**	
		R2 3ST	R2 4ST	R2 4SG	RM 4SG	U 3SG	U 4SG
Total Number of Intersections		39	24	28	25	45	121
Major Street AADT	2005	6275	5375	7511	12867	25578	36689
	2006	6556	5391	7721	12971	26171	36838
	2007	6686	5293	7518	12424	25787	36797
	2008	6252	5658	7579	12272	25964	36444
	2009	5825	5410	7529	11978	24098	35363
Minor Street AADT	2005	3617	3107	4273	6812	14347	22798
	2006	3777	3119	4418	7084	15116	22860
	2007	3774	3070	4303	6897	15384	22447
	2008	3707	3137	4318	7211	14756	22298
	2009	3465	2925	4336	6878	14097	22070
Fatal and Injury Crashes KABC	2005	28	25	48	46	113	815
	2006	30	23	55	48	112	756
	2007	27	16	33	57	123	715
	2008	23	17	38	44	109	698
	2009	26	27	45	46	80	700
Fatal and Injury Crashes KAB[a]	2005	20	18	30	23		
	2006	21	16	29	27		
	2007	17	12	18	27		
	2008	11	10	21	19		
	2009	13	21	29	23		

a: Using the KABCO scale, these include only KAB crashes; crashes with severity level C (possible injury) are not included.

3.3 Intersection Calibration Results

Table 3.6 contains the calibration results for all included intersection types. Note that the derived calibration factors in urban areas are generally much larger than those in rural areas. For instance, in 2005, the uncalibrated SPF equation for four-leg signalized urban and suburban intersection crashes underestimates KABC crashes by a factor of 2.05. However, in the same year, crash frequency for rural two-lane, four-leg signaled intersections was underestimated by a factor of 1.28, and in every other rural case for 2005, the crash rate was actually overestimated. This pattern is present for every year of the study, which upholds the notion that the uncalibrated HSM SPFs tend to underestimate Florida’s crash rates in urban areas.

Table 3.6 Intersection Calibration Results

Calibration Factor Time Frame		**Calibration Factors by Facility Type**					
		Rural Two-Lane Two-Way Roads			**Rural Multilane Highways**	**Urban and Suburban Arterials**	
		R2 3ST	R2 4ST	R2 4SG	RM 4SG	U 3SG	U 4SG
HSM SPF that was Calibrated		Eq. 10-8	Eq. 10-9	Eq. 10-10	Eq. 10-11 Eq. 10-12	Eq. 12-21, 12-24, 12-29, & 12-31	Eq. 12-21, 12-24, 12-29, & 12-31
Fatal and Injury Crashes KABC	2005	0.79	0.72	1.28	0.35	1.98	2.05
	2006	0.80	0.66	1.44	0.36	1.90	1.91
	2007	0.72	0.47	0.89	0.44	2.10	1.82
	2008	0.65	0.47	1.00	0.34	1.87	1.79
	2009	0.80	0.80	1.21	0.37	1.41	1.84
Fatal and Injury Crashes KAB[a]	2005	1.06	1.00	2.02	0.47		
	2006	1.05	0.89	1.91	0.54		
	2007	0.84	0.68	1.22	0.57		
	2008	0.58	0.54	1.40	0.40		
	2009	0.75	1.21	1.96	0.50		

a: Using the KABCO scale, these include only KAB crashes; crashes with severity level C (possible injury) are not included.

CHAPTER 4
SUMMARY AND CONCLUSIONS

This study focused on the development of calibration factors for the segment- and intersection SPFs (for fatal- and injury- crashes) from the HSM using data from Florida. The estimated calibration factors have been presented in this document.

In the case of segment SPFs, the calibration factors were developed using state-wide data spanning multiple years. A systematic procedure was developed (and implemented using a python script) to extract the relevant data items from the state RCI and CARS databases and to assemble these in a format conducive for calibrations. A key component of this procedure involves segmenting roadways into homogenous segments. State-specific collision type distributions were also determined from the crash data as a replacement to the default values provided in the HSM. However, all CMFs were used directly from the HSM. Sensitivity analyses were conducted to assess the impacts (on the crash predictions) of assumptions made about attributes (such as driveway density) for which data were not available. Predictive validations were undertaken to compare the relative performances of the calibrated- and uncalibrated- equations.

In addition to the development of statewide factors, geographic stratifications were also undertaken (for segment SPFs) to develop separate factors by FDOT districts and based on population densities. Such district-level or population-group-level calibration factors may be used instead of the state-level factors if the localized factors were derived using adequate data. For instance, in analyzing a rural two-lane two-way segment in District 1, district level calibration factors can be used as these were developed based on over 400 miles of roadway experiencing about 190 crashes per year. Counties with very high population densities were found to systematically have a higher calibration factors compared to other regions. Thus, the use of the state-wide factors in these cases would result in an under prediction of crashes.

Finally, for two of the segment types, SPFs were also re-estimated entirely using local data and the predictive performance of these local SPFs were compared to those of the calibrated HSM equations. For the chosen segment types, the performance of the locally estimated equations was not any superior to that of the calibrated HSM equations based on the metrics used in the comparison.

In the case of intersection SPFs, significantly limited data were available and the data assembly procedure involved manual steps (such as look ups of images of intersections to determine it attributes). State wide calibration factors were developed with available data.

The calibration factors provided in this report are to be used along with the appropriate SPFs for project-level safety analyses conducted in the state of Florida. Specifically, the expected crashes predicted by the SPF equations in the HSM are to be scaled by the appropriate calibration factors (and other crash modification factors as needed). However, it is useful to acknowledge that the intersection equations were calibrated using relatively smaller sample sizes and so caution must be taken in using these factors.

It is anticipated that these equations will be re-calibrated periodically (such as yearly) and the new calibration factors be to be added to those already developed and presented in this report. It is useful to note that the application of the Empirical Bayes method for multi-year before-and-after studies benefit from the use of year-specific historical calibration factors instead of the applying one calibration factor across the entire time horizon of analysis.

Although this study resulted in the development of an extensive set of calibration factors to facilitate the application of HSM methods in Florida, there are several avenues for enhancements.

The current effort focused only on "on system" roadway segments and intersections of two "on-system" roads. This is primarily because the AADT and crash data are available only for these segments. Thus, the calibration factors do not reflect the safety patterns at a substantial volume of roadways and intersections in the state. To address this issue, it would be beneficial to develop methodologies to collect or estimate AADTs at other locations so that additional segments and intersections can also be used for the calibration analysis.

Data from the short-form crash reports are not stored in the state's electronic crash database. Thus, the database misses a large volume of low severity (property damage only) crashes. Correspondingly, the HSM SPF equations for "total crashes" could not be calibrated in this effort. In this context, enhancing the crash data base to include all crashes would facilitate the calibration of these additional equations.

In the overall calibration process, the most time consuming step was the process of data assembly. The RCI and the crash database together do provide a strong foundation of data for the calibration of segment-level SPFs, although the potential for further enhancements also exist. In this context, efforts to explicitly link the crash data base, the RCI, and the intersection database would be of substantial value from the standpoint of future re-calibrations. Specifically, if an intersection database could be mapped to the intersecting roadway segments (using RCI identifiers), the process of extracting the data elements from the different sources could be efficiently automated. Even if these linkages are fully established, one needs to go through a process of segmentation to create homogenous roadway stretches needed for analysis (for calibrating segment-level SPFs). However, this process has been automated in this study.

Data on the following roadway attributes would be beneficial from the standpoint of calibrating and applying the SPFs: driveway density, roadside hazard rating, and roadside fixed-object density and offset distance. The current calibrations were performed using "default" values of these attributes (and hence the corresponding crash modification factors are taken to be 1). Explicitly incorporating the effect of bike lanes on safety (crash rates) is also important from the state's stand point. In the current study, the SPFs for urban and suburban four-lane divided roads were calibrated separately for those segments that had bike lanes and those that did not, and significant differences were observed. However, the total volume of data related to bike lanes from the RCI is still relatively small (but increasing, up from 50 miles/92 crashes in 2006 to 83 miles/187 crashes in 2008). In future, with the availability of additional data, the development of a crash modification factor for bike lanes would be of value. Alternatively, a separate SPF may be developed for arterials with bike lanes.

The crash modification factors attributes such as surface width and shoulder type were obtained from the HSM (i.e, Florida specific CMFs were not developed). The calibration factors developed reflect these assumptions made. At the same time, in this study, we found that a substantial fraction of the roadway segments conformed to the "base" conditions on most roadway attributes.

The current study also developed Florida-specific collision type distributions to replace the default values provided in the HSM. Such distributions can also be generated yearly from the state crash database. However, this study did not find substantial benefit for using these localized distributions over the HSM default simply because these affect only a relatively small proportion of the segments which were of the "non basic" type, which are the ones needing crash modification factors. With the inclusion of additional roadway segments (such as off-system roads) in the calibration procedure, the benefits of using state specific CMFs and collision-type distributions have to be re-examined.

The current HSM does not cover facilities such as freeways, toll roads, or highways with six or more lanes. Using the crash data and the RCI, it is feasible to develop these SPF equations locally for Florida and this is identified as a key next step. It would also be worthwhile to explore re-estimating all the HSM segment SPF equations using statewide data and then subsequently recalibrating these Florida-specific equations yearly and possibly by local geographic areas such as districts or counties with similar population densities. This would allow for Florida's extensive available roadway segment data to be put to its fullest use, rather than used in calibration, which is designed for use with a much smaller sample size. Estimation of crash prediction models specific to Florida would also allow for the exploration of alternative model forms (other than negative binomial) that may result in more accurate measures of safety for Florida.

Unlike in the case of the calibration of the segment SPFs, the calibration of the intersection SPFs was critically impacted by data issues. While the segment equations at the state levels were calibrated based on several hundreds of miles of roadway, the intersection equations were calibrated based on few (order of 10s) cases. Further, the data assembly involved significant manual effort (linking intersection to the intersecting roads in the RCI to determine the AADTs, looking up the intersection attributes using Google imaging tools etc). Again, this is unlike in the case of the segment equations in which the data assembly procedure was automated using a script. Thus, a critical next step in the context of calibrating intersection SPFs would be to develop and maintain a repository of intersections with data on crashes, AADTs, and the relevant geometric conditions required by the SPFs and CMFs. The calibration factors should be re-calculated using these larger samples. The crash modification factors and collision-type distributions used in the intersection calibrations were obtained from the HSM in this study. The replacement of the above with Florida-specific factors and distributions may be explored after the base calibrations have been performed with larger samples.

As in the case of segments, the current HSM does not cover all intersection types. The development of the SPFs for these and the possibility of re-estimating all the HSM intersection SPF equations using statewide data for any one year may also be explored once a data base of adequate samples has been established.

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APPENDIX A:
PROCEDURE FOR CREATION OF HOMOGENEOUS SEGMENTS

Appendix A is divided into two sections. First section briefly describes the steps used in the procedure for creation of homogenous segmentation. Detailed methodology for each step is then presented in the next section. Following figure is the simple representation of the objective, creation of homogenous segments:

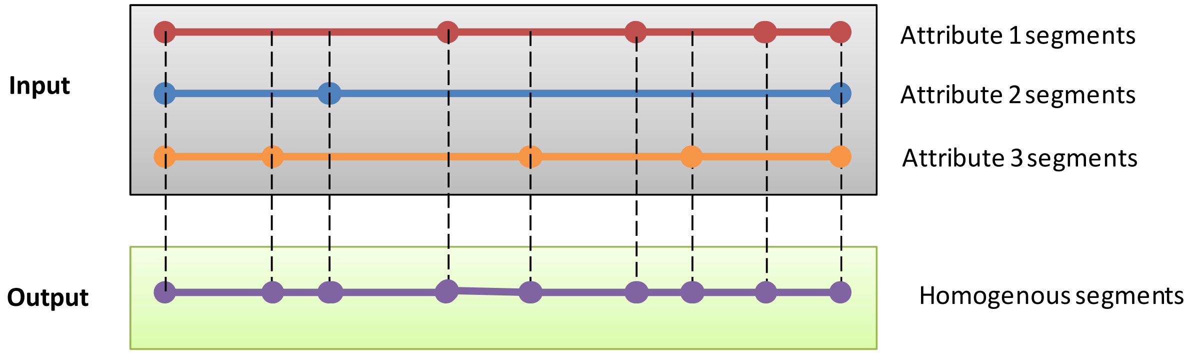


Figure A.1 – Creation of homogenous segments

1. Overall Procedure:

Following sequential steps are performed in order to achieve the objective:

Step1: Export the data from Microsoft access database to the text format.
Output: RCI2005.txt, RCI2006.txt, RCI2007.txt, and RCI2008.txt
Step2: Now from this text file, extract each attribute (total 31 attributes) into a separate text file.
Output:

FunClass.txt, MaxSpeed.txt, MedWidth.txt, RoadMedian.txt, NoLanes.txt, ShldType.txt, SectAADT.txt, ShldWidth.txt, SurfWidth.txt, TypePark.txt, StatExpt.txt, Intersection.txt, HrzPtInt.txt, HighMastLum_L.txt, HighMastLum_R.txt, SignLum_L.txt, SignLum_R.txt, StandLum_L.txt, StandLum_R.txt, UnderdeckLum_L.txt, UnderdeckLum_R.txt, LocalLum_L.txt, LocalLum_R.txt, ShldType2.txt, ShldType3.txt, ShldWidth2.txt, ShldWidth3.txt, BikeLaneCd.txt, BikeSltCd.txt, UrbSize.txt, and LandUse.txt.
Step3: Sort the extracted files by RoadSide , RoadwayID, and Begin_Post and save them into comma-delimited (.csv) format.
Output:

FunClassN.csv, MaxSpeedN.csv, MedWidthN.csv, RoadMedianN.csv, NoLanesN.csv, ShldTypeN.csv, SectAADTN.csv, ShldWidthN.csv, SurfWidthN.csv, TypeParkN.csv, StatExptN.csv, IntersectionN.csv, HrzPtIntN.csv, HighMastLum_LN.csv, HighMastLum_RN.csv, SignLum_LN.csv, SignLum_RN.csv, StandLum_LN.csv, StandLum_RN.csv, UnderdeckLum_LN.csv, UnderdeckLum_RN.csv, LocalLum_LN.csv, LocalLum_RN.csv, ShldType2N.csv, ShldType3N.csv, ShldWidth2N.csv, ShldWidth3N.csv, BikeLaneCdN.csv, BikeSltCdN.csv, UrbSizeN.csv, and LandUseN.csv.
Step4: Remove inactive roads (‘StatExptN.csv’) from all other files except ‘IntersectionN.csv’.
Output:

FunClassN1N.txt, MaxSpeedN1N.txt, MedWidthN1N.txt, RoadMedianN1N.txt, NoLanesN1N.txt, ShldTypeN1N.txt, SectAADTN1N.txt, ShldWidthN1N.txt, SurfWidthN1N.txt, TypeParkN1N.txt, HrzPtIntN1N.txt, HighMastLum_LN1N.txt, HighMastLum_RN1N.txt, SignLum_LN1N.txt, SignLum_RN1N.txt, StandLum_LN1N.txt, StandLum_RN1N.txt, UnderdeckLum_LN1N.txt, UnderdeckLum_RN1N.txt, LocalLum_LN1N.txt, LocalLum_RN1N.txt, ShldType2N1N.txt, ShldType3N1N.txt, ShldWidth2N1N.txt, ShldWidth3N1N.txt, BikeLaneCdN1N.txt, BikeSltCdN1N.txt, UrbSizeN1N.txt, and LandUseN1N.txt.

