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16. Abstract

A safety analysis of a specific location requires the knowledge of "base crash rates", also known in the literature as "expected values", for identifying crash patterns at the study location. Base crash rate models were developed for the following nine crash types: (a) Injury (b) PDO (c) Total (d) Wet (e) Night (f) Rear end (g) Sideswipe (h) Fixed object and (i) Left turn crashes. These models were developed for intersection legs (also called intersection approaches) as the crash behavior of different legs within the same intersection were likely to be different. Base crash rates for the following eight leg types were modeled based on the type of control: (a) Signalized legs at four way signalized intersections (b) Signalized legs at three way signalized intersections (c) No control legs at one way stop controlled intersections (d) Stop controlled legs at one way stop controlled intersections (e) No control legs at two way stop controlled intersections (f) Stop controlled legs at two way stop controlled intersections (g) No control legs at intersections with flashing beacons and (h) Stop controlled legs at intersections with flashing beacons. This study focused on intersections formed by two or more State or US routes. To evaluate the complex interaction among the dependent and independent variables, Automatic Interaction Detection (AID) technique was used. After the completion of AID analysis, stepwise multiple regression technique was used to develop mathematical models for the split groups. It is recommended that the AID and regression models developed in this study (Appendices II and III) be used for estimating statewide base crash rates in Ohio.

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Final Report

CRASH BASE RATES FOR INTERSECTIONS IN OHIO

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February 2007

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Disclaimer Statement

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CRASH BASE RATES FOR INTERSECTIONS IN OHIO

1. Introduction

A report by Federal Highway Administration (FHWA) titled "National Agenda for Intersection Safety" quotes that in the year 2000, more than 2.8 million intersection related crashes occurred in the nation, which amounted to 44 percent of all reported crashes. According to FHWA, in the year 2004, over 9,117 Americans lost their lives as a result of intersection related crashes, and each year more than 2.7 million intersection crashes occur (over 45 percent of all reported crashes). [1,2] According to the Ohio Department of Public Safety, 70,396 crashes were reported in Ohio at four way intersections, 41,195 crashes at T-intersections, and 2,791 crashes at Y-intersections in 2005. In the year 2004, in Ohio, 75,172 crashes were reported at four way intersections, 44,481 crashes at T-intersections, and 3,033 crashes at Y-intersections. [3]. These statistics point to the need for improved safety and efficiency measures for intersections.

Identifying intersections that are deemed hazardous and determining effective remedies to alleviate the situation is a challenge to traffic engineers and planners. A problem location is one that presents a risk to the user in terms of high probability of crash occurrence or severity. Currently, the Ohio Department of Transportation (ODOT) uses the Highway Safety Program – Ohio Enhanced Crash Location Identification System (OECLIS), which is the standard for crash monitoring and is used for identification and "internal ranking" of safety projects.

A safety analysis of a specific location requires the knowledge of "base crash rates", also known in the literature as "expected values", for identifying crash patterns at the study location. The base crash rates will allow ODOT to objectively determine whether a crash pattern at a study location is significantly higher than the same crash pattern at other locations with similar geometric, traffic, and environmental factors. However, base crash rates for crash patterns that can be used uniformly across all processes or tools on a statewide basis are currently not available within ODOT.

Several crash and non-crash based methods are available to identify problem locations. For example, the crash rate method utilizes crash frequency and exposure to identify problem locations. After the crash rate for each crash type is calculated for a study intersection, each crash rate is to be compared to the "base crash rate". If the calculated crash rate for any crash type at a particular location is found to be higher than the "base crash rate," then that location is chosen for further study to determine if a safety problem actually exists at that location and, if so, what counter measure(s) can be used. Base crash rates are developed from real-world crash data collected from sites located within each highway agency jurisdiction. A set of base rates will assist ODOT in analyzing intersections consistently and uniformly on a statewide basis. With the use of the base crash rates, the safety related analysis performed by ODOT will give more reliable results.

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2. Objective

The primary objective of this study is to develop a set of mathematical models to estimate base crash rates for intersections in Ohio. The models will estimate the incremental changes in the dependent variables (crash rate for different types of crashes) resulting from changes in the independent variables (including geometric features, operational controls, and environmental conditions). Crash data and inventory data available with ODOT will be used to develop and validate the models. This methodology used in this study is similar to those successfully used by the previous research studies, "Rational Schedule of Base Accident Rates for Rural Highways in Ohio- Phase I and II." [4, 5, 6].

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3. Methodology

The methodology adopted in this research is outlined using a flow chart as shown in Figure 1. It consists of four steps:

Step 1: Data collection

- Select all intersections which are formed by two or more State or US routes.
- Collect crash data and average daily traffic (ADT) for each intersection leg from ODOT. Calculate population density for each intersection using GIS and census data.
- Using ODOT photologs, collect intersection data including type of control, number and types of lanes, and number of intersection legs.
- Integrate all the data into a single master database

Step 2: Data processing and analysis

- Analyze the independent and dependent variables that can be used in the models.
- Randomly divide the master database into two sets of 1/3 and 2/3 data sets. The larger set will be used for model building and the smaller set for model validation.