Step5: Sort selected files by RoadwayID, Begin_Post, and RoadSide , and save them into comma-delimited (.csv) format.
Output:

NoLanesN1N.csv, SurfWidthN1N.csv, MaxSpeedN1N.csv, FunClassN1N.csv, SectAADTN1N.csv, RoadMedianN1N.csv, MedWidthN1N.csv, UrbSizeN1N.csv, and LandUseN1N.csv

Step6: Perform consistency check to selected files and delete any duplicate or wrongly entered data.
Output:

NoLanesN1N1.txt, SurfWidthN1N1.txt, FunClassN1N1.txt, MaxSpeedN1N1.txt, SectAADTN1N1.txt, RoadMedianN1N1.txt, MedWidthN1N1.txt, UrbSizeN1N1.txt, LandUseN1N1.txt

Step7: Perform consistency check to the remaining files (except light pole data files) and delete any duplicate or wrongly entered data.
Output:

HrzPtIntN1N1.txt, ShldTypeN1N1.txt, ShldWidthN1N1.txt, TypeParkN1N1.txt, ShldType2N1N1.txt, ShldType3N1N1.txt, ShldWidth2N1N1.txt, ShldWidth3N1N1.txt, BikeLaneCdN1N1.txt, BikeSltCdN1N1.txt

Step8: Sort selected files by RoadwayID, Begin_Post, and RoadSide , and save them into comma-delimited (.csv) format.
Output:

NoLanesN1N1.csv, ShldTypeN1N1.csv, ShldWidthN1N1.csv, SurfWidthN1N1.csv, TypeParkN1N1.csv, HrzPtIntN1N1.csv, MaxSpeedN1N1.csv, FunClassN1N1.csv, SectAADTN1N1.csv, RoadMedianN1N1.csv, MedWidthN1N1.csv, ShldType2N1N1.csv, ShldType3N1N1.csv, ShldWidth2N1N1.csv, ShldWidth3N1N1.csv, BikeLaneCdN1N1.csv, BikeSltCdN1N1.csv, UrbSizeN1N1.csv, LandUseN1N1.csv

Step9: Combine two roadsides (‘L’ and ‘R’) of a segment into one and save them as ‘D’ (Divided). Also, rename segments with ‘C’ as ‘U’ (Undivided).
Output:

NoLanesN1N1 _Combined.txt, SurfWidthN1N1 _Combined.txt, MaxSpeedN1N1 _Combined.txt, ShldTypeN1N1 _Combined.txt, ShldWidthN1N1 _Combined.txt, TypeParkN1N1 _Combined.txt, HrzPtIntN1N1 _Combined.txt, ShldType2N1N1 _Combined.txt, ShldType3N1N1 _Combined.txt, ShldWidth2N1N1 _Combined.txt, ShldWidth3N1N1 _Combined.txt, BikeLaneCdN1N1 _Combined.txt, BikeSltCdN1N1 _Combined.txt

Step10: Add all attributes one by one and make a final file with homogenous segments.
Output: NoLanesN1N1_CombinedN35.txt

Step11: Remove curved portions of the homogenous segments.
Output: NoLanesN1N1_CombinedN38.txt

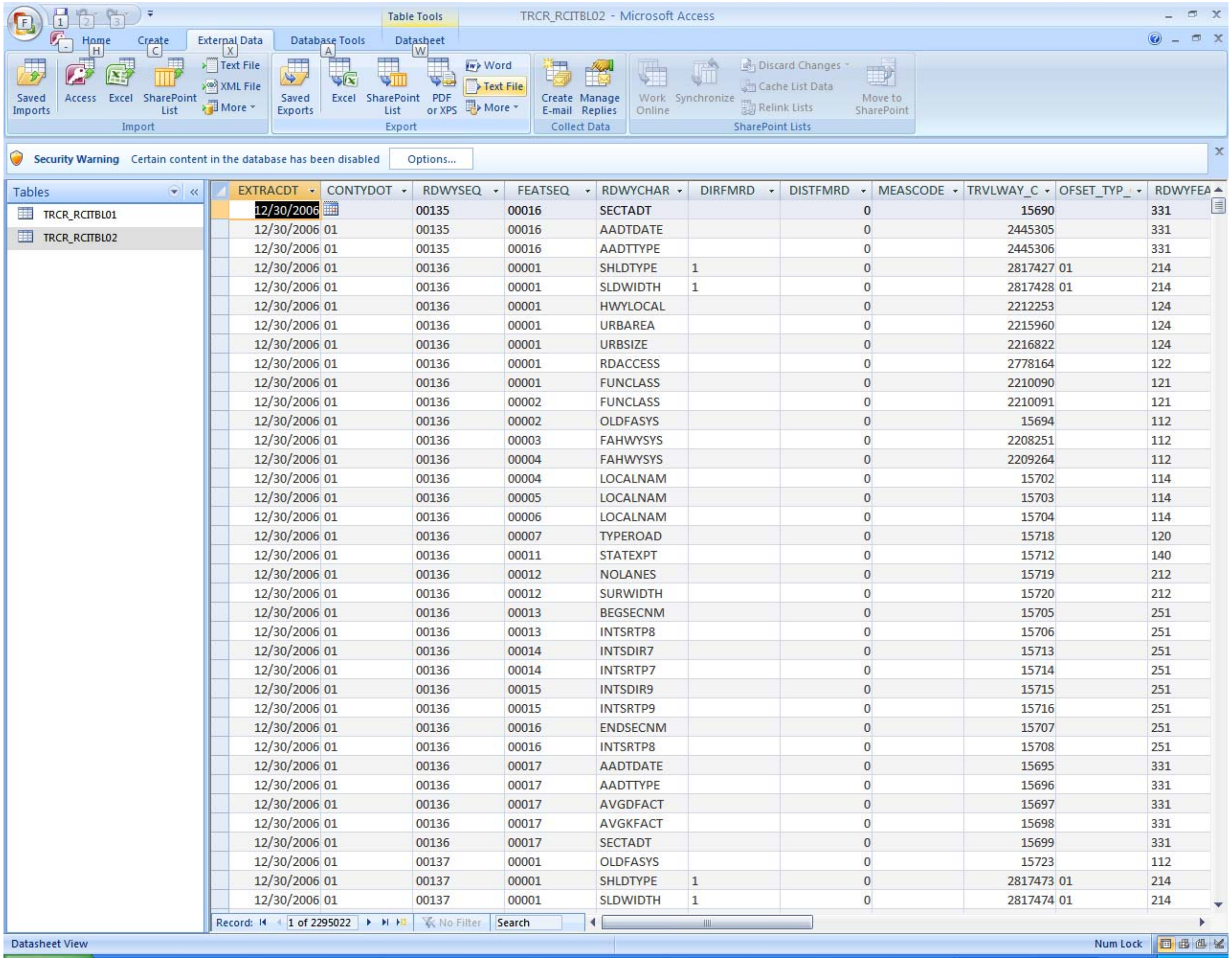
Step12: Using the appropriately sorted intersection file (Intersection.csv), make sure that there are no intersections with a segment. This is achieved by breaking a segment at the intersection milepost.
Output: NoLanesN1N1_CombinedN_interns.txt
Step13: Map light poles to the segments.
Output: NoLanesN1N1_CombinedN_SegmentsWithLights10.txt
Step14: Map intersections to the homogenous segments from previous step.
Output: Segments_2005_Interns.txt
Step15: Map crashes to the segments.
Output: Segments_2005_Interns_Crashes.txt

2. Detailed Methodology

Following sections describe detailed methodology of each step. Additionally, flow charts are attached at the end.

Step 1: Export data from Microsoft Database (Manual)

Open the RCI database file in Microsoft access data base, Figure A.2. Double click on the second table that has roadway characteristics (RDWYCHAR). Now, go to ‘Export’ under ‘External Data’ and click on ‘Text File’. Save the new text file to your desired location with name format as ‘RCIyear.txt’, e.g. ‘RCI2005.txt’.



Security Warning Certain content in the database has been disabled

EXTRACDT	CONTYDOT	RDWYSEQ	FEATSEQ	RDWYCHAR	DIRFMRD	DISTFMRD	MEASCODE	TRVLWAY_C	OFSET_TYP_	RDWYFEA
12/30/2006		00135	00016	SECTADT		0		15690		331
12/30/2006	01	00135	00016	AADTDATE		0		2445305		331
12/30/2006	01	00135	00016	AADTTYPE		0		2445306		331
12/30/2006	01	00136	00001	SHLDTYPE	1	0		2817427	01	214
12/30/2006	01	00136	00001	SLDWIDTH	1	0		2817428	01	214
12/30/2006	01	00136	00001	HWYLOCAL		0		2212253		124
12/30/2006	01	00136	00001	URBAREA		0		2215960		124
12/30/2006	01	00136	00001	URBSIZE		0		2216822		124
12/30/2006	01	00136	00001	RDACCESS		0		2778164		122
12/30/2006	01	00136	00001	FUNCLASS		0		2210090		121
12/30/2006	01	00136	00002	FUNCLASS		0		2210091		121
12/30/2006	01	00136	00002	OLDFASYS		0		15694		112
12/30/2006	01	00136	00003	FAHWYSYS		0		2208251		112
12/30/2006	01	00136	00004	FAHWYSYS		0		2209264		112
12/30/2006	01	00136	00004	LOCALNAM		0		15702		114
12/30/2006	01	00136	00005	LOCALNAM		0		15703		114
12/30/2006	01	00136	00006	LOCALNAM		0		15704		114
12/30/2006	01	00136	00007	TYPEROAD		0		15718		120
12/30/2006	01	00136	00011	STATEXPT		0		15712		140
12/30/2006	01	00136	00012	NOLANES		0		15719		212
12/30/2006	01	00136	00012	SURWIDTH		0		15720		212
12/30/2006	01	00136	00013	BEGSECNM		0		15705		251
12/30/2006	01	00136	00013	INTSRTP8		0		15706		251
12/30/2006	01	00136	00014	INTSDIR7		0		15713		251
12/30/2006	01	00136	00014	INTSRTP7		0		15714		251
12/30/2006	01	00136	00015	INTSDIR9		0		15715		251
12/30/2006	01	00136	00015	INTSRTP9		0		15716		251
12/30/2006	01	00136	00016	ENDSECNM		0		15707		251
12/30/2006	01	00136	00016	INTSRTP8		0		15708		251
12/30/2006	01	00136	00017	AADTDATE		0		15695		331
12/30/2006	01	00136	00017	AADTTYPE		0		15696		331
12/30/2006	01	00136	00017	AVGDFACT		0		15697		331
12/30/2006	01	00136	00017	AVGKFACT		0		15698		331
12/30/2006	01	00136	00017	SECTADT		0		15699		331
12/30/2006	01	00137	00001	OLDFASYS		0		15723		112
12/30/2006	01	00137	00001	SHLDTYPE	1	0		2817473	01	214
12/30/2006	01	00137	00001	SLDWIDTH	1	0		2817474	01	214

Figure A.2 - Export data from Microsoft Access database

SCRIPT STEPS

Script is written using Python and before running the script, one of the two pre-requisites, Figure A.3, includes providing the name of the working folder (workspace), where exported RCI data (RCI2005.txt) is located. Also, names of the RCI file (filename), intersection file, and crash file are required.

```
mainWorkspace = "C:/Documents and Settings/nsdhakar/Academics/RCI_data/2005/"
RCIFile = "RCI2005.txt"
intersectionFile = "Intersection.csv"
crashFile = "CrshOn05N.csv"
```

Figure A.3– Inputs to the script

Step 2: Extract Attribute Files

Variable ‘RDWYCHAR’ in RCI data contains the roadway characteristics/ attributes. Rows that have the desired roadway characteristic is extracted and written to a new file. For a roadway characteristic following variables are extracted from the RCI data: Attribute name (RDWYCHR), County (CONTYDOT), Roadway ID (RDWYID), Begin milepost (BEGSECPT), End milepost (ENDSECPT), Roadway side (RDWYSIDE), and Attribute value (RCDVALUE) . Roadway attributes considered for this project are provided in Table A.1.

Table A.1 – Roadway Attributes

Variable in RCI	**Description**	**Value Labels**
NOLANES	Number Of Through Roadway Lanes	
SURFWIDTH	Through Pavement Surface Width	
ROADSIDE	Median Type	‘D’ – Divided ‘U’ - Undivided
SECTAADT	Section AADT	
FUNCLASS	Functional Classification	01 – RURAL – Principal Arterial–Interstate 02 – RURAL – Principal Arterial–Other 06 – RURAL – Minor Arterial 07 – RURAL – Major Collector 08 – RURAL – Minor Collector 09 – RURAL – Local 11 – URBAN – Principal Arterial–Interstate 12 – URBAN – Principal Arterial–Other Freeways and Expressways 14 – URBAN – Principal Arterial–Other 16 – URBAN – Minor Arterial 17 – URBAN – Collector 19 – URBAN – Local
MAXSPEED	Maximum Speed	
MEDWIDTH	Median Width	
SHLDTYPE	Highway Shoulder Type	0 – Raised Curb (no shoulder or width exists) 1 – Paved with or without striping (including paved parking and bike slots) 2 – Paved with Warning Device (raised or indented strips) 3 – Lawn (number of feet to support road bed) 4 – Gravel/Marl 5 – Valley Gutter (not a barrier) 6 – Curb & Gutter 7 – Other 8 – Curb with resurfaced gutter
SHLDTYP2	Other Highway Shoulder Type	
SHLDTYP3	Other Highway Shoulder Type	
SHLDWIDTH	Highway Shoulder Width	
SHLDWTH2	Other Highway Shoulder Width	
SHLDWTH3	Other Highway Shoulder Width	
RDMEDIAN	Road Median	
TYPEPARK	Type of parking	
NOHMSLUM	Number of High Mast Luminaries	
NOSGMLUM	Number of Sign Luminaries	

NOSTDLUM	Number of Standard Luminaries	
NOUDKLUM	Number of Underdeck Luminaries	
NOLOCLUM	Number of Local Luminaries	
BIKELNCD	Bicycle Lane	0 – Undesignated, 1 – Designated
BIKSLTCD	Bicycle Slot	0 – Undesignated, 1 – Designated
URBSIZE	Urban Size	1 – Rural 2 – Small Urban (5,000 - 49,999 population) 3 – Small Urbanized (50,000 - 199,999 population) 4 – Large Urbanized (200,000 - 499,999 population) 5 – Metropolitan (500,000 or more population)
LANDUSE	Land Use	1 – Central Business District (CBD) 2 – High Density Business/Commercial Center 3 – Low Density Commercial 4 – High Density Residential 5 – Low Density Residential 6 – Other
STATEXPT	Non Active Segments	
INTSDIRx	Intersection Direction	where x = 1, 2,…9
HRZPTINT	Curves	

For crashes, HIGHESTINJ (Severity Level) and SITELOCA (Crash location – intersection related) are used from the crash database.

Following is the structure of the extracted attribute files:

CHAR	COUNTY	ROADWAY	BEGIN_POST	END_POST	RDWYSIDE	ATTRIBUTE

Step 3: Sort Extracted Files

Attribute files created in the previous step are sorted by RDWYSIDE, ROADWAY, and BEGIN_POST, to make sure that in a file all segments with same roadside are together. Outputs of this process are comma delimited files (.CSV).

STEP 4: Remove Inactive Segments

In the RCI data, section status is represented by 'STATEXPT'. Variable Codes along with their share for each year are shown in the Table A.2 below.

Table A.2 – Remove inactive segments

Section Status	**% Share**			
	2005	**2006**	**2007**	**2008**
'1' – Pending	1.2	1.2	1.1	0.7
'2' - Active on SHS	**11.1**	**11.3**	**11.1**	**9.1**
'4' – Inactive	1.4	1.9	2.5	5.2
'5' – Deleted	1.7	2.2	2.2	2
'7' - Active Exclusive	9	9.9	10.9	25.4
'9' - Active off the SHS	75.6	73.6	72.1	56.6
'17' - Active off Exclusive	-	-	-	0.9
Total	**100**	**100**	**100**	**100**

In step 2, data for segment status attribute (STATEXPT) was exported to 'StatExp.txt'. This attribute is combined to each attribute file by using 'Combine two attributes' process (Step 10) - details of this process are provided later. Afterwards, in each file, only those segments that have section status as 'Active on SHS' (STATEXPT = 2) are retained. At the end of this step, only active on system segments are present in each attribute file.

Statistics of rows deleted (Percentage share), in each file, during this step are presented in Table A.3.