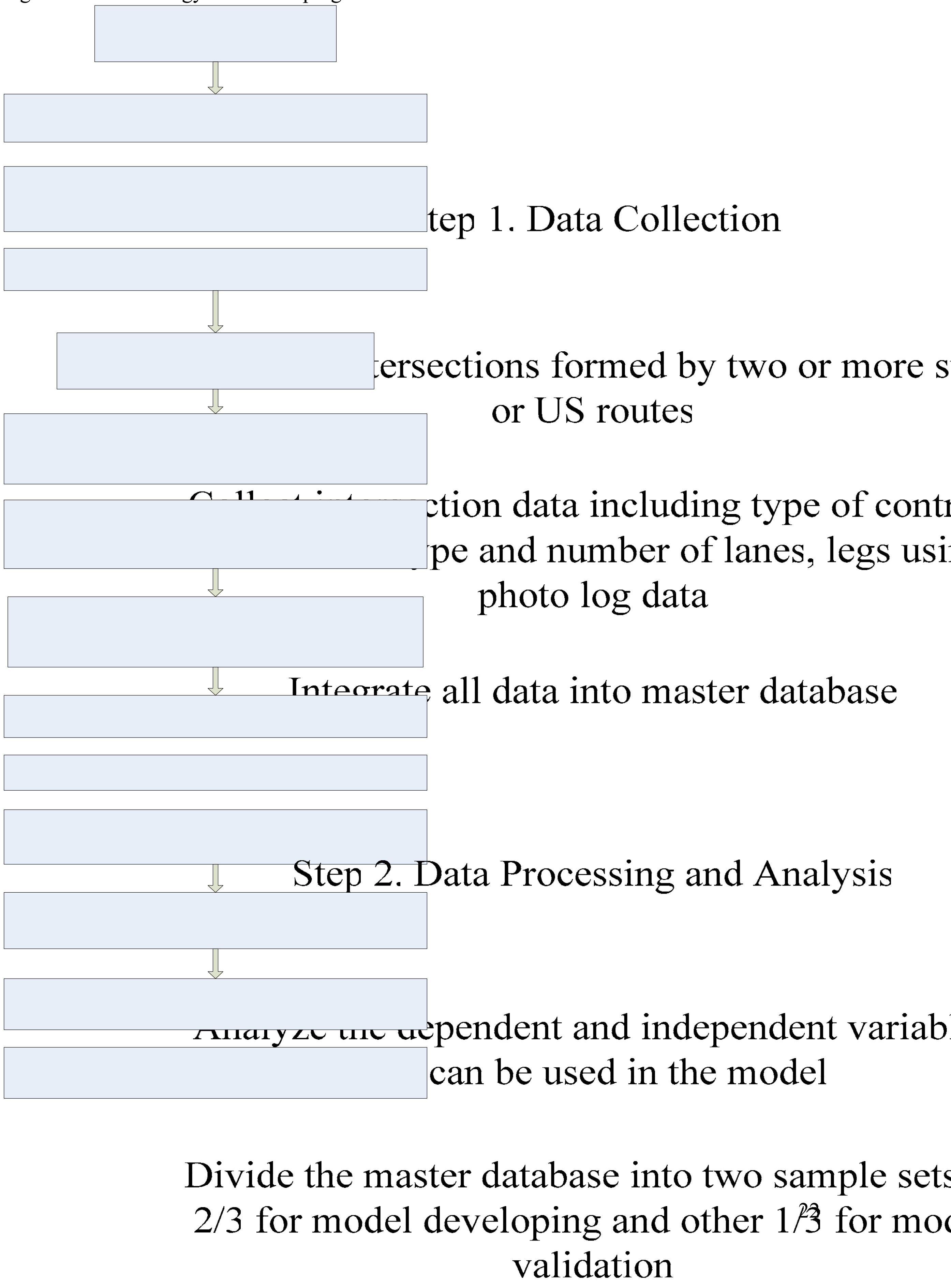
Step 3: Model building with AID and Regression Analysis

- Apply the Automatic Interaction Detection (AID) technique on the larger data set to split the data into exclusive groups.
- Use stepwise multiple regression technique on each AID terminal cell to further reduce variance.

Step 4: Model Validation

- Validate the regression equations using the 1/3 data set that was not used in the model building; and calculate the estimated and observed means, and standard error of estimate (SEE) for the models.
- Examine the reasonability of relationships between independent and dependent variables in each model.

Figure 1. Methodology for Developing Crash Estimation Model



4. Data Collection

This study examines all intersections in Ohio that are formed by two or more State and/or US routes. Data collection involved the extraction of required data on the dependent and independent variables needed for developing models. ODOT provided crash data for Ohio for the years 2001–2003. The data set provided the information about the following parameters for each intersection as a whole.

- Intersection Number
- District number
- County code
- Network Linear Feature Identification
- Log point
- Latitude and longitude
- Shoulder width
- Speed limit
- Population of municipality where the intersection is in
- ADT along the routes*
- Total fatal crashes
- Total injury crashes
- Total fixed object crashes
- Total angle crashes
- Total rear end crashes
- Total side swipe crashes
- Total turning crashes
- Total wet crashes
- Total night crashes
- Total crashes

*Since the ADT for the intersections (i.e. entering volume) was not available, the ADT of the route is assumed to be the ADT of the intersection leg. In cases of T intersections, where one leg is common to two routes, the ADT of the route with smaller route number is taken as the ADT of the leg.

Upon further request by the researchers, ODOT provided a list of crashes for the years 2001-2003 that included the legs on which the crashes had occurred. The data included:

- Intersection Number
- Network Linear Feature Identification
- Log point
- Traffic crash year
- Leg
- Crash severity
- Road condition
- Light condition
- Crash type
- Occurrence

Information about the type of control for each leg and intersection (for example, signal control, two way stop control, four way stop control etc) and number and type of lanes (for example, number and type of left turn lanes, right turn lanes, or through lanes) were not available from ODOT. Hence, the researchers had to manually retrieve the information by viewing the photologs of the intersections and their respective legs,

Photologs are pictures of roadway segments taken along the State and US routes in Ohio by ODOT. These photologs can be accessed through the ODOT intranet. ODOT provided permission to the researchers to access photologs through internet. With the use of Virtual Private Network (VPN), ODOT photologs were accessed by the researchers. Using the search menu, the photologs could be accessed using "Roadview Explorer" in Java applets. A picture of the Roadview Explorer, search applet, and viewer are shown in Figures 2 through 4.