Table A.3 – Deleted Rows (% share)

	2005	**2006**	**2007**	**2008**
NoLanes	71.61	72.5	73.53	74.71
ShldType	69.9	71.26	71.65	72.1
ShldWidth	70.41	71.69	71.89	71.85
SurfWidth	72.07	72.87	73.73	74.66
TypePark	34.52	34.92	35.95	36.27
HrzPtInt	12.29	12.69	13.02	13.3
MaxSpeed	37.42	40.35	41.08	45.15
FunClass	85.01	84.8	84.82	84.85
SectAADT	65.41	65.16	65.52	65.9
RoadMedian	52.83	53.93	55.1	56.69
MedWidth	51.88	53.26	54.57	56.32
HighMastLum_L	23.08	33.8	34.15	33.27
HighMastLum_R	52.16	57.23	56.93	54.21
SignLum_L	9.95	11.31	11.16	11.09
SignLum_R	31.36	31.97	31.72	32.91
StandLum_L	33.22	31.64	31.97	30.3
StandLum_R	56.29	55.88	56.38	54.77
UnderdeckLum_L	11.9	12.94	13	12.86
UnderdeckLum_R	24.63	24.91	25.39	25.97
LocalLum_L	9.67	8.3	8.57	6.67
LocalLum_R	8.87	9.02	9.28	7.5
ShldType2	51.91	53.88	54.37	55.22
ShldType3	54.28	52.78	65.91	65.29
ShldWidth2	52.93	54.79	55.27	55.6
ShldWidth3	53.73	52.34	65.4	64.02
BikeLaneCd	10.58	11.27	11.63	9.64
BikeSltCd	4.76	2.91	2.89	4.78
UrbSize	83.91	83.67	83.68	83.88
LandUse	65.89	68.7	70.04	69.86

Step 5: Sort Extracted Files

In next step, selected output files from the previous step are sorted by ROADWAY, BEGIN_POST, and RDWYSIDE. Outputs of this process are comma delimited files (.CSV). Following are the files that undergo this step:
NoLanesN1N.txt, SurfWidthN1N.txt, MaxSpeedN1N.txt, FunClassN1N.txt, SectAADTN1N.txt, RoadMedianN1N.txt, MedWidthN1N.txt, UrbSizeN1N.txt, and LandUseN1N. txt

Step 6 & 7: Consistency Check
Before using the RCI data, we make sure that the obtained data is proper and consistent. That is achieved by making a process to perform consistency check, which identifies and removes possibly wrongly entered data. The step is divided in two parts: part 1 and part 2.

Consistency Check (Part 1):

Following files goes through this part: NoLanesN1N.csv, SurfWidthN1N.csv, FunClassN1N.csv, MaxSpeedN1N.csv, SectAADTN1N.csv, RoadMedianN1N.csv, MedWidthN1N.csv, UrbSizeN1N.csv, and LandUseN1N.csv.

Consistency Check (Part 2):

Following files goes through this part: HrzPtIntN1N.csv, ShldTypeN1N.csv, ShldWidthN1N.csv, TypeParkN1N.csv, ShldType2N1N.csv, ShldType3N1N.csv, ShldWidth2N1N.csv, ShldWidth3N1N.csv, BikeLaneCdN1N.csv, and BikeSltCdN1N.csv. Following rules, explained with examples, are used for consistency check:

(i) Duplicate rows with everything same

CHAR	COUNTY	ROOADWAY	BEGIN_POST	END_POST	RDWYSIDE	SHLDTYPE
SHLDTYPE	10	10000031	4.448	4.634	C	3
SHLDTYPE	10	10000031	4.448	4.634	C	3

(ii) Duplicate rows with everything same except attribute value

CHAR	COUNTY	ROOADWAY	BEGIN_POST	END_POST	RDWYSIDE	SHLDTYPE
SHLDTYPE	10	10000031	4.634	4.818	C	0
SHLDTYPE	10	10000031	4.634	4.818	C	8

(iii) Single side segment

CHAR	COUNTY	ROOADWAY	BEGIN_POST	END_POST	RDWYSIDE	SHLDTYPE
SHLDTYPE	10	10000112	0.765	0.948	C	0

SHLDTYPE	10	10000112	0.948	1.074	L	6
SHLDTYPE	10	10000112	1.074	1.483	C	3

(iv)Multiple segments with some parts overlapped

CHAR	COUNTY	ROOADWAY	BEGIN_POST	END_POST	RDWYSIDE	SHLDTYPE
SHLDTYPE	10	10000117	0	0.048	C	3
SHLDTYPE	10	10000117	0.048	0.126	C	6
SHLDTYPE	10	10000117	0.048	0.17	C	0
SHLDTYPE	10	10000117	0.126	0.189	C	3
SHLDTYPE	10	10000117	0.17	0.875	C	3
SHLDTYPE	10	10000117	0.189	0.315	C	0
SHLDTYPE	10	10000117	0.315	1	C	3
SHLDTYPE	10	10000117	0.875	1	C	5

Another example of such case:

CHAR	COUNTY	ROOADWAY	BEGIN_POST	END_POST	RDWYSIDE	SHLDTYPE
SHLDTYPE	10	10000125	1.007	1.513	C	0
SHLDTYPE	10	10000125	1.007	1.261	C	3
SHLDTYPE	10	10000125	1.261	1.387	C	0
SHLDTYPE	10	10000125	1.387	1.513	C	3

For all cases above, involved rows are deleted. Table A.4 shows counts and percentage shares of the deleted rows during this step.

Table A.4 – Deleted rows during consistency check (count and % share)

	2005	2006	2007	2008
NoLanes	262 (2.28)	262 (2.26)	266 (2.31)	269 (2.2)
SurfWidth	272 (2.29)	272 (2.29)	279 (2.36)	282 (2.25)
FunClass	48 (2.6)	47 (2.54)	47 (2.53)	48 (2.52)
MaxSpeed	296 (4.97)	296 (4.96)	285 (4.8)	276 (4.61)
SectAADT	316 (5.26)	311 (5.15)	309 (5.15)	308 (5.08)
RoadMedian	227 (3.56)	233 (3.52)	241 (3.49)	261 (3.36)
MedWidth	238 (3.56)	240 (3.48)	245 (3.43)	265 (3.34)
UrbSize	59 (3.1)	58 (3.02)	59 (3.06)	59 (2.99)
LandUse	29 (2.49)	29 (2.45)	27 (2.28)	28 (2.26)
HrzPtInt	395 (4.37)	392 (4.28)	384 (4.2)	381 (4.16)
ShldType	650 (4.79)	670 (4.86)	695 (4.85)	772 (4.82)
ShldType2	474 (5.09)	498 (5.16)	530 (5.24)	595 (5.1)
ShldType3	8 (5.16)	8 (5.23)	3 (3.33)	3 (3.57)
ShldWidth	678 (4.81)	703 (4.9)	741 (4.93)	840 (4.97)
ShldWidth2	482 (5.22)	509 (5.3)	544 (5.39)	610 (5.22)
ShldWidth3	8 (5.16)	8 (5.23)	3 (3.3)	3 (3.39)
TypePark	306 (3.94)	303 (3.92)	295 (3.87)	291 (3.81)
BikeLaneCd	20 (3.15)	57 (4.21)	55 (3.57)	100 (3.41)
BikeSltCd	6 (2.31)	24 (2.99)	27 (2.87)	53 (2.77)

Note: Number in the bracket represents % share

Step 8: Sort Files

Files obtained from consistency checks are sorted by ROADWAY, BEGIN_POST, and RDWYSIDE. Outputs of this step are comma delimited files (.CSV).

Step 9: Combine Sides (L and R) of a Segment

In the original RCI data, a segment can have a roadside value of ‘C’ (Center), or ‘L’ (Left) or ‘R’ (Right). In this step, segment with roadside ‘C’ is renamed to ‘U’ (undivided) and segments with roadsides ‘L’ and ‘R’ are combined together to represent as one segment with roadside ‘D’ (divided). Adopted algorithm is explained in the next paragraph.

For a roadway, if a segment has roadside ‘L’ or ‘R’ then it is saved to the ‘List’ and a segment with same begin_post and end_post is searched. Once found, a new segment from the overlapped part with new attribute value and road side as ‘D’ (divided) is written to the output. Attributes for different road sides (L or R) are written in respective columns. Attribute value of a segment with roadside ‘C’ is written in the column corresponding to roadside ‘L’. Following example explains the process.

Table A.5 – Combine sides input

COUNTY	ROADWAY	BEGIN_POST	END_POST	RDWYSIDE	NOLANES
4	4040000	12.621	14.132	C	2
4	4040000	14.132	14.681	L	2
4	4040000	14.132	14.445	R	2
4	4040000	14.445	14.535	R	1
4	4040000	14.535	14.681	R	1

In the Table A.5, first segment has roadside ‘C’, thus it is simply written to the output with roadside ‘U’. For this segment lanes are written in ‘NOLANES-L’ column. Next segment is with road side ‘L’, so we save this in the ‘List’ and look for a segment with roadside ‘R’ that has begin_post between the begin and end posts of the saved segment. Once found, overlapped part of the found segment and saved segment is written to the output with road side ‘D’. Now segment in the ‘List’ are overwritten with the non overlapped segment. This process is repeated until there is no non-overlapped segment left. Output of the segment in Table A.5 looks as below, Table A.6:

Table A.6 - Combine sides output

COUNTY	ROADWAY	BEGIN_POST	END_POST	RDWYSIDE	NOLANES-L	NOLANES-R
4	4040000	12.621	14.132	U	2	0
4	4040000	14.132	14.445	D	2	2
4	4040000	14.445	14.535	D	2	1
4	4040000	14.535	14.681	D	2	1

Step 10: Combine Attributes

In this step all roadway attributes are combined to one file. Attributes are combined one by one; in short, at a time one new attribute is combined to the master file. Therefore, this step involves iterative process of combining two files (attributes) until all files are processed. Next, the algorithm used for combining two attributes is explained.

Following four cases are considered in the process of combining two attributes of a segment:

Case1: Begin_Post and End_Post of Segment2 are less and higher than Begin_Post of Segment1 resp. Also End_Post of Segment2 is less than or equal to End_Post of Segment1.

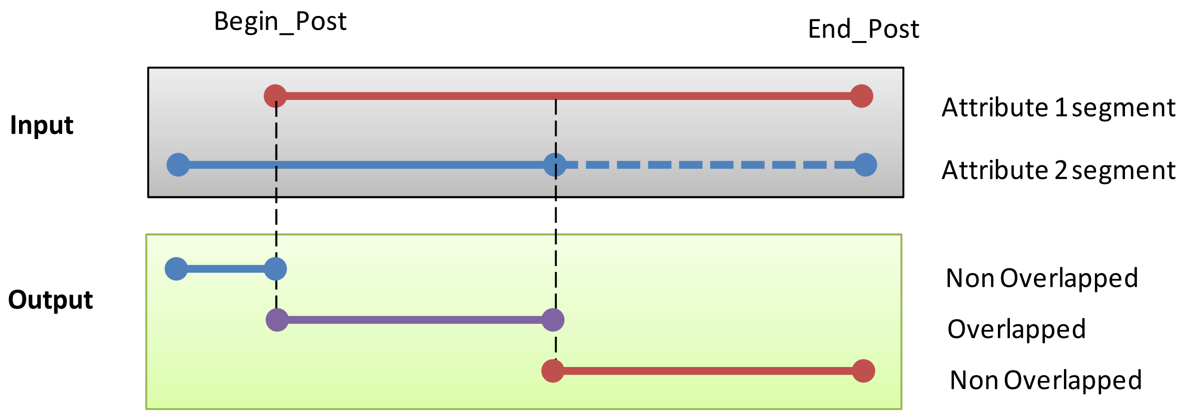


Figure A.4 – Combine sides - Case 1

Case2: Begin_Post of segment2 is in the between Begin_Post and End_Post of Segment1 and End_Post of Segment 2 is less than or equal to End_Post of Segment1.

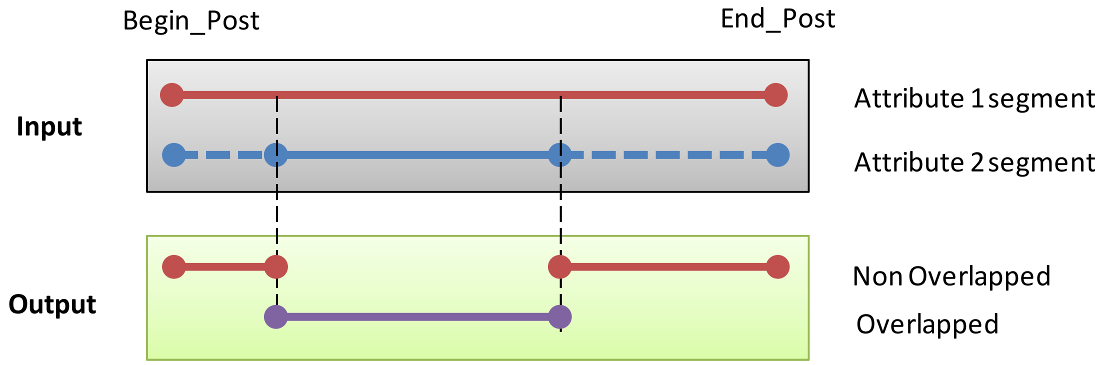


Figure A.5 – Combine sides - Case 2

Case3: Begin_Post of segment1 is in the between Begin_Post and End_Post of Segment2 and End_Post of Segment 2 is higher than End_Post of Segment1.

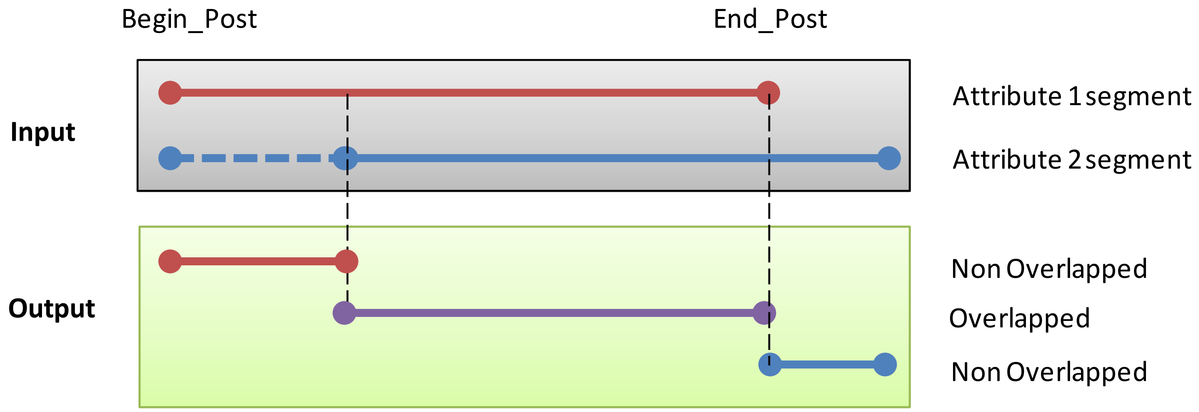


Figure A.6 – Combine sides - Case 3

Case4: Begin_Post and End_Post of Segment2 are less and higher than Begin_Post of Segment1 resp. Also End_Post of Segment2 is higher than End_Post of Segment1.

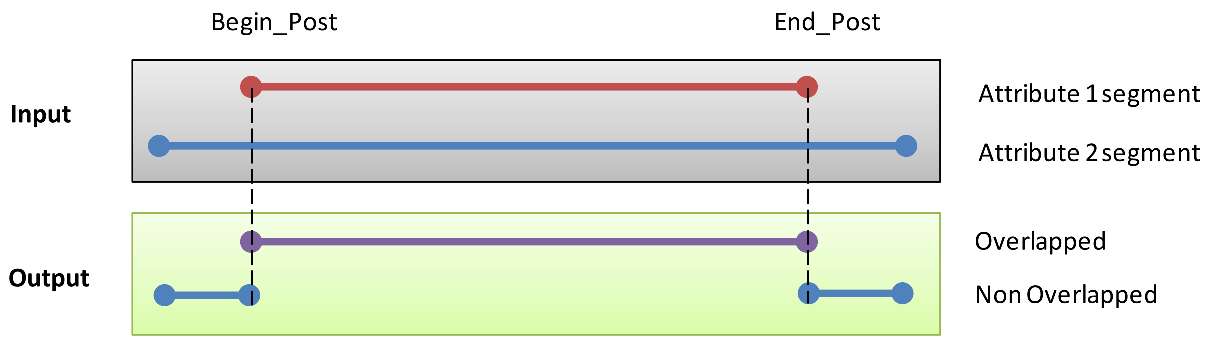


Figure A.7 – Combine sides - Case 4

In above figures, dotted line represents the possible range of segment2 within the limits of segment1 and solid line represents the actual segment length.

In each case, a segment is broken into an overlapped segment and non-overlapped segments. Overlapped segment contains attributes from both segments. Non-overlapped segment that is before the overlapped segment is written to the output. Non-overlapped segment that is after the overlapped segment further searches for segment2 or segment1 (depends on where this non-overlapped segment comes from) that might have some part of it overlapped. This process continues until the entire length of non-overlapped segment is found or begin_post of segment1 or segment2 starts at or after end_post of non-overlapped segment.

Additionally, every time two attributes are combined, the output file is sorted by roadwayID, and begin_post to maintain the structure of the input files. As output file is already sorted by roadway, it has to be sorted by begin_post only. First, segments that belong to a roadway are saved into a list and then these are sorted by begin_post. Sorted segments are then written to the output with corresponding roadwayIDs. This process is repeated for all roadways until end of the file is reached.