Figure 2. Roadview Explorer Applet

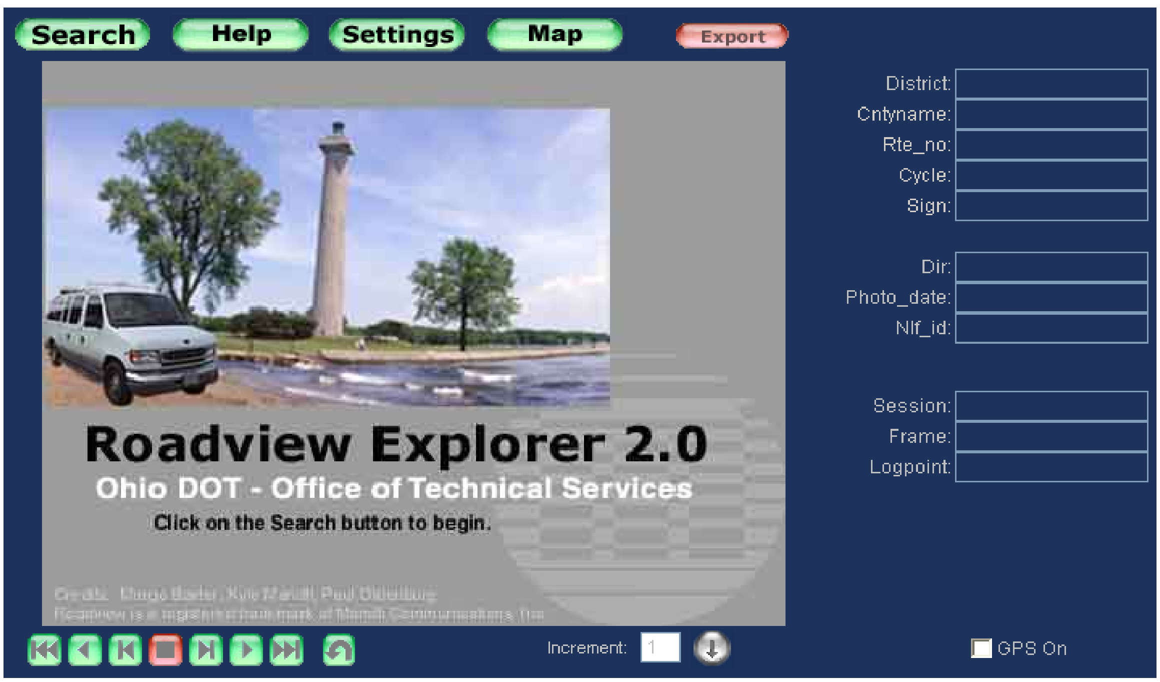


Figure 3. Roadview Explorer Search Applet

Figure 4. Roadview Viewer

With the help of the Roadview Explorer, each intersection listed in the database was examined for all legs, including the type of control (signalized, stop control, no control, etc), number of lanes (left only, left and through, through, right and through, right only, etc), and the orientation of the route were noted. A spreadsheet template was prepared to record the data from the photologs. The template is shown in the Table 1.

Table 1. Template Used to Collect Intersections Details Using Photologs

NLF ID	Intersection Number	Route No	Log Point	Leg No	Type of Intersection	Type of Leg	Upper / Lower leg	Number of Lanes							Type of Lane	Remarks
								Left turn Lane	Left/ Through	Through Lanes	R/T/L	R/L	Right/ Through	Right Turn Lanes		

<u>Types of Intersections</u>

The types of intersection controls included:

1. Signalized (4 legs)
2. Signalized T (3 legs)
3. Two way stop control
4. Four way stop control
5. One way stop control
6. Three way stop control
7. Flashing beacons
8. Unspecified control
9. No control
10. Yield control

<u>Type of Lanes</u>

The types of intersection lanes included:

1. Left turn lanes
2. Left/through lanes
3. Through lanes
4. Right turn lanes
5. Right/through lanes
6. Right/left turn lanes
7. Right/through/left turn lanes

Types of Legs

The types of intersection legs included:

1. Signalized legs at four way signalized intersections
2. Signalized legs at three way signalized intersections
3. No control legs at one way stop controlled intersections
4. Stop controlled legs at one way stop controlled intersections
5. No control legs at two way stop controlled intersections
6. Stop controlled legs at two way stop controlled intersections
7. No control legs at intersections with flashing beacons
8. Stop controlled legs at intersections with flashing beacons

Intersections with four way stop control, yield control, and three way stop control were excluded from the analysis due to the lack of adequate sample size.

Ramps, over/under passes, and corresponding one way streets were excluded from this study. The dataset provided by ODOT had information on about 51,000 intersection legs. However, photologs were available for only State and US routes. Hence, only those intersections that had photologs for all intersection legs were considered in this study.

In the database provided by ODOT, the point where a route changed from one county to another was also considered as an intersection. This could only be verified by viewing the photologs but not from the database. The log points of some intersections were not exact.
Though the log point of one approach indicated an intersection, the log point of the other approach did not show the intersection. In such cases, moving the images forward or backward revealed the necessary details for the intersections. In some cases, latitudes and longitudes were used to locate the intersections on the route. In summary, this task consisted of the retrieval of information from photologs for 1104 intersections comprising of 3980 legs and was laborious and time consuming.

The population density data were calculated by using a GIS software and census block data for the year 2000. The population density data within one mile radius around the intersection was used.

The ODOT database did not provide information about left turn crashes. The database provided by ODOT had information on "From" and "To" directions of vehicles involved in the crash, (e.g. North, East, West, South, etc). Using intersection crash configuration tables and crash diagrams provided by ODOT, an algorithm was developed to identify left turn crashes.

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5. Data Processing

The next step was the integration of all the data sets, which were in different formats.

The ODOT database for crashes by intersection leg listed all accidents individually including crash severity, road conditions, light conditions, and crash types. The fatal and injury crashes were combined into injury crashes. A master database was developed using the two sets of data provided by ODOT (one for intersections and the other for intersection legs), data collected from photologs, population densities calculated from census data, and left turn crashes identified by the algorithm. Crashes were identified according to the following crash types:

1. Injury crashes
2. PDO crashes
3. Total crashes
4. Fixed object crashes
5. Sideswipe crashes
6. Rear end crashes
7. Left turn crashes
8. Wet pavement crashes
9. Night crashes.

The identification of crashes was completed by using the SAS software. At some intersections, two or more routes overlapped (e.g. at T-intersections). Common legs had to be identified, as the database had only information by route, and did not have information about common legs. The routes were analyzed and common legs were identified, and the crash data were combined for the common legs, as routes by themselves did not provide an exact number of crashes on the legs. During this combining process, the ADT and speed limit on the route with the lower route number was assigned to the common leg.

The final master database had the following information for each intersection leg:

- Intersection Number
- District number
- County code
- Network Linear Feature Identification
- Log point
- Latitude and longitude
- Approach (upper or lower leg)
- Type of intersection
- Type of leg control
- Number of left turn lanes
- Number of left and through lanes
- Number of through lanes

- Number of right and through lanes
- Number of right turn lanes
- Number of right/left turn lanes
- Number of left turn lanes
- Speed limit
- Population density
- ADT for the route
- Total injury crashes
- Total PDO crashes
- Total crashes
- Total fixed object crashes
- Total left turn crashes
- Total rear end crashes
- Total sideswipe crashes
- Total wet crashes
- Total night crashes

6. Data Analysis

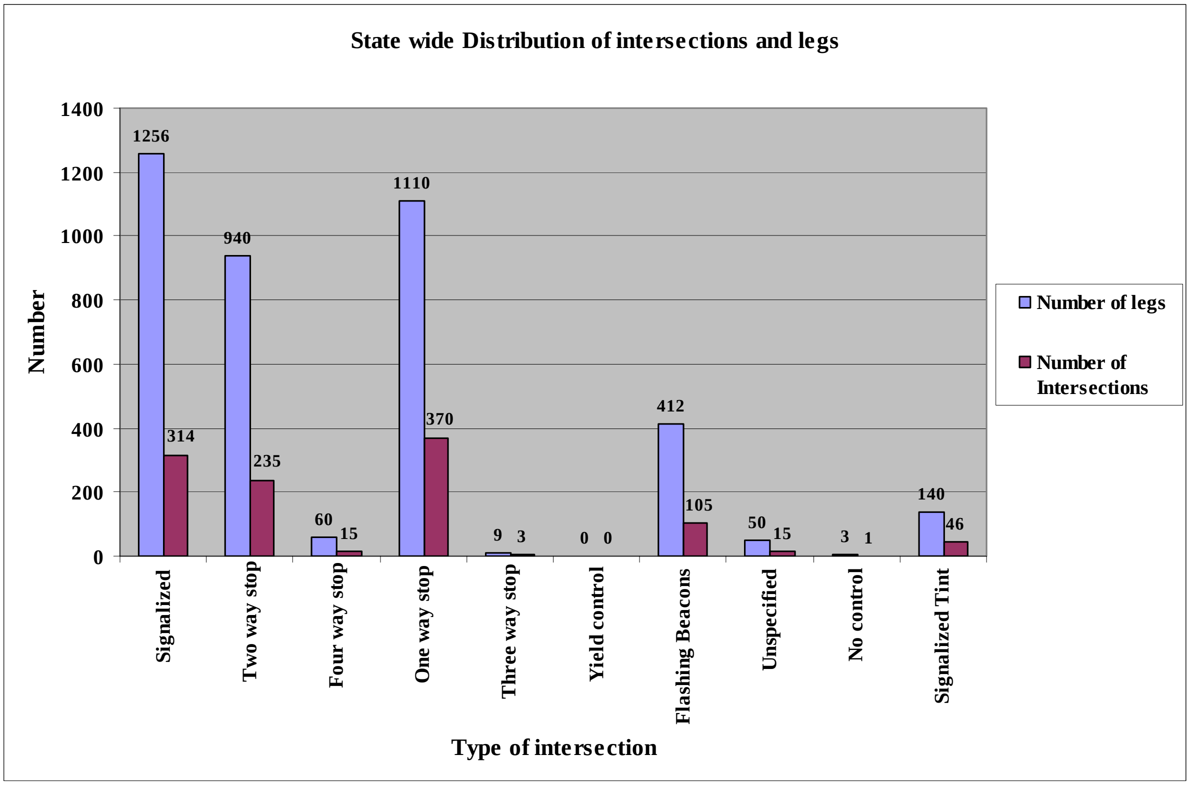
The master data file contained details about 1104 intersections comprising of 3980 legs. It provided information on all the intersections in Ohio which are formed by State and/or US routes and for which photologs were available.

The statewide distribution of various types of intersections is shown in Table 2. Figure 4 shows the distribution in the form of a bar diagram.