Step 11: Remove Curves

RCI data for curves contain begin and end posts of the curved segments. Therefore, first, process of 'combining two attributes' (step 10) is used to combine curve segments as an attribute to the segments. Additionally, in this process, an indicator 'curve' is assigned to the segments with '1' for a curved segment and '0' otherwise. Afterwards, segments that have indicator values as '1' are removed. This step is illustrated in Figure A.8.

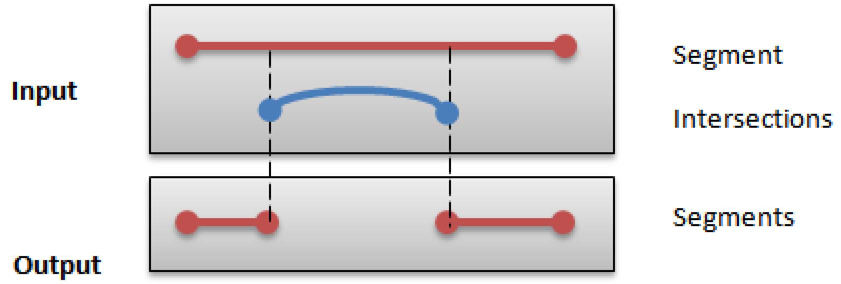


Figure A.8 – Remove curves

Following Table A.7 provides statistics on the loss of segments during this step:

Table A.7 – Curve statistics

Segments	**2008**	**2007**	**2006**	**2005**
With Curves	56252	49668	48552	47320
Without Curves	40259	34195	33320	32510
Curves	15993	15473	15232	14810
%	**28.43**	**31.15**	**31.37**	**31.30**

Step 12: Intersections

Objective of this step is to make sure that there are no intersections within a segment. Therefore, all intersections are kept at the edge of the segment by breaking the segment at the milepost of the intersection. Also, before using the intersection file, it is sorted by ROADWAYID, and MILEPOST. Following example, Figure A.9, demonstrates the process:

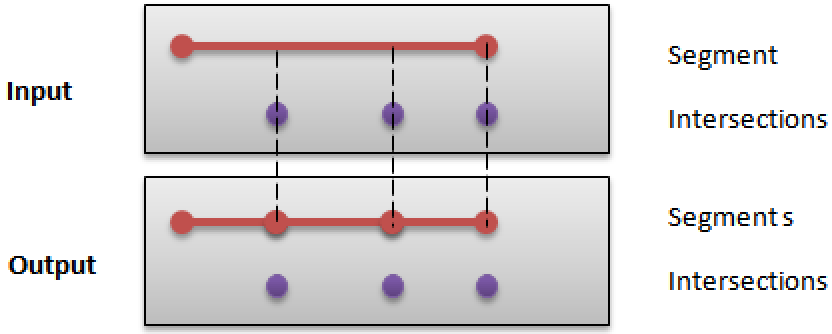


Figure A.9 – Intersections

Step 13: Map Light Poles

Light pole data extracted from the RCI database provides number of light poles for a length of the segment. So, first, light pole densities (no. of milepost per mile) are calculated for all segments. Then these light pole densities are assigned to the segments, obtained in the previous step, by using the weighted average method. Below are few examples explaining the assignment of light pole density to a segment:

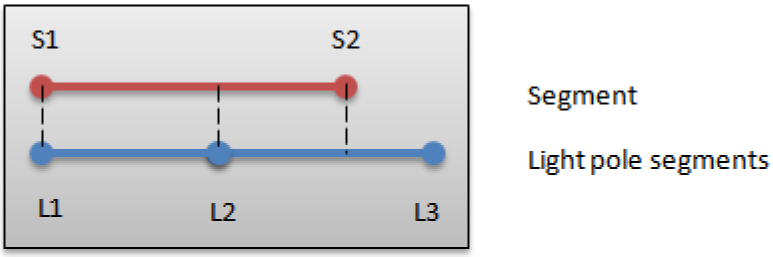


Figure A.10 – Map light poles – example 1

For the above, density = [P1*(L2-L1) + P2*(S2-L2)]/ [S2-S1]

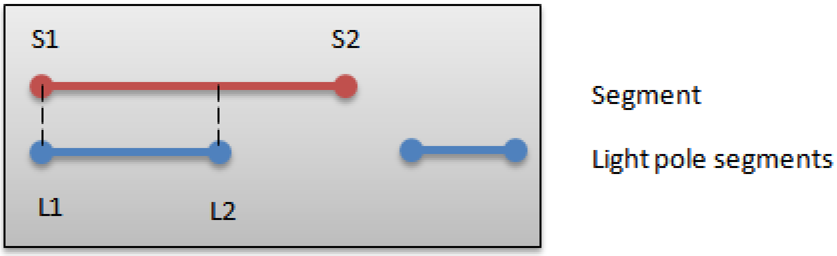


Figure A.11 – Map light poles – example 2
In this case, density = [P1*(L2-L1)]/ [S2-S1]

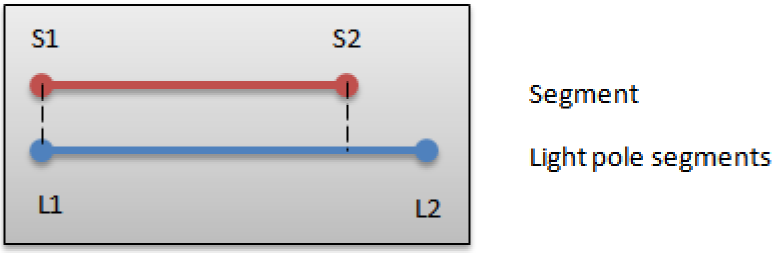


Figure A.12 – Map light poles – example3
In this case, density = P1

Step 14: Map Intersections to Segments

As in Step 12, homogenous segments are already broken at the intersections; a segment can have maximum 2 intersections – both at the ends. Count of intersections on a segment is further used to determine if segment is lit. Intersections are mapped using the similar algorithm as in crashes, explained in step 15. Also, before using the intersection file, it is sorted by ROADWAYID, and MILEPOST.

Step 15: Map Crashes to Segments

This step maps crashes to the homogenous segments obtained in last step. Before using the crash file, it is sorted by ROADWAYID, and MILEPOST. The step is performed in three stages. *First*, using the variable 'SITELOCA' in the crash file, intersection related crashes are removed. This is achieved by removing crashes with 'SITELOCA' = 2 (at intersection) and 'SITELOCA' = 7 (influenced by intersection). *Second*, in the output file, for all crashes within a roadway an index is generated from n to 1. Where n is the total no. of crashes within a roadway. Index helps in identifying the last crash point on a roadway. Finally, *third*, these crashes are mapped to the homogenous segments.

Process, first, for a segment in the segment file looks into the crash file for a crash point with the same roadwayID. If found, it makes sure that crash milepost is between begin and end mileposts of the segment. If yes, it counts this crash point as on the segment; else goes to next crash point without mapping the crash point. While moving to the next crash point, it also makes sure that roadwayID is same and crash index is higher than 1 otherwise it exits the crash file and moves to next segment. This is repeated until last segment is reached in the segment file. Moreover, information of highest injury severity is stored by using variable 'HIGHESTINJ' in the crash file. Following are the values associated with this variable:

0 – Not coded
1 – No injury
2 – Possible injury
3 – Non-incapacitating injury
4 – Incapacitating injury
5 – Fatality (within 30 days)
6 – Nontraffic fatal

Following Table A.8 shows statistics on mapped crashes.

Table A.8 – Crash statistics

Crashes	**2005**		**2006**		**2007**		**2008**	
	Count	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Intersection Related	88448	52.77	82513	51.64	80183	49.47	75721	49.84
Mapped	59271	35.37	57914	36.24	60586	37.38	56354	37.09
No Mapped	19876	11.86	19362	12.12	21330	13.16	19860	13.07
Total	**167595**	**100**	**159789**	**100**	**162099**	**100**	**151935**	**100**

FINAL OUTPUT:

Following is the structure of the final output file:

COUNTY	ROADWAY	BEGIN_POST	END_POST	MEDIAN_TYPE	ATTRIBUTES	LIGHT POLE DENSITIES	INTERSECTIONS	CRASHES

Final output has following attributes: NoLanes, SurfWidth, FunClass, AADT, MaxSpeed, MedWidth, ShldType, ShldType2, ShldType3, RoadMedian, TypePark, ShldWidth , ShldWidth2, ShldWidth3, UrbSize, LandUse, TypePark, BikeLaneCd, and BikeSltCd. Other than total crash counts, crashes are categorized in following levels: NoInj (Cat. O), PossInj (Cat. C), NoInCapInj (Cat. B), InCapInj (Cat. A) Fatality (Cat. K), NonTraffFat, and NotCoded.

APPENDIX B:
FLORIDA-SPECIFIC CRASH DISTRIBUTIONS

The Tables in the HSM which give default crash type distributions to be used in the calculation of CMFs are Table 10-4 and Table 11-6. Table 10-12, Table 11-19, and Table 12-23 in the HSM give nighttime crash proportions for use in calculating the lighting CMF.

The HSM specifies that local crash distributions can be used to replace the default crash distributions provided in the HSM. Table B-1 compares the Florida crash type distributions for rural two-lane roads to the HSM default distributions given in Table 10-4 of the HSM. Table B-2 shows the sum of the proportions from Table B-1 that are relevant to CMF calculation in Chapter 10 of the HSM. Table B-3 compares the Florida crash type distributions for KABC severity level crashes on rural multilane highways to the HSM default distributions given in Table 11-6 of the HSM. Table B-4 shows the sum of the proportions from Table B-3 that are relevant to CMF calculation in Chapter 11 of the HSM. Table B-5 and Table B-6 also compare crash type proportions for rural multilane highways, but only including crashes of KAB severity levels. Table B-7 displays the Florida nighttime crash proportions by facility type.

In order to determine the Florida crash distributions, the same crashes that were mapped to each segment for calibration were used. The "Harmful Event" variable from the vehicle level crash report, in addition to the number of vehicles involved in the crash, were used to identify the crash type. Table B-8 shows how the crash types defined in the "Harmful Event" variable were mapped to the HSM crash types.

TABLE B-1. Florida Crash Distribution for Rural Two-Lane Roads

Collision Type	2005	2006	2007	2008	HSM FI Proportions
Animal	0.032	0.027	0.037	0.043	0.038
Bicycle	0.000	0.001	0.001	0.001	0.004
Pedestrian	0.011	0.009	0.013	0.014	0.007
Overturned	0.092	0.111	0.125	0.101	0.037
Run off road	0.317	0.302	0.340	0.337	0.545
Other Single	0.031	0.030	0.032	0.028	0.007
Total Single Vehicle	**0.483**	**0.480**	**0.548**	**0.524**	**0.638**
Angle	0.147	0.161	0.141	0.140	0.101
Head-on	0.053	0.052	0.043	0.051	0.034
Rear-end	0.202	0.183	0.186	0.178	0.165
Sideswipe	0.053	0.052	0.040	0.046	0.038
Other Multivehicle	0.059	0.071	0.043	0.062	0.026
Total Multivehicle	**0.514**	**0.519**	**0.453**	**0.477**	**0.362**

TABLE B-2. Rural Two-Lane Florida Crash Proportion Used for CMF Calculation

Proportion Used for CMF Calculation	Head-on, Sideswipe, and Single Vehicle Run-off-the-Road Crashes				
	2005	2006	2007	2008	HSM FI Default
p_{ra} for CMF_{1r}	0.423	0.406	0.423	0.434	0.617
p_{ra} for CMF_{2r}					

TABLE B-3. KABC Florida Crash Distribution on Rural Multilane Divided Highways

Collision type	2005	2006	2007	2008	HSM FI Proportions
Head-on	0.018	0.021	0.021	0.013	0.013
Sideswipe	0.048	0.055	0.042	0.031	0.027
Rear-end	0.228	0.226	0.180	0.214	0.163
Angle	0.115	0.113	0.127	0.099	0.048
Single – non run off the road	0.359	0.347	0.375	0.395	0.727
Single – run off the road	0.142	0.154	0.159	0.167	
Other	0.090	0.084	0.097	0.081	0.022

TABLE B-4. KABC Florida Crash Proportion Used for CMF Calculation on Rural Multilane Divided Highways

Proportion of Crashes for CMF Calculation	Head-on, Sideswipe, and Single Vehicle Run-off-the-Road Crashes				
	2005	2006	2007	2008	HSM FI Default
p_{ra} for CMF$_{1rd}$	0.208	0.230	0.222	0.211	0.467

TABLE B-5. KAB Florida Crash Distribution on Rural Multilane Divided Highways

Collision type	2005	2006	2007	2008	HSM FI Proportions
Head-on	0.019	0.023	0.027	0.015	0.018
Sideswipe	0.046	0.042	0.036	0.023	0.022
Rear-end	0.210	0.191	0.163	0.189	0.114
Angle	0.110	0.113	0.124	0.101	0.045
Single – non run off the road	0.357	0.365	0.366	0.395	0.778
Single – run off the road	0.173	0.187	0.188	0.194	
Other	0.085	0.079	0.096	0.084	0.023

TABLE B-6. KAB Florida Crash Proportion Used for CMF Calculation on Rural Multilane Divided Highways

Proportion of Crashes for CMF Calculation	Head-on, Sideswipe, and Single Vehicle Run-off-the-Road Crashes				
	2005	2006	2007	2008	HSM FI Default
p_{ra} for CMF$_{1rd}$	0.238	0.252	0.251	0.232	0.497

TABLE B-7. Florida Proportion of Fatal and Injury Crashes that Occur at Night

Facility Type	2005	2006	2007	2008	HSM Default
Rural Two-Lane	0.331	0.352	0.375	0.367	0.370
Rural Multilane Divided	0.318	0.329	0.338	0.323	0.426
Urban Two-Lane	0.289	0.295	0.307	0.304	0.316
Urban Three-Lane	0.257	0.246	0.316	0.283	0.304
Urban Four-Lane Undivided	0.254	0.266	0.239	0.229	0.365
Urban Four-Lane Divided	0.253	0.268	0.259	0.269	0.410
Urban Five-Lane	0.239	0.227	0.231	0.232	0.274

TABLE B-8. Harmful Event Converted to HSM Crash Types

Even t Code	Event Description	HSM Crash Type for Rural Two Lane	HSM Crash Type for Rural Multilane
01	Collision With MV in Transport (Rear-end)	Rear-end	Rear-end
02	Collision With MV in Transport (Head-on)	Head-on	Head-on
03	Collision With MV in Transport (Angle)	Angle	Angle
04	Collision With MV in Transport (Left Turn)	Angle	Angle
05	Collision With MV in Transport (Right Turn)	Angle	Angle
06	Collision With MV in Transport (Sideswipe)	Sideswipe	Sideswipe
07	Collision With MV in Transport (Backed Into)	Other multivehicle	Other
08	Collision With Parked Car	Run off road	Single - run off the road
09	Collision With MV on Other Roadway	Other multivehicle	Other
10	Collision With Pedestrian	Pedestrian	Single - non run off the road
11	Collision With Bicycle	Bicycle	Single - non run off the road
12	Collision With Bicycle (Bike Lane)	Bicycle	Single - non run off the road
13	Collision With Moped	Other multivehicle	Other
14	Collision With Train	Other single vehicle	Single - non run off the road
15	Collision With Animal	Animal	Single - non run off the road
16	MV Hit Sign/Sign Post	Run off road	Single - run off the road
17	MV Hit Utility Pole/Light Pole	Run off road	Single - run off the road
18	MV Hit Guardrail	Run off road	Single - run off the road
19	MV Hit Fence	Run off road	Single - run off the road
20	MV Hit Concrete Barrier Wall	Run off road	Single - run off the road
21	MV Hit Bridge/Pier/Abutment Rail	Run off road	Single - run off the road
22	MV Hit Tree/Shrubbery	Run off road	Single - run off the road
23	Collision With Construction Barricade/Sign	Run off road	Single - run off the road
24	Collision With Traffic Gate	Other single vehicle	Single - non run off the road
25	Collision With Crash Attenuators	Run off road	Single - run off the road
26	Collision With Fixed Object Above Road	Other single vehicle	Single - non run off the road
27	MV Hit Other Fixed Object	Run off road	Single - run off the road
28	Collision With Moveable Object On Road	Other single vehicle	Single - non run off the road
29	MV Ran Into Ditch/Culvert	Run off road	Single - run off the road
30	Ran Off Road Into Water	Run off road	Single - run off the road
31	Overturned	Other single vehicle	Single - non run off the road
32	Occupant Fell From Vehicle	Other single vehicle	Single - non run off the road
33	Tractor/Trailer Jackknifed	Other single vehicle	Single - non run off the road
34	Fire	Other single vehicle	Single - non run off the road
35	Explosion	Other single vehicle	Single - non run off the road
36	Downhill Runaway	Other single vehicle	Single - non run off the road
37	Cargo Loss or Shift	Other single vehicle	Single - non run off the road
38	Separation of Units	Other single vehicle	Single - non run off the road
39	Median Crossover	Run off road	Single - run off the road
77	All Other (Explain)	Other Single/Multi	Other
88	Unknown	Removed from analysis	Removed from analysis
00	N/A	Removed from analysis	Removed from analysis

APPENDIX C:
FLORIDA BIKE LANE CALIBRATION

Bike lane mileage is growing at a rapid rate in Florida, as it is now standard practice to accommodate bicycles in any new construction or resurfacing projects. CMFs for bike lanes are available through the CMF clearinghouse website, which is funded by the Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center (11). However, none of these CMFs have a quality rating greater than three out of five stars, and the general trend shows an increase in both total crashes and fatal and injury crashes with the presence of bike lanes, contradicting the trend stated in Part D of the HSM. CMFs for dedicated bike lanes are not given in the Part C crash prediction section of the HSM or in the Part D CMF section; however, it is noted that there is a trend of decreased total crashes and bicycle crashes on segments with dedicated bike lanes (1).