Table 2. Statewide Distribution of Types of Intersections and Legs

No.	Type of Intersection	Number of Intersections	Number of Legs
1	Signalized – 4 way	314	1256
2	Two way stop	235	940
3	Four way stop	15	60
4	One way stop	370	1110
5	Three way stop	3	9
6	Yield control	0	0
7	Flashing Beacons	105	412
8	Unspecified	15	50
9	No control	1	3
10	Signalized T-intersection	46	140
		1104	3980

Figure 5. Statewide Distribution of Intersections and Legs

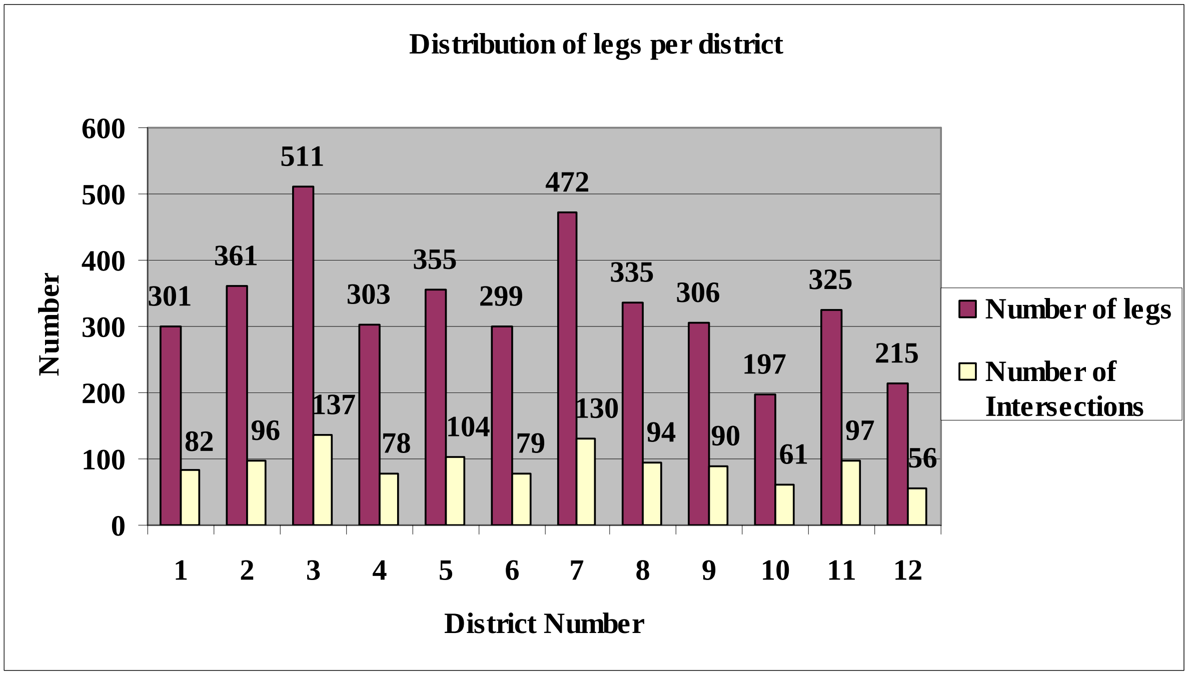


The distribution of number of intersections and legs by districts is shown in Table 3 and the bar diagram representation is in Figure 6.

Table 3. Distribution of Intersections and Legs by District

District No	Number of Intersections	Number of legs
1	82	301
2	96	361
3	137	511
4	78	303
5	104	355
6	79	299
7	130	472
8	94	335
9	90	306
10	61	197
11	97	325
12	56	215
	1104	3980

Figure 6. Distribution of Intersections and Legs by District

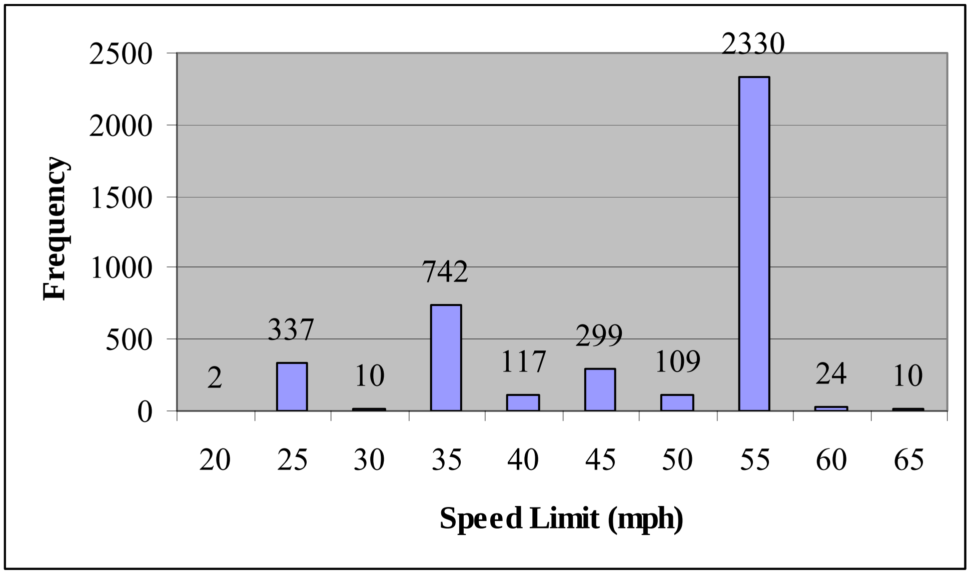


The posted speed limit distribution is shown in Table 4 and is represented graphically in Figure 6.

Table 4. Posted Speed Limit Distribution

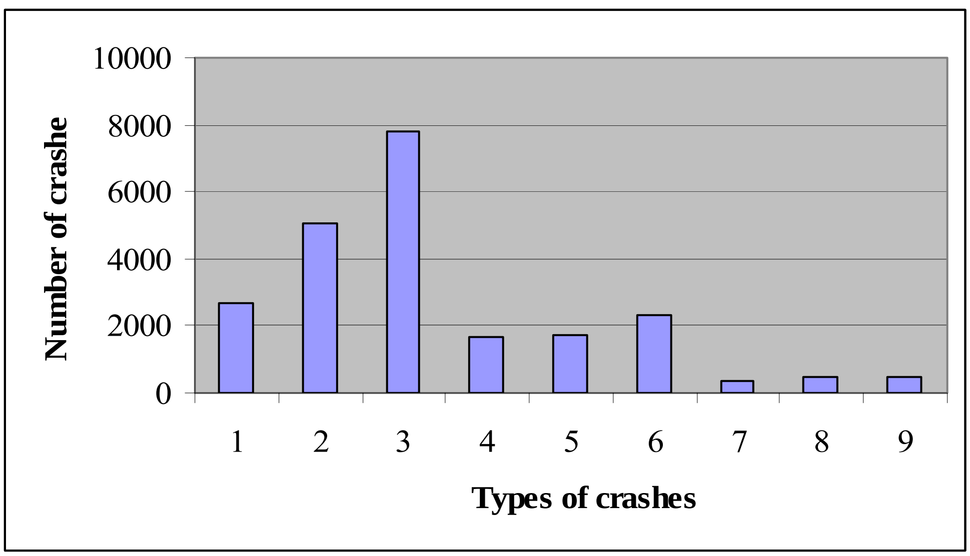
Speed limit (mph)	Frequency
20	2
25	337
30	10
35	742
40	117
45	299
50	109
55	2330
60	24
65	10

Figure 7. Posted Speed Limit Distribution



The distribution of crashes by type is shown in Figure 8.

Figure 8. Distribution of Crashes by Crash type



Key: 1= Injury crashes; 2=PDO crashes; 3=Total crashes; 4=Fixed object crashes; 5=Sideswipe crashes; 6=Rear end crashes; 7=Left turn crashes, 8=Wet pavement crashes, 9=Night crashes.

As the intersections in each district were further divided according to type of control, the sample size for each district turned out to be very small. A further division of this data into two categories, 2/3 data for model development and 1/3 data for model validation, made the sample size for each district so small that it was not meaningful to develop models for each district. Hence the rest of this report deals with the development of AID and regression models on a statewide basis with the data combined for all districts. This should help ODOT to implement the results of this study on a statewide basis in a uniform and consistent manner.

Districtwide distributions of intersections and legs are shown in Appendix I.

Variable Identification

After analyzing the available data, the following independent variables were selected for inclusion in analysis for each type of intersection leg:

1. Number of left turn lanes
2. Number of left/through lanes
3. Number of through lanes
4. Number of right/through lanes
5. Number of right turn lanes
6. Number of right/left turn lanes
7. Number of right/through/left turn lanes
8. Population density (persons per area of 1 mile radius)
9. Speed limit (mph)
10. Average daily traffic (ADT)

This research is aimed at developing crash rate models on a leg basis. In some types of intersections, such as one way stop controlled, two way stop controlled, and flashing beacon controlled, all legs do not have the same type of control, and they were further classified as stop controlled legs, or legs with no control. Signalized intersection legs for four way signalized intersections and three way signalized intersections were treated differently. After analyzing the data for different types of intersection control, the following types of legs were established:

Types of intersections	Type of legs
1. Signalized (4 legs)	Signalized leg
2. Signalized T (3 legs)	Signalized leg
3. T intersection with one way stop control	a) leg with stop control
	b) leg with no control
4. Two way stop control	a) leg with stop control
	b) leg with no control
5. Flashing beacons	a) leg with stop control
	b) leg with no control

The dependent variables are the following nine types of crashes:

1. Injury crashes
2. PDO crashes
3. Total crashes

4. Wet crashes
5. Night Crashes
6. Rear end crashes
7. Sideswipe crashes
8. Fixed object crashes
9. Left turn crashes

The master data file was divided into two sets, one for model development and one for model validation, through a random selection process. The random selection was done using MS Excel. The larger data set consisting of 2/3 of the total data had 2570 legs and was used for developing candidate models. The smaller data set consisting of 1/3 of the sample had 1288 legs and was used for model validation.

The distribution of the samples is shown in the Table 5.

Table 5 Distribution of Samples for Modeling and Validation

Types of intersections	Type of legs	Total Sample	Two third sample size	One third sample size
1. Signalized (4 legs)	signalized	1256	837	419
2. Signalized T (3 legs)	signalized	140	93	47
3. T intersection with one way stop control	a) stop control	740	493	247
	b) no control	370	247	123
4. Two way stop control	a) stop control	470	313	157
	b) no control	470	313	157
5. Flashing beacons	a) stop control	182	121	61
	b) no control	230	153	77
		3858	2570	1288

7. Model Building Using Automatic Interaction Detection and Regression Technique

7.1. Automatic Interaction Detection (AID)

The next task is to determine the type of relationship that may exist between the dependent and the independent variables. The Automatic Interaction Detection technique (AID) is a multivariate procedure suggested by Morgan and Sonquist, which performs stepwise splitting [7]. The algorithm is called automatic as it naturally incorporates interaction among predictors. It splits the data into two mutually exclusive groups such that the data in the same group are similar to each other, yet different from the data in other groups. Assumptions about linearity are not made and the independent variables may exhibit interaction and/or be nominally scaled. It begins with a single cluster of cases and searches a candidate set of predictor variables for a way to split the cluster into two clusters. The algorithm first calculates the total sum of squares for the data set and examines all (n-1) ways for each independent variable to split the data into two subgroups.

$$TSS = \sum_{i-1}^{n} (y_i - \bar{y})^2$$

where TSS = Total sum of squares
n = Number of observations in the data set
y_i = the value of the dependent variable
$\bar{y}$ = the mean value of the dependent variable

The between sum of squares (BSS) about the mean of these subgroup on the dependent variable is calculated on each possible split. The between sum of squares for the subgroups j and k with sample size of m and (n-m) respectively is

$$BSS = \sum_{i=1}^{n} (y_i - \bar{y})^2 - \left[\sum_{i=1}^{m} (y_{ij} - \bar{y}_j)^2 + \sum_{i=1}^{n-m} (y_{ik} - \bar{y}_k)^2 \right]$$

If any prospective split exceeds the threshold limit of reducibility coefficient, the split giving the largest ratio of BSS/TSS is selected and two subgroups are created from the subgroups until no further significant reduction in the variance is possible. The variance explained, R_{AID}^2, is the summation of Sum of Squares (SS) of each terminal cell divided by the TSS.

$$R_{AID}^2 = \frac{\sum_{i=1}^{n} SS_i}{TSS}$$

The AID technique is applied using the computer package SYSTAT version 11.0 for Windows.