Rather than develop a local CMF for the presence of bike lanes, the approach taken simply considers facilities with bike lanes as a separate facility type. The urban and suburban four-lane divided facility type had the highest presence of bike lanes, so these segments were split into two categories, with and without bike lanes, for calibration comparison. Table C-1 shows the calculated calibration factors of the two newly separated facility types in comparison with the original facility type categorization that did not take bike lanes into account. In 2005, the bike lane mileage was significantly less and there were not enough fatal and injury crashes for calibration factor computation. Although not evident in 2007, 2006 and 2008 each show a much lower calibration factor for segments with bike lanes. Potential reasons for this reduction in expected crashes include wider effective shoulder widths, lower speeds, driver behavior, or improved pavement conditions on what are possibly newly resurfaced roads. Further research is needed in this area to determine the safety impact of bike lanes, and how bike lanes can be included in HSM analysis.

TABLE C-1. Calibration Comparison for Bike Lane Facilities

Segment Description	Calibration Factor by Year		
	2006	2007	2008
Urban and Suburban Four-Lane Divided Segments with Bike Lanes			
Number of Segments	443	534	899
Total Length (mi.)	40.9	50.4	83.4
Total Observed Crashes	92	129	187
Calibration Factor	1.395	1.652	1.344
Urban and Suburban Four-Lane Divided Segments without Bike Lanes			
Number of Segments	7063	6972	6607
Total Length (mi.)	929.7	920.2	887.3
Total Observed Crashes	2742	2787	2595
Calibration Factor	1.620	1.653	1.625
All Urban and Suburban Four-Lane Divided Segments			
Calibration Factor for all Segments	1.611	1.653	1.602

APPENDIX D:
SENSITIVITY ANALYSIS TABLES

Table D-1. KABC Rural Two-Lane Sensitivity Analysis

Assumptions		Difference in Crashes per Mile					
Driveway Density (driveways/mi.)	Roadside Hazard Rating	Minimum	5%	Mean	95%	Maximum	Standard Deviation
5	3	-	-	-	-	-	-
5	1	-0.31	-0.14	-0.06	-0.02	0.00	-0.040
5	5	0.01	0.02	0.07	0.16	0.35	0.047
10	1	-0.31	-0.10	-0.02	0.00	0.00	0.039
10	3	0.00	0.02	0.04	0.05	0.07	0.010
10	5	0.01	0.05	0.11	0.21	0.35	0.051
2.5	1	-0.30	-0.14	-0.06	-0.02	0.00	0.040
2.5	3	0.00	0.00	0.00	0.00	0.03	0.002
2.5	5	0.01	0.02	0.07	0.16	0.37	0.047

Table D-2. KAB Rural Two-Lane Sensitivity Analysis

Assumptions		Difference in Crashes per Mile					
Driveway Density (driveways/mi.)	Roadside Hazard Rating	Minimum	5%	Mean	95%	Maximum	Standard Deviation
5	3	-	-	-	-	-	-
5	1	-0.21	-0.09	-0.04	-0.01	0.00	0.027
5	5	0.00	0.01	0.05	0.11	0.24	0.031
10	1	-0.21	-0.07	-0.02	0.00	0.00	0.026
10	3	0.00	0.01	0.03	0.03	0.05	0.007
10	5	0.01	0.03	0.07	0.14	0.24	0.034
2.5	1	-0.20	-0.09	-0.04	-0.01	0.00	0.027
2.5	3	0.00	0.00	0.00	0.00	0.02	0.001
2.5	5	0.00	0.01	0.05	0.11	0.24	0.031

Table D-3. Urban and Suburban Two-Lane Sensitivity Analysis

Assumptions		Difference in Crashes per Mile					
Driveway Density (driveways/mi.)	**Roadside Fixed Objects (objects/mi.)**	**Minimum**	**5%**	**Mean**	**95%**	**Maximum**	**Standard Deviation**
29.37	**14.71**	-	-	-	-	-	-
29.37	29.41	0.01	0.03	0.10	0.21	1.28	0.063
14.69	14.71	-2.38	-0.70	-0.37	-0.12	-0.03	0.196
14.69	29.41	-1.26	-0.55	-0.29	-0.09	-0.02	0.147
58.74	14.71	0.06	0.23	0.74	1.39	4.77	0.393
58.74	29.41	0.07	0.28	0.88	1.69	6.33	0.478

Table D-4. Urban and Suburban Three-Lane Sensitivity Analysis

Assumptions		Difference in Crashes per Mile					
Driveway Density (driveways/mi.)	**Roadside Fixed Objects (objects/mi.)**	**Minimum**	**5%**	**Mean**	**95%**	**Maximum**	**Standard Deviation**
35.98	**14.71**	-	-	-	-	-	-
35.98	29.41	0.01	0.02	0.07	0.13	0.16	0.032
17.99	14.71	-0.68	-0.46	-0.28	-0.09	-0.06	0.111
17.99	29.41	-0.54	-0.36	-0.22	-0.08	-0.05	0.083
71.95	14.71	0.12	0.18	0.56	0.92	1.35	0.222
71.95	29.41	0.14	0.20	0.64	1.07	1.56	0.261

Table D-5. Urban and Suburban Four-Lane Undivided Sensitivity Analysis

Assumptions		Difference in Crashes per Mile					
Driveway Density (driveways/mi.)	**Roadside Fixed Objects (objects/mi.)**	**Minimum**	**5%**	**Mean**	**95%**	**Maximum**	**Standard Deviation**
44.43	**14.71**	-	-	-	-	-	-
44.43	29.41	0.01	0.04	0.13	0.26	0.63	0.078
22.22	14.71	-4.48	-1.85	-0.95	-0.29	-0.09	0.553
22.22	29.41	-4.02	-1.66	-0.86	-0.26	-0.08	0.495
88.86	14.71	0.19	0.58	1.91	3.70	8.97	1.105
88.86	29.41	0.21	0.64	2.11	4.10	9.93	1.224

Table D-6. Urban and Suburban Four-Lane Divided Sensitivity Analysis

Assumptions		Difference in Crashes per Mile					
Driveway Density (driveways/mi.)	**Roadside Fixed Objects (objects/mi.)**	**Minimum**	**5%**	**Mean**	**95%**	**Maximum**	**Standard Deviation**
13.87	**14.71**	-	-	-	-	-	-
13.87	29.41	0.00	0.04	0.11	0.20	0.42	0.053
6.94	14.71	-0.42	-0.20	-0.12	-0.04	-0.01	0.052
6.94	29.41	-0.02	-0.02	-0.01	-0.01	0.01	0.003
27.74	14.71	0.01	0.08	0.23	0.40	0.83	0.104
27.74	29.41	0.02	0.12	0.35	0.62	1.28	0.161

Table D-7. Urban and Suburban Five-Lane Sensitivity Analysis

Assumptions		Difference in Crashes per Mile					
Driveway Density (driveways/mi.)	**Roadside Fixed Objects (objects/mi.)**	**Minimum**	**5%**	**Mean**	**95%**	**Maximum**	**Standard Deviation**
40.62	**14.71**	-	-	-	-	-	-
40.62	29.41	0.01	0.03	0.07	0.11	0.15	0.025
20.31	14.71	-1.87	-1.28	-0.75	-0.31	-0.09	0.310
20.31	29.41	-1.74	-1.20	-0.70	-0.28	-0.08	0.290
81.24	14.71	0.18	0.62	1.51	2.56	3.73	0.620
81.24	29.41	0.19	0.66	1.59	2.71	3.95	0.655

APPENDIX E:
GEOGRAPHIC SEGMENTATION

Table E-1. Rural 4-Lane Divided District Calibration

District	Average Crashes/Year	C_d / C_o				
		2005	**2006**	**2007**	**2008**	**Avg.**
D1	115.5	0.91	1.08	0.90	1.11	1.00
D2	117	0.81	0.83	1.01	0.79	0.86
D3	49.25	0.76	0.78	0.93	0.96	0.86
D4	65.25	1.65	1.41	1.23	1.38	1.42
D5	190	1.15	1.06	0.99	0.99	1.05
D6	14.75	1.33	1.06	2.12	1.22	1.43
D7	24.75	0.73	0.84	0.82	0.97	0.84

Table E-2. Urban 2-Lane Undivided District Calibration

District	Average Crashes/Year	C_d / C_o				
		2005	**2006**	**2007**	**2008**	**Avg.**
D1	144.5	1.21	1.26	1.11	0.96	1.14
D2	116	0.89	1.03	0.87	1.08	0.96
D3	158.5	1.02	0.92	1.06	1.00	1.00
D4	76.5	0.73	0.82	0.89	0.77	0.81
D5	127.5	0.74	0.80	0.69	0.87	0.78
D6	96	0.80	0.79	0.94	0.70	0.81
D7	205	1.58	1.37	1.41	1.52	1.47

Table E-3. Urban 3-Lane District Calibration

District	Average Crashes/Year	C_d / C_o				
		2005	**2006**	**2007**	**2008**	**Avg.**
D1	22.5	1.25	1.50	1.16	1.34	1.31
D2	8.5	0.47	0.41	1.39	1.05	0.83
D3	21.5	1.05	1.24	1.13	0.95	1.09
D4	14.5	0.67	0.34	0.65	0.85	0.63
D5	27	1.50	1.12	1.18	1.19	1.25
D6	6.75	0.46	0.83	0.28	0.46	0.51
D7	21.5	1.26	1.50	1.32	1.15	1.31

Table E-4. Urban 4-Lane Undivided District Calibration

District	Average Crashes/Year	C_d / C_o				
		2005	2006	2007	2008	Avg.
D1	37	1.19	1.61	0.87	1.09	1.19
D2	44.75	0.85	0.73	0.79	0.93	0.82
D3	52.25	1.38	1.26	0.80	0.77	1.05
D4	41	0.71	0.76	0.87	1.01	0.84
D5	60.25	1.35	1.12	1.42	1.10	1.25
D6	38	0.56	0.65	1.13	0.90	0.81
D7	56.25	1.06	1.13	1.10	1.23	1.13

Table E-5. Urban 5-Lane District Calibration

District	Average Crashes/Year	C_d / C_o				
		2005	2006	2007	2008	Avg.
D1	82.50	0.84	0.90	1.01	0.60	0.84
D2	182.00	1.12	1.32	1.25	1.45	1.29
D3	170.25	1.17	1.13	1.08	1.00	1.10
D4	119.25	1.02	0.96	1.08	0.99	1.02
D5	301.00	1.00	0.93	0.92	1.00	0.96
D6	81.00	0.62	0.80	0.76	0.83	0.75
D7	69.25	1.22	0.90	0.88	0.99	1.00

Above are the detailed results for the FDOT District Geographic Segmentation analysis performed for each facility type not described in section 2.5.1.

Table E-6. Rural 4 Lane KABC Population Density-Calibration

District	Average Crashes/Year	C_g / C_o				
		2005	2006	2007	2008	Avg.
G1	52.50	1.20	1.05	1.26	1.12	1.16
G2	89.25	1.17	1.11	1.20	1.39	1.22
G3	305.75	0.99	0.99	0.89	0.93	0.95
G4	129.00	0.87	0.96	1.07	0.92	0.95

Table E-7. Urban 2 Lane Undivided KABC Population Density-Calibration

District	Average Crashes/Year	C_g / C_o				
		2005	2006	2007	2008	Avg.
G1	281.75	1.13	1.16	1.28	1.20	1.19
G2	280.75	1.03	0.94	0.95	0.98	0.98
G3	207.00	0.89	1.01	0.83	0.92	0.91
G4	132.50	0.91	0.89	0.96	0.80	0.89

Table E-8. Urban 3 Lane KABC Population Density-Calibration

District	Average Crashes/Year	C_g / C_o				
		2005	2006	2007	2008	Avg.
G1	31.25	1.64	1.29	1.86	1.95	1.69
G2	31.75	0.74	0.94	0.91	0.66	0.81
G3	34.00	1.31	1.16	0.77	1.17	1.10
G4	17.50	0.59	0.70	0.83	0.70	0.70

Table E-9. Urban 4 Lane Undivided KABC Population Density-Calibration

District	Average Crashes/Year	C_g / C_o				
		2005	2006	2007	2008	Avg.
G1	181.25	0.85	0.89	1.03	1.04	0.95
G2	102.00	1.31	1.41	0.83	0.94	1.12
G3	20.50	0.82	0.62	0.91	0.74	0.78
G4	17.75	1.19	0.66	1.43	0.93	1.05

Table E-10. Urban 3 Lane KABC Population Density-Calibration

District	Average Crashes/Year	C_g / C_o				
		2005	2006	2007	2008	Avg.
G1	449.25	0.95	1.15	1.14	1.19	1.11
G2	270.75	0.94	0.92	0.85	0.83	0.88
G3	243.75	1.17	0.90	0.97	0.87	0.98
G4	27.00	1.17	0.78	1.21	1.58	1.18

The above tables show the results for the remaining facility types not discussed in section 2.5.2 (Segmentation by Population Density). The reader will note that in cases where sufficient data is available, these results also appear to support the trend of higher group-to-overall factor ratios in counties with higher population density.

APPENDIX F:
INTERSECTION LOCATIONS

Figure F-1. Rural Two-Lane, 3-Approach Stop

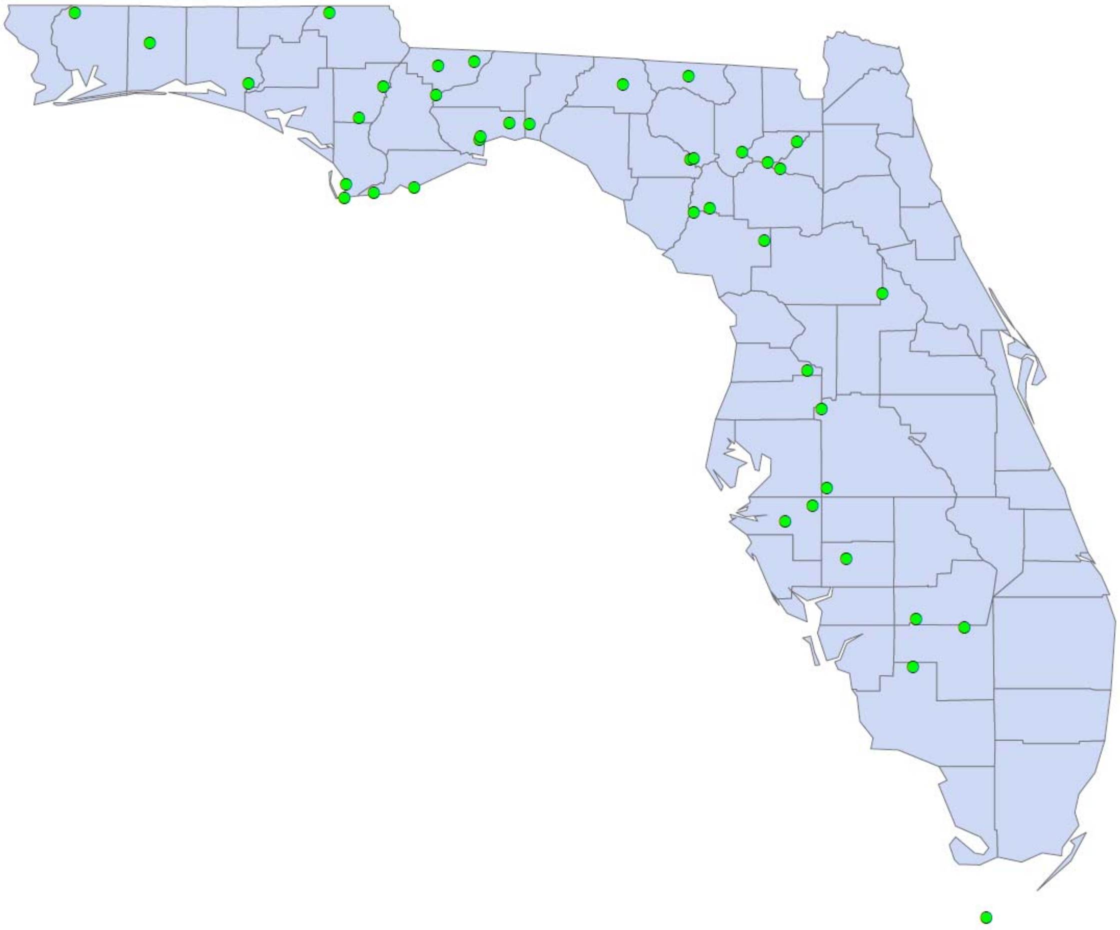


Table F-1. Rural Two-Lane, Three-Approach Stop Controlled Intersections.

County ID	Node ID	Latitude Coordinates	Longitude Coordinates	Major Roadway ID	Major Road Milepost	2nd Roadway ID	2nd Road Milepost
32	145	30.5242094	-82.96076161	32010000	19.9	32040000	0
33	68	29.95016456	-82.94897283	33010000	29.764	33030000	8.724
16	304	27.70471097	-82.02020218	16190000	2.128	16250000	4.547
28	149	29.88851179	-82.336908	28040000	5.708	28060000	0.657
5	4	26.8124745	-81.4127828	5040000	0	5090000	2.505
60	205	30.47161729	-85.96237612	60030000	27.427	60100000	0
3	67	26.48555655	-81.43465589	3050000	7.058	3080000	42.798
57	405	30.75071757	-86.63689398	57010000	10.559	57080000	12.709
56	98	30.3883142	-84.68465259	56010000	19.353	56050000	0
7	44	26.75421839	-81.08169881	7010000	31.822	7030000	12.259
13	710	27.58998253	-82.11873337	13060000	19.226	13070000	0
51	132	29.78224021	-85.30038014	51010000	0	51070000	9.199
59	17	30.08408462	-84.38755983	59010000	7.815	59030000	11.543
50	158	30.59288642	-84.66872638	50050000	11.185	50070000	10.587
39	142	30.07039291	-82.22426087	39020000	17.565	39040000	0
37	29	29.95576735	-82.92766637	37030000	0.08	37040000	0
49	73	29.75757555	-84.83316345	49010000	17.543	49060000	0
59	149	30.19973726	-84.1835265	59100000	16.631	59110000	14.244
35	185	30.46238027	-83.40989343	35060000	5.999	35070000	16.457
59	22	30.10471275	-84.38031056	59010000	9.337	59110000	0
29	403	30.00370723	-82.59735356	29030000	10.414	29080000	0
47	93	30.45027144	-85.04585477	47020000	21.475	47030000	0
16	615	28.24807102	-82.05571616	16210000	16.308	16330000	0
47	54	30.23500496	-85.20811644	47020000	2.46	47040000	0
39	79	29.93167755	-82.42322048	39020000	0.65	39070000	0
51	202	29.68620187	-85.30909621	51001000	0	51502000	5.803
53	1264	30.95091404	-85.41071626	5307000	7.643	5307000	0

				0		1	
50	816	30.62031387	-84.42476083	50020000	10.502	50040027	0.165
31	8001	29.59088138	-82.92638729	31010000	0	31040000	0.612
31	48	29.61853541	-82.81839836	31030000	2.44	31050000	0
13	658	27.47456889	-82.30773985	13050000	16.835	13140000	0
11	1079	29.03987545	-81.64013716	11100000	12.772	11190000	0.569
4	34	27.22557903	-81.88865271	4040000	11.486	4060000	10.991
8	275	28.50713209	-82.15435828	8060000	2.049	8070000	9.519
54	2	30.18958277	-84.04963918	54090000	0	54110000	1.586

Figure F-2. Rural 2-Lane, 4-Approach Signal

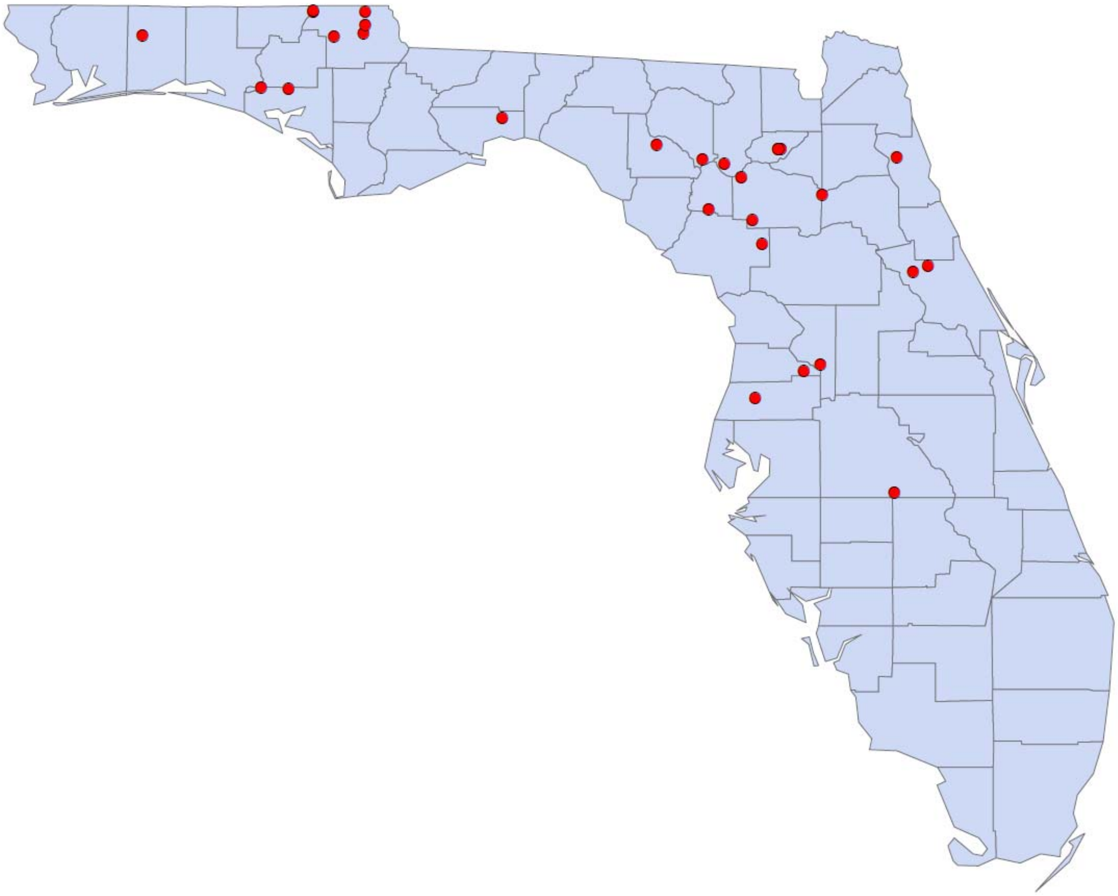


Table F-2. Rural Two-Lane, Four-Approach Signalized Intersections.

County ID	Node ID	Latitude Coordinates	Longitude Coordinates	Major Roadway ID	Major Road Milepost	2nd Roadway ID	2nd Road Milepost
53	285	30.87009276	-85.1623136	53090000	7.639	53130000	24.069
8	273	28.50796545	-82.17032925	8030000	2.082	8070000	8.543
46	155	30.43120237	-85.68750166	46050000	7.733	46060000	19.907
26	383	29.82697005	-82.59690285	26020064	0.619	26030000	26.189
26	331	29.53720163	-82.51911809	26030000	4.161	26090000	2.83
53	543	30.9572394	-85.5166433	53060000	8.883	53070000	1.323
79	1172	29.22518575	-81.32149868	79090000	11.586	79100000	13.117
39	32	30.02340589	-82.32414025	39010000	3.533	39020000	10.254
29	10	29.92301009	-82.71382278	29020000	4.312	29050000	7.588
14	26	28.32136015	-82.50305934	14010000	11.321	14120000	12.438
18	110	28.5551807	-82.05469984	18020000	0	18030000	4.21
53	549	30.96251742	-85.51670141	53060000	9.247	53070000	0.959
33	27	30.05305256	-83.17517595	33010000	13.592	33040000	19.157
39	27	30.02320009	-82.34417615	39010000	4.738	39050000	13.986
53	10	30.79229076	-85.37654832	53010000	4.778	53030000	16.215
16	3160	27.67786272	-81.55369897	16090000	0	16170000	2.585
76	483	29.70970936	-82.04409455	76070000	7.18	76080000	0.368
34	129	29.37431578	-82.45634057	34030000	20.192	34040000	11.013
79	980	29.18749919	-81.42122522	79050000	12.183	79100000	6.427
53	279	30.81230471	-85.17480311	53090000	3.558	53120000	21.173
53	421	30.95762163	-85.16235222	53070000	23.108	53090000	13.767
39	106	30.01793964	-82.34481057	39020000	8.86	39090000	2.499
37	41	29.95239617	-82.86072869	37030000	4.138	37070000	2.755
31	24	29.61337189	-82.81802891	31010000	7.789	31030000	2.099
78	408	29.9694542	-81.53818097	78060000	6.303	78070000	0
59	59	30.23252694	-84.22996139	59040000	5.596	59100000	12.889
61	186	30.44295219	-85.87401915	61040000	1.701	61121000	1.072
57	418	30.79716595	-86.68162628	57070000	4.592	57080000	8.117

Figure F-3. Rural 2-Lane, 4-Approach Stop

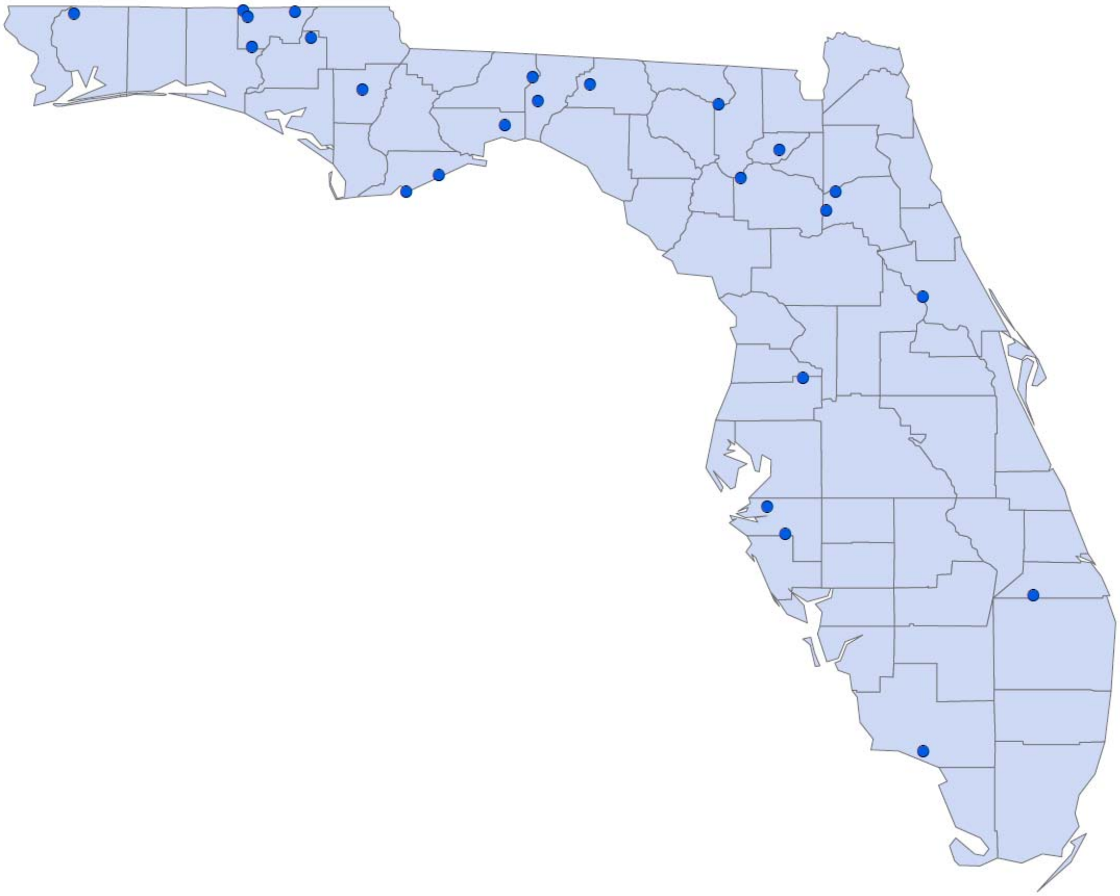


Table F-3. Rural Two-Lane, Four-Approach Stop Controlled Intersections.

County ID	Node ID	Latitude Coordinates	Longitude Coordinates	Major Roadway ID	Major Road Milepost	2nd Roadway ID	2nd Road Milepost
13	53	27.39917729	-82.30433874	13050000	22.134	13160000	15.567
3	29	25.91082428	-81.36452099	3010000	44.151	3040000	0
49	49	29.73620798	-84.88785937	49010000	13.882	49580000	5.439
79	5196	29.020481	-81.36688777	79070000	1.193	79070005	0
58	292	30.95295384	-87.15037964	58060000	21.79	58080000	5.446
52	165	30.97575213	-85.99784321	52040000	20.397	52050000	6.711
52	174	30.9317624	-85.96622841	52040000	16.679	52050000	6.725
14	337	28.4639742	-82.18342672	14050000	21.161	14150000	0
55	263	30.5235942	-84.02417802	55020000	16.699	55150000	0.111
52	107	30.96520458	-85.64666881	52030000	15.568	52050000	26.732
76	460	29.60784943	-82.02539779	76050000	2.038	76070000	0
35	92	30.47068145	-83.63516874	35010000	6.107	35050000	12.621
34	92	29.39339663	-82.44855845	34040000	12.768	34080000	0
49	102	29.85110891	-84.66478626	49010000	30.26	49040000	0
49	1	29.72066612	-85.10589913	49010000	0	49090000	0
58	296	30.95289972	-87.14727705	58060000	21.977	58080000	5.633
89	198	26.97762244	-80.61430851	89050000	1.409	89060000	0
54	29	30.35850095	-83.99009836	54060000	0	54090000	13.774
90	324	24.77256866	-80.93593908	90040000	11.713	90050000	0
61	108	30.78999334	-85.5391164	61002000	0	61080000	26.972
32	49	30.32979834	-82.75904205	32010000	1.273	32020000	0.107
52	8	30.72656657	-85.93770633	52010000	6.462	52040000	1.653
59	146	30.19056016	-84.21564504	59040000	2.582	59110000	12.211
26	1665	29.83100086	-82.60604133	26020064	0	26040000	1.707
76	502	29.7382904	-81.96287003	76080000	5.702	76110000	1.291
47	10	30.43668458	-85.1858034	47010000	12.56	47040000	15.795

39	23	30.02141332	-82.34506827	39050000	13.85	39090000	2.739
13	692	27.58828997	-82.4255159	13020000	11.249	13060000	0

Figure F-4. Rural Multilane, 4-Approach Signal

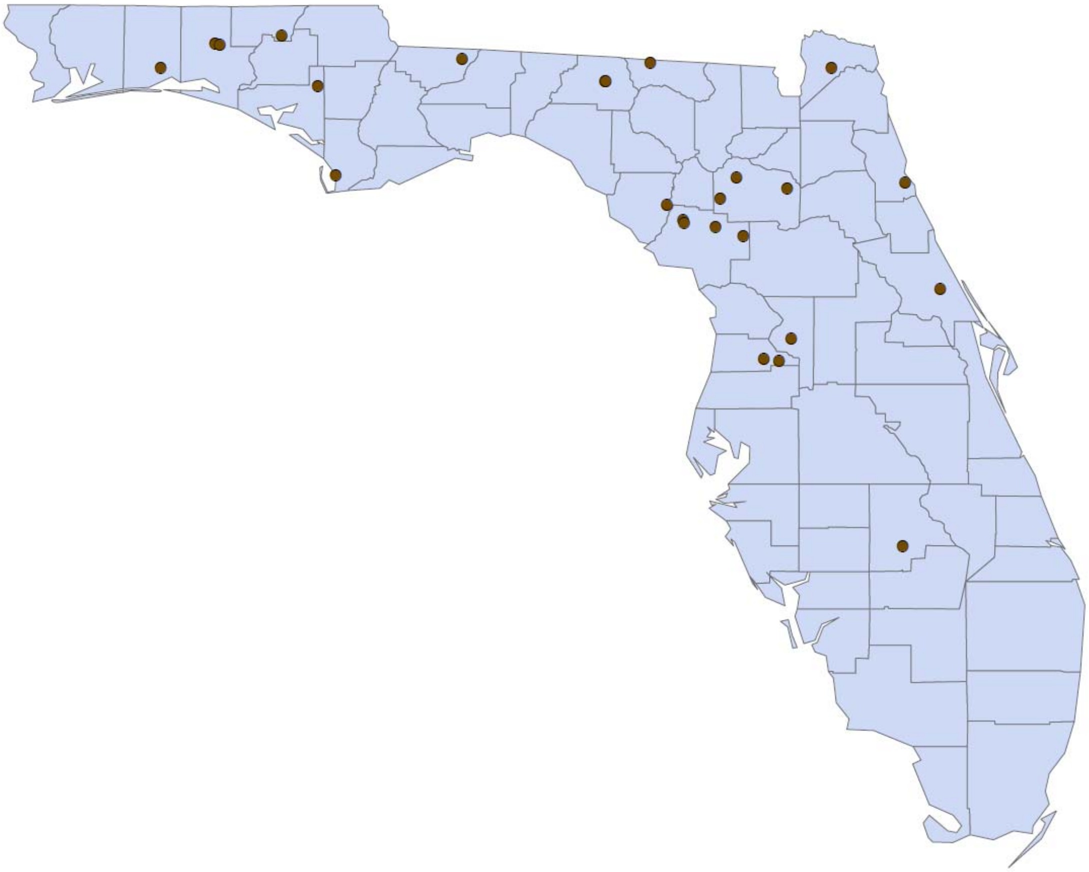


Table F-4. Rural Multilane, Four-Approach Signalized Intersections.

County ID	Node ID	Latitude Coordinates	Longitude Coordinates	Major Roadway ID	Major Road Milepost	2nd Roadway ID	2nd Road Milepost
60	61	30.72136916	-86.11537169	60010000	17.019	60070000	0
32	173	30.60260157	-83.09956952	32010000	30.969	32070000	11.669
57	882	30.56328993	-86.52809844	57050000	4.071	57150000	4.916
79	779	29.01121247	-81.06882972	79070000	20.202	79120000	17.59
30	31	29.60154041	-82.98183189	30010000	25.838	30030000	23.492
74	29	30.56367451	-81.82976498	74030000	4.611	74040000	15.637
34	135	29.38736623	-82.44727624	34010000	34.918	34040000	12.348
8	125	28.52321012	-82.30314285	8050000	6.117	8070000	0
51	1	29.81218705	-85.30351245	51010000	2.11	51020000	0
35	107	30.46940484	-83.41494928	35010000	19.983	35040000	0
26	345	29.64669812	-82.60663001	26030000	13.606	26070000	3.03
18	18	28.66489761	-82.11246686	18010000	6.842	18060000	10.252
8	93	28.50786583	-82.19528513	8070000	7.026	8120000	2.041
35	250	30.46941853	-83.41005561	35010000	20.275	35060000	6.483
26	134	29.71685438	-82.13980149	26060000	20.308	26130000	11.758
52	51	30.78810089	-85.67983048	52010000	23.478	52030000	3.075
34	278	29.4747054	-82.85962427	34050000	35.655	34110000	19.331
26	233	29.79371799	-82.49431915	26020000	17.962	26110000	0.485
50	281	30.62403939	-84.41529701	50040000	0.839	50040027	0.789
46	2	30.43560188	-85.42732948	46040000	25.223	46050000	23.449
34	181	29.49664248	-82.86829811	34010000	7.394	34150000	6.624
60	42	30.73409405	-86.14860242	60010000	14.833	60060000	0
9	10	27.20832022	-81.32866291	9010000	12.164	9060000	14.464
34	70	29.44759302	-82.64234355	34010000	22.359	34070000	32.932
78	262	29.7564846	-81.31286023	78010000	7.415	78090000	10.621

Figure F-5. Urban 3-Approach Signal

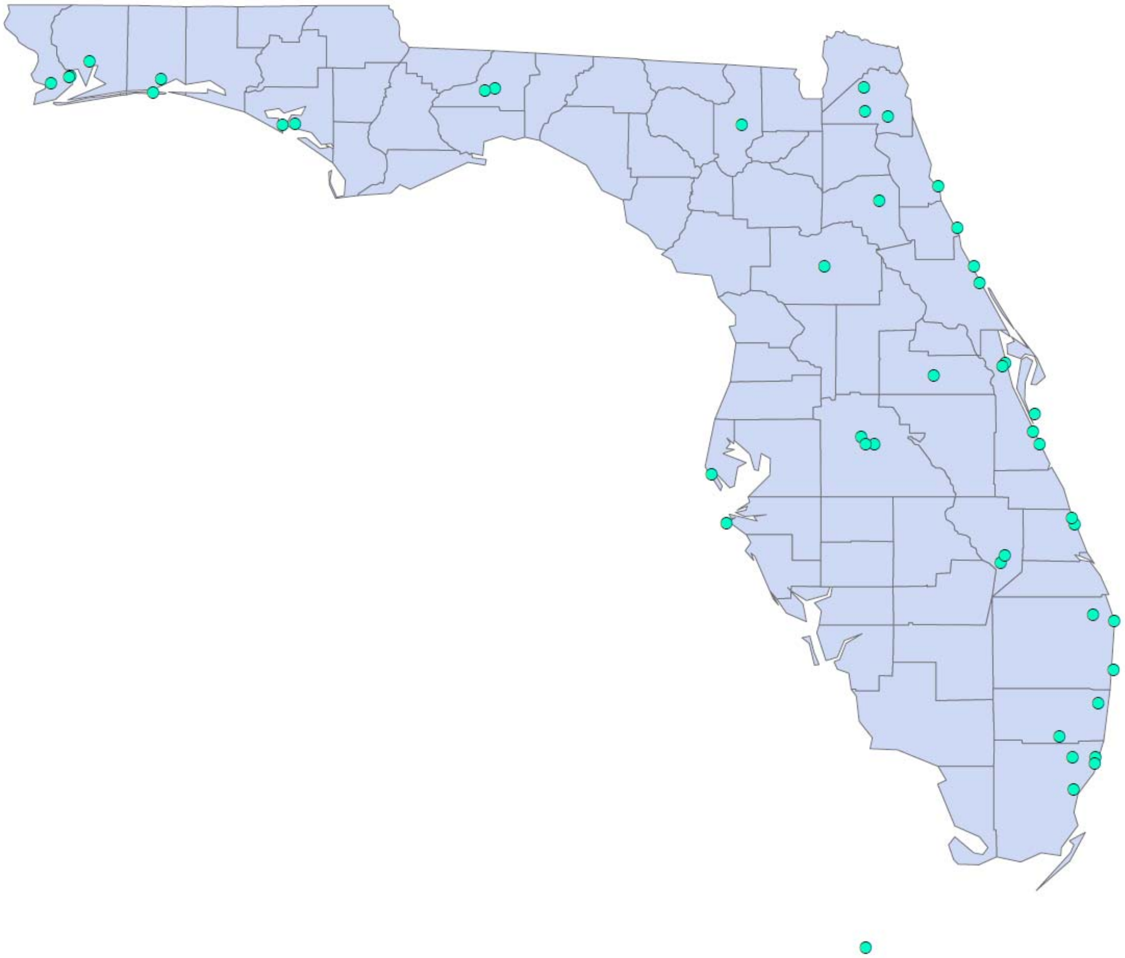


Table F-5. Urban, Three-Approach Signalized Intersections.

County ID	Node ID	Latitude Coordinates	Longitude Coordinates	Major Roadway ID	Major Road Milepost	2nd Roadway ID	2nd Road Milepost
15	510	27.80095288	-82.80106602	15100000	7.955	15140000	0
70	1272	28.21271738	-80.59785677	70004000	4.59	70060000	26.099
57	40	30.40410618	-86.61320681	57030000	11.15	57110000	0
87	702	25.86718095	-80.34004636	87038000	0	87090000	8.83
87	2923	25.87001373	-80.18557907	87034000	0.94	87038000	9.7
78	72	29.77069502	-81.25430523	78040000	7.357	78090000	14.485
55	118	30.4381211	-84.28063338	55040000	11.703	55080000	0
48	187	30.52019077	-87.1742609	48020000	24.69	48030000	5.471
91	7	27.19821575	-80.82952499	91010000	4.781	91020000	0
76	130	29.66848273	-81.65671557	76020000	22.964	76030000	1.064
70	726	28.55749148	-80.79783948	70020000	35.699	70030000	0
87	3508	25.82555391	-80.18692169	87030000	14.554	87250000	5.822
46	249	30.18344677	-85.7271848	46020000	1.295	46140001	0
72	2622	30.43976623	-81.76445908	72018000	0	72080000	10.299
93	169	26.46169689	-80.0583221	93030000	9.18	93060000	9.784
16	1762	28.00793978	-81.75134421	16120000	1.38	16121000	0.627
48	1333	30.51106998	-87.1853317	48003000	7.281	48030000	4.535
91	112	27.24648751	-80.80191122	91060000	0	91070000	11.297
58	36	30.62178487	-87.04359712	58010000	11.621	58050000	0
86	2924	26.23142405	-80.16558881	86039000	2.482	86130000	3.228
94	1283	27.49853872	-80.34540221	94005000	6.168	94010000	17.059
46	388	30.18939463	-85.6409384	46001000	3.576	46040000	2.644
70	520	28.00382802	-80.56329211	70010000	11.406	70180000	6.698
48	70	30.47336618	-87.30703813	48020000	7.788	48190000	0
87	6680	25.64689426	-80.33272145	87020000	17.597	87047000	0
86	1	26.00778315	-80.43261082	8604000	0	8606000	3.544

				0		0	
16	850	28.0585475	-81.78278836	16020000	11.054	16140000	0
70	5187	28.53245217	-80.81886802	70001000	2.394	70006000	6.797
72	631	30.28203587	-81.7552479	72012000	0.83	72017000	0
93	298	26.84091567	-80.19872386	93001000	0	93310000	13.521
70	575	28.09380899	-80.610154	70020000	1.128	70022000	40
16	1100	28.00273324	-81.6927137	16300000	2.482	16300101	1.377
94	64	27.45488187	-80.32720102	94010000	13.847	94050000	17.945
90	118	24.56990813	-81.75254651	90003000	2.895	90010000	3.927
75	168	28.47691287	-81.28529223	75080000	9.974	75200000	0
57	869	30.49700569	-86.55756446	57040000	8.476	57150000	0
72	1313	30.24418585	-81.60025239	72070000	12.089	72292000	0
13	1078	27.4682716	-82.69961534	13040000	0	13080000	6.666
29	674	30.18644821	-82.59686756	29002000	3.471	29010000	12.48
79	253	29.10784195	-80.97318814	79010000	24.954	79190000	0
55	1798	30.41926528	-84.35054404	55002100	0.225	55160100	0
79	623	29.22035938	-81.01123542	79080000	1.059	79080001	0.77
93	378	26.79818972	-80.05469975	93020000	14.539	93040000	0
36	954	29.21884812	-82.03357743	36080000	7.217	36518000	8.46
73	28	29.48098514	-81.12738217	73020000	8.191	73030000	4.017

Figure F-6. Urban 4-Approach Signal

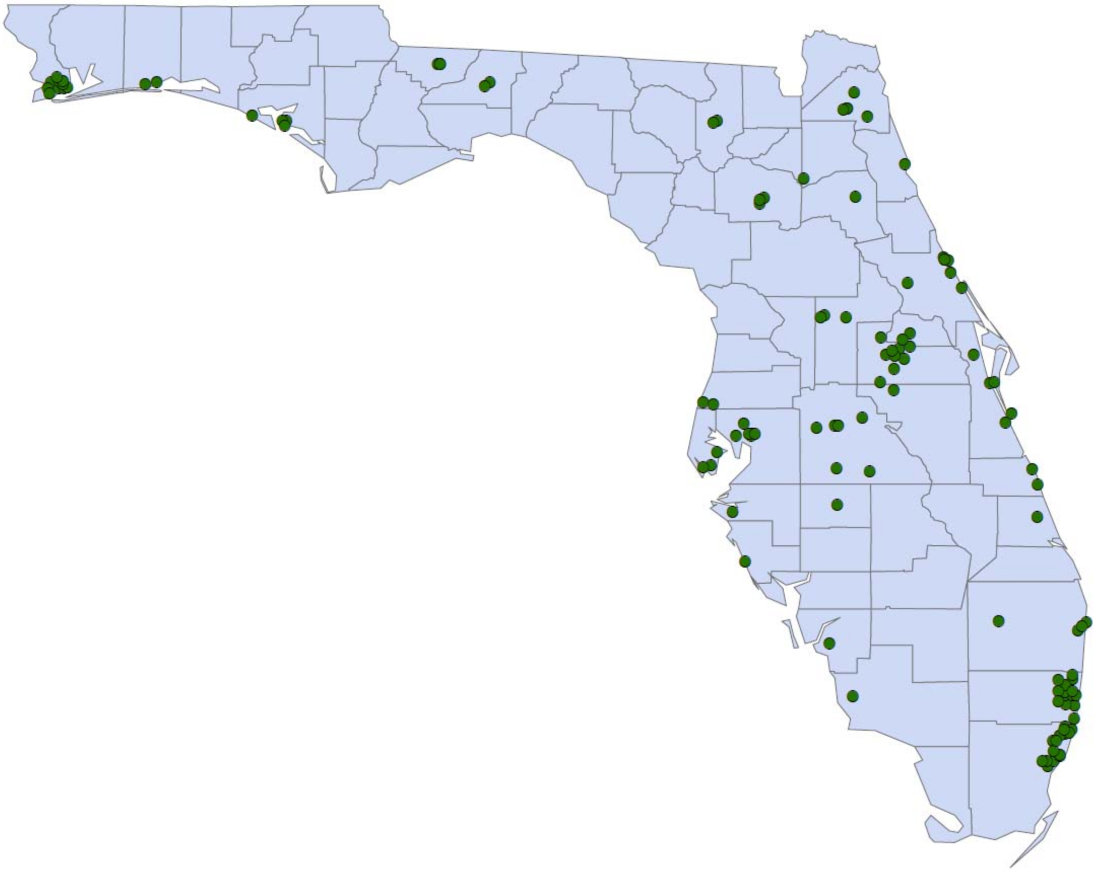


Table F-6. Urban, Four-Approach Signalized Intersections.

County ID	Node ID	Latitude Coordinates	Longitude Coordinates	Major Roadway ID	Major Road Milepost	2nd Roadway ID	2nd Road Milepost
86	1226	25.99675392	-80.14269857	86010000	1.532	86018000	6.547
71	19	29.78574516	-82.03130198	71040000	1.124	71110000	6.245
87	931	25.89945589	-80.18644551	87008000	8.637	87034000	2.975
93	2763	26.68644907	-80.66781118	93130000	0.29	93170000	0.58
29	259	30.17886647	-82.66681826	29010000	8.033	29090000	11.348
75	207	28.524258	-81.33102639	75012000	0	75080000	15.851
94	115	27.41269032	-80.3990891	94003000	0	94030000	20.523
87	3013	25.84520819	-80.26618226	87080900	34.939	87281000	8.196
86	2350	26.12080536	-80.2524677	86006000	0	86220000	10.343
16	264	27.73368604	-81.57266653	16040000	15.064	16170000	6.851
86	2292	26.19378179	-80.25207264	86014000	0	86220000	15.573
72	733	30.28215366	-81.72598498	72017000	1.751	72170000	6.743
11	146	28.81222679	-81.91647092	11002000	0	11010000	2.365
55	242	30.46007975	-84.2279794	55003000	7.876	55020000	3.356
10	1776	27.99622318	-82.37309714	10030000	4.772	10030102	0
48	73	30.46110976	-87.30100514	48012000	0	48020000	8.702
70	2190	28.35696491	-80.70015812	70100000	10.706	70140000	0
10	247	27.98142041	-82.40161187	10330000	0.911	10340000	6.34
11	102	28.82642107	-81.88743244	11010047	0	11040000	4.472
72	1224	30.27009235	-81.75643091	72012000	0	72295000	0.831
15	2110	27.8646572	-82.63806091	15090000	6.939	15240000	3.376
75	6755	28.60899571	-81.28871055	75090000	4.125	75205000	0.336
79	616	29.21225402	-81.01935503	79080000	0.23	79080001	0
3	510	26.15482714	-81.68698443	3001000	6.464	3030001	16.205
16	845	28.05886194	-81.78866584	16020000	10.695	16160000	0
86	2675	26.3043419	-80.15252288	86012000	0	86065000	11.671

79	462	29.23247937	-81.05429148	79190000	10.389	79190007	0
75	2588	28.35739063	-81.49708471	75035001	0.895	75039000	2.034
13	1455	27.44729908	-82.5303865	13121000	4.06	13160000	1.001
87	1097	25.70732348	-80.28578117	87030000	2.751	87062000	0.217
48	245	30.45274756	-87.22053825	48004000	9.647	48070000	2.686
48	1384	30.47332135	-87.21222213	48003000	4.025	48012000	5.516
93	131	26.67573861	-80.05472321	93050000	5.838	93120000	20.812
55	304	30.43689382	-84.26180583	55005000	0	55080000	1.143
46	170	30.18980865	-85.67886087	46001000	1.304	46110000	1.554
10	295	27.99608541	-82.41404107	10005000	2.845	10030000	2.267
87	9017	25.92157718	-80.2130663	87140000	10.812	87140001	0.965
50	95	30.58802407	-84.59110644	50010000	19.849	50080000	15.389
86	2159	26.18845752	-80.15522851	86014000	6.248	86065000	3.57
50	108	30.5881648	-84.57577614	50010000	20.763	50020000	0
70	300	28.13894791	-80.58110946	70060000	20.909	70120000	8.398
57	250	30.44956461	-86.63852895	57003000	0	57110000	4.318
87	1132	25.73989797	-80.23796449	87030000	6.534	87240000	0
48	741	30.46670967	-87.24231083	48012000	3.569	48040000	3.543
11	1967	28.81000096	-81.73650127	11010000	14.028	11240002	0.038
88	165	27.74869381	-80.43564934	88010000	14.267	88050000	5.879
48	1365	30.44749971	-87.212613	48003000	2.211	48005000	1.182
86	554	26.1661003	-80.15458198	86065000	2.036	86090000	6.352
75	5600	28.45025535	-81.40076457	75002000	4.618	75010000	7.062
86	115	26.09280097	-80.13658021	86010000	8.286	86010001	2.547
46	98	30.18953902	-85.64997022	46001000	3.033	46060000	2.212
75	6025	28.57832143	-81.41644207	75190000	4.993	75250000	8.44
78	298	29.89096332	-81.32465414	78010000	16.758	78010027	0
72	853	30.39100466	-81.67929115	72150000	2.715	72291000	9.812

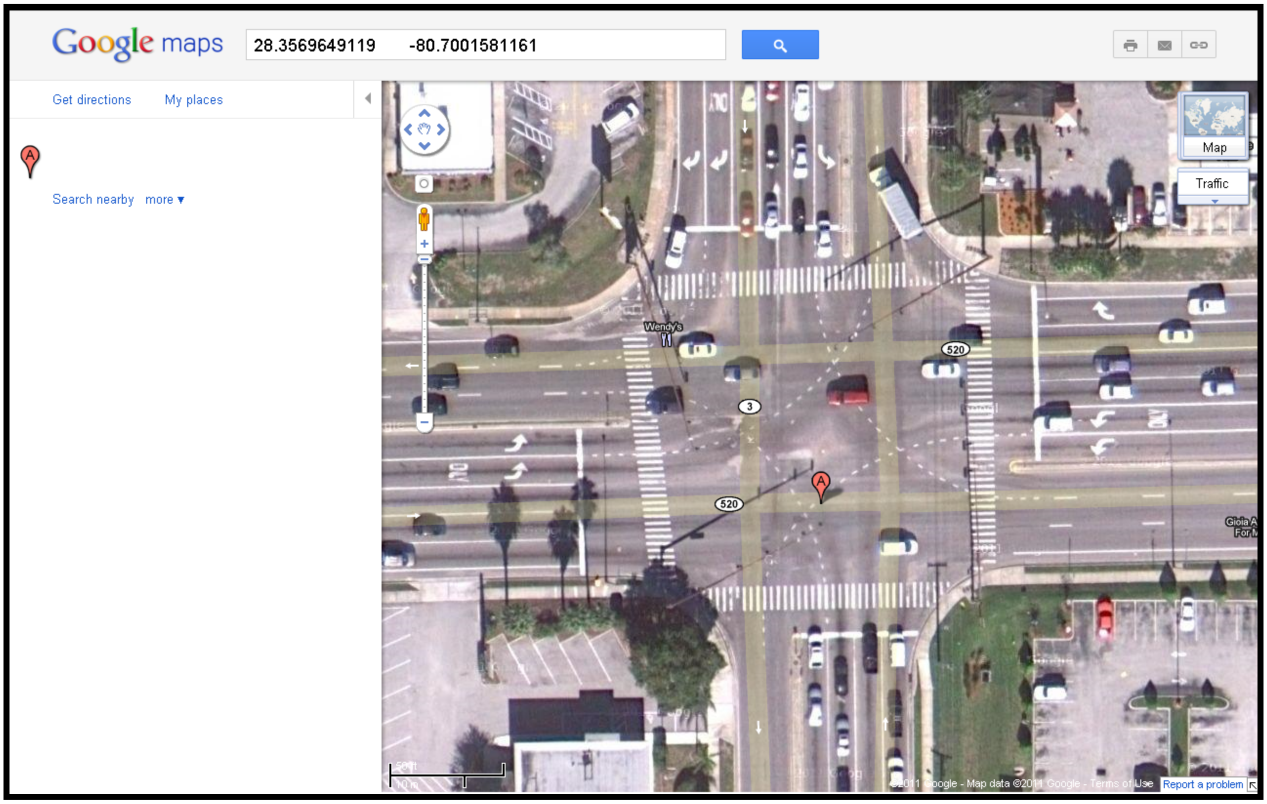
70	1167	28.0786503	-80.62144767	70012000	5.528	70050000	14.993
86	569	26.16677511	-80.13170787	86090000	7.775	86170000	2.338
46	306	30.15882365	-85.66034475	46020000	6.362	46040000	0
77	256	28.70351349	-81.29128153	77070000	2.543	77070002	0
26	23	29.6520409	-82.31132038	26050000	3.379	26070000	21.167
29	83	30.18934085	-82.63705725	29010000	10.055	29070000	3.031
15	1132	27.77730589	-82.67952178	15010000	2.51	15150000	4.874
93	1057	26.61777838	-80.11355431	93070000	20.359	93180000	5.677
48	575	30.42120951	-87.31730691	48004000	3.01	48110000	7.989
15	1411	27.76256434	-82.73492133	15110000	1.775	15230000	0
76	441	29.65831235	-81.668453	76020000	21.935	76110000	20.583
87	1714	25.94253897	-80.20499399	87026000	5.529	87140000	12.604
79	936	29.05480025	-81.30432945	79040000	15.172	79050000	0
86	1014	26.18662334	-80.20365267	86014000	3.22	86100000	14.794
70	2166	28.55438717	-80.84673203	70001000	0	70110000	5.489
87	1059	25.66646779	-80.32361988	87020000	19.057	87046000	3.002
26	21	29.61443564	-82.34086216	26010000	11.628	26050000	0
87	2986	25.89977928	-80.17842686	87008000	9.136	87190000	1.394
87	929	25.89859884	-80.2028706	87008000	7.614	87008001	0
87	2615	25.77079679	-80.2879972	87053000	3.018	87062000	4.57
50	107	30.58816129	-84.57696884	50010000	20.692	50140000	0
87	2972	25.70108844	-80.3661752	87055000	2.018	87072000	2.022
10	3520	27.98154773	-82.50536987	10130000	11.05	10340000	0
86	1029	26.2354204	-80.20478409	86039000	0	86100000	18.132
75	6151	28.67299726	-81.49279924	75120000	0.202	75120001	0.348
10	250	27.99619324	-82.39353656	10030000	3.522	10330000	2.145
79	455	29.21970878	-81.04725519	79190000	9.411	79220000	0.99
72	1311	30.22074247	-81.58564814	72028000	1.912	72070000	10.244

48	113	30.42068002	-87.24125658	48020000	13.473	48050000	21.029
48	144	30.42307443	-87.20706814	48003000	0.496	48020000	15.535
57	271	30.46523303	-86.55581904	57040026	0.819	57130000	6.205
87	915	25.84076263	-80.28997295	87002000	0.758	87080900	33.208
16	912	28.10667982	-81.62310346	16020000	22.46	16090000	34.807
92	189	28.30455223	-81.40368407	92010000	11.764	92030000	0
70	664	28.35569796	-80.73255804	70020000	20.999	70100000	8.727
79	428	29.12758648	-81.00512341	79190000	2.521	79230000	2.382
48	1244	30.38076993	-87.30853058	48004000	0	48050000	15.354
86	2258	26.27238558	-80.25016582	86028000	0	86220000	21.003
12	1913	26.52817896	-81.85259087	12004000	10.726	12011000	3
79	2221	29.22243181	-81.04872684	79190000	9.619	79190006	0
14	51	28.21691191	-82.73735976	14030000	3.028	14570000	0
48	1518	30.49727638	-87.2550987	48013000	0	48013001	20.015
86	517	26.2744712	-80.15197846	86028000	6.108	86065000	9.612
87	2229	25.92609939	-80.15590089	87170000	3.568	87190000	3.767
16	25	27.75190626	-81.80147842	16030000	7.575	16040000	0
16	829	28.0576373	-81.81340474	16020000	9.11	16120000	7.125
79	214	29.02355579	-80.92635822	79010000	18.176	79070001	0.934
26	566	29.63646262	-82.33937188	26004000	0.924	26010000	13.125
75	975	28.59308524	-81.3649731	75006000	1.095	75030000	5.373
46	194	30.23034941	-85.88766243	46090000	0.551	46160000	6.087
87	2939	25.70230834	-80.334133	87047000	3.911	87055000	4.018
10	174	28.06931238	-82.4511433	10040000	8.207	10350000	0.499
87	1372	25.7503427	-80.23823119	87054000	1.532	87240000	0.715
86	538	26.16477953	-80.20326386	86090000	3.323	86100000	13.3
88	33	27.63968659	-80.39517183	88010000	6.268	88060009	0.114
87	1534	25.88283217	-80.24308024	87052000	0	87240000	9.853

86	327	26.10457395	-80.20143875	86100000	9.142	86210000	0
14	1676	28.20598148	-82.66612577	14570002	1.66	14570101	0.191
72	1146	30.28213156	-81.73036278	72017000	1.489	72291000	0.423
77	340	28.6609167	-81.3414777	77010000	1.748	77080000	7.453
93	1579	26.65092453	-80.0880714	93006000	4.388	93016000	7.153
75	5539	28.54384645	-81.39730379	75010000	13.546	75030000	0
6	24	27.50017901	-81.79782332	6010000	11.136	6050000	16.604
48	159	30.42532773	-87.18356877	48012000	9.601	48020000	16.959
75	5040	28.5523869	-81.45647594	75050000	12.277	75270000	7.101
16	712	28.03857301	-81.94088465	16060000	11.687	16331000	0
17	42	27.09985642	-82.44427525	17010000	17.131	17020000	0

APPENDIX G:
EXTRACTION OF INTERSECTION ATTRIBUTES FROM GOOGLE MAPS

The geographic coordinates found in the RCI were entered directly into Google Earth, allowing the program to focus on the intersection in question (see below).

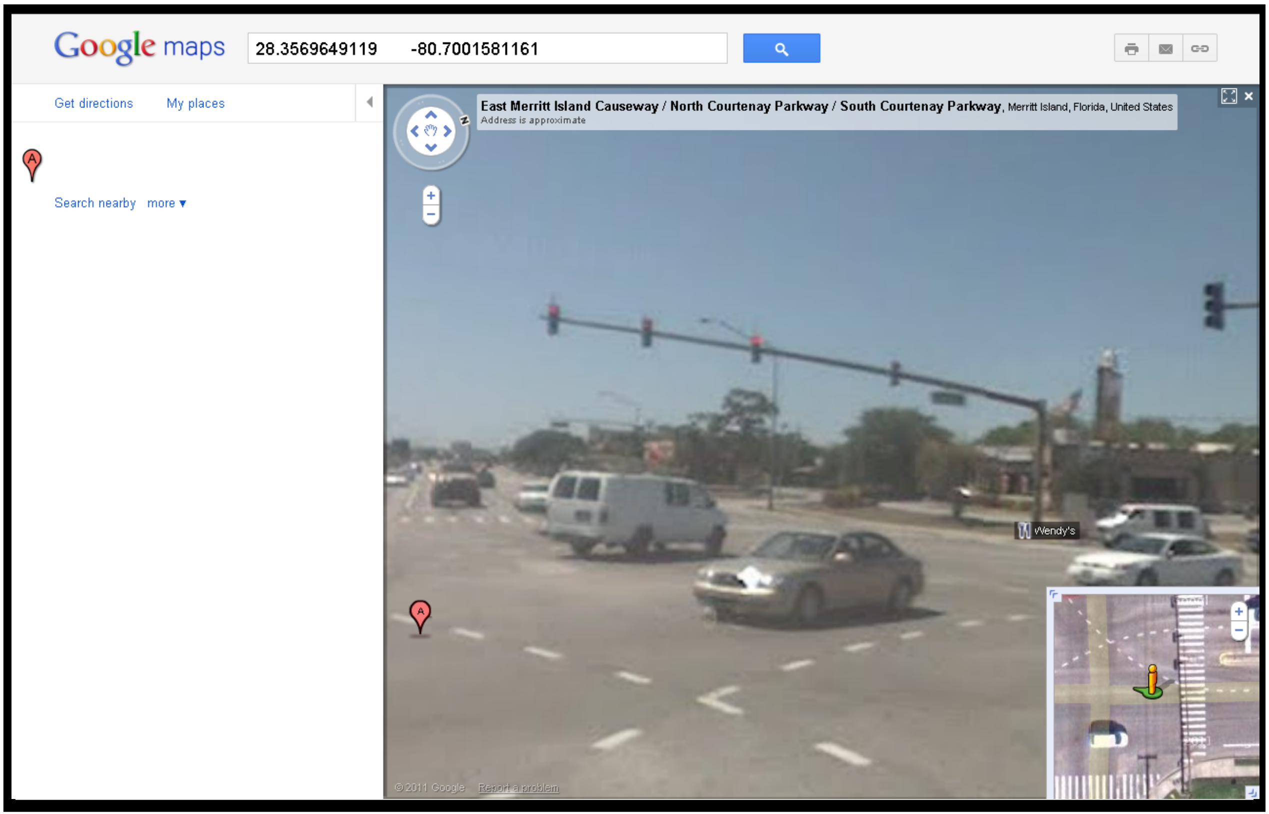


28.3569649119 -80.7001581161

Figure G-1. Overhead View, Google Earth.

Attributes such as left-turn only lanes, right-turn only lanes, and skew could easily be recorded using this view. Pedestrian activity was estimated by taking into account contributing factors such as crosswalks, sidewalks, retail, and residential buildings. Vehicle-pedestrian modification factors can also be found by counting the bus stops, schools, and alcohol sales establishments (Google Earth helpfully provides symbols specifically identifying bus stops and schools).

The program also allows the user to access a street view (seen below), that provides a driver's-eye vantage point.



28.3569649119 -80.7001581161

East Merritt Island Causeway / North Courtenay Parkway / South Courtenay Parkway, Merritt Island, Florida, United States
Address is approximate

Figure G-2. Street View, Google Earth.

This setting provides a view of other attributes required by the HSM, including lighting, red-light cameras, and traffic signals. Left-turn signal phasing was deduced from the shape of the signal boxes and number of approaching turn lanes.

Using the above methods, each factor needed for use in either an SPF or CMF equation was counted and added to the intersection attributes from the RCI.