The minimum proportion reduction (PRE) in error determines the minimum reduction in error for the tree allowed at any split. For example, the AID will allow splitting only if the prospective split can reduce the variance by at least 1%. The sensitivity of AID runs was tested by varying minimum PRE. AID with low minimum PRE ended up with small terminal cells which were not suitable for further analysis. The minimum sample size of the terminal cell was set as 30. Based on the trial runs a default value of 0.01 was used for further analysis.

AID runs were made for 9 types of crashes and 8 types of legs. Hence a total of 72 runs were made and it resulted in 192 terminal cells. The AID trees for signalized legs are shown as an example in Figures 9 through 16.

A complete set of AID trees is included in Appendix II.

Figure 9. AID Tree for Signalized Intersection Legs - Injury Crashes

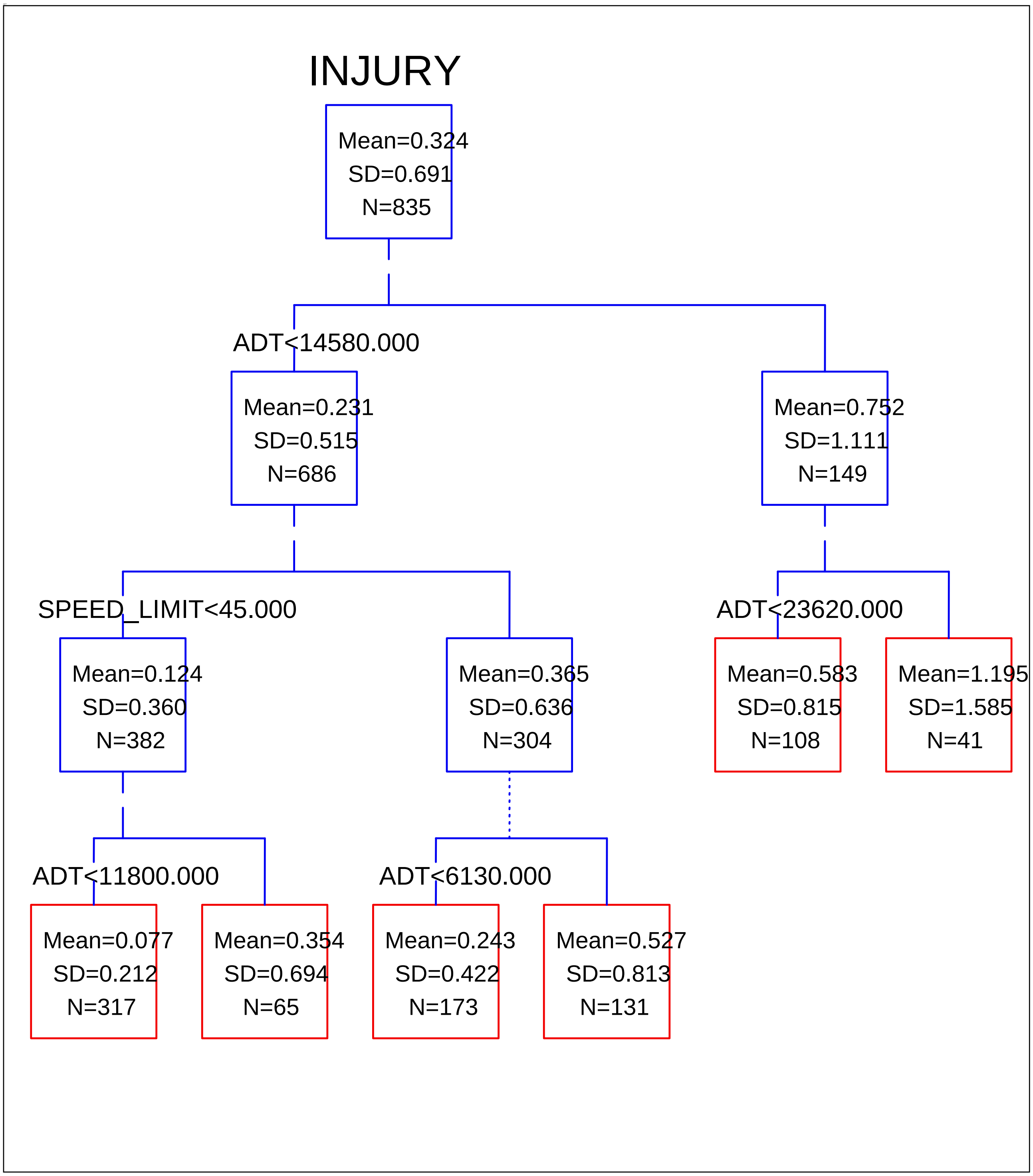


Figure 10. AID Tree for Signalized Intersection Legs - PDO Crashes

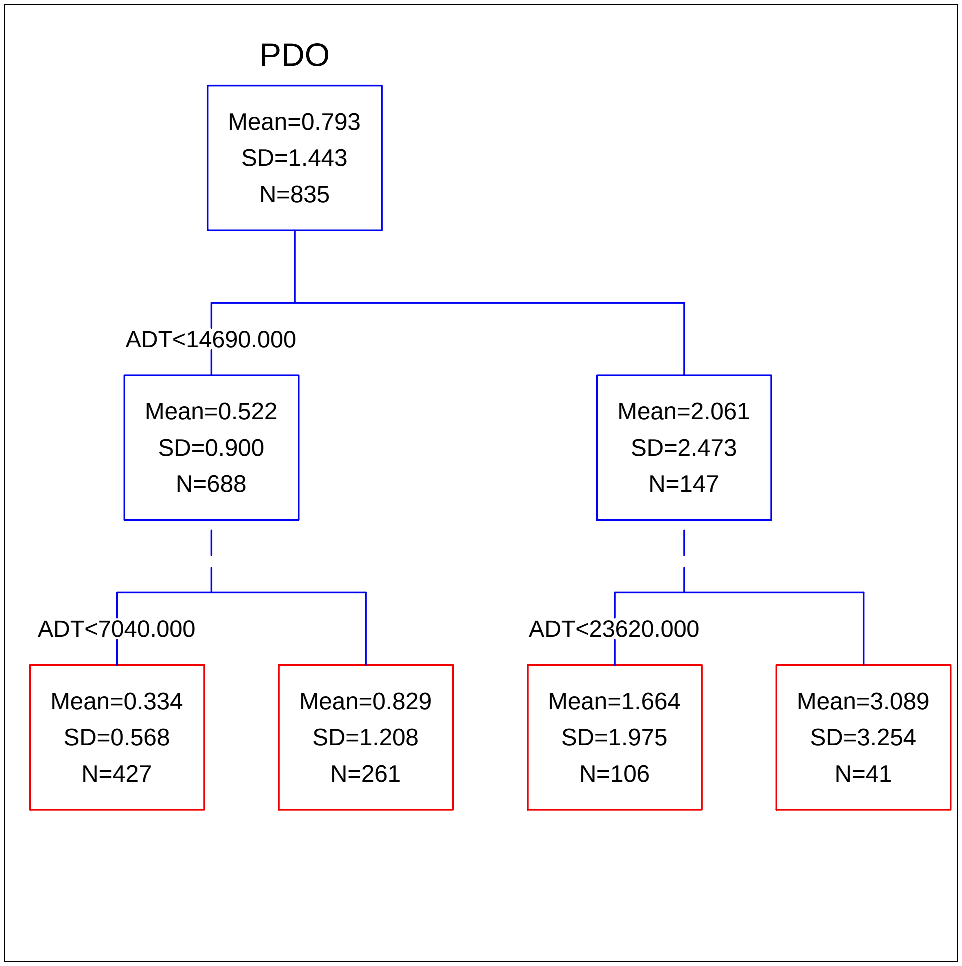


Figure 11. AID Tree for Signalized Intersection Legs- Total Crashes

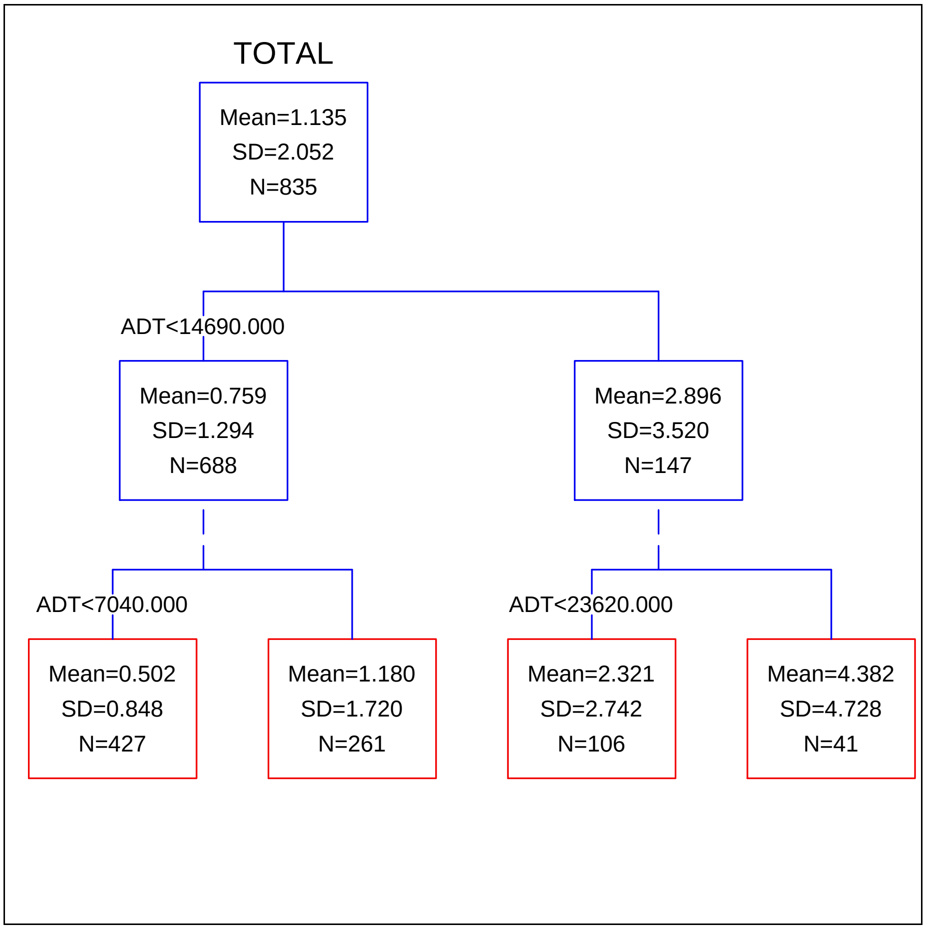


Figure 12. AID Tree for Signalized Intersection Legs - Wet Pavement Crashes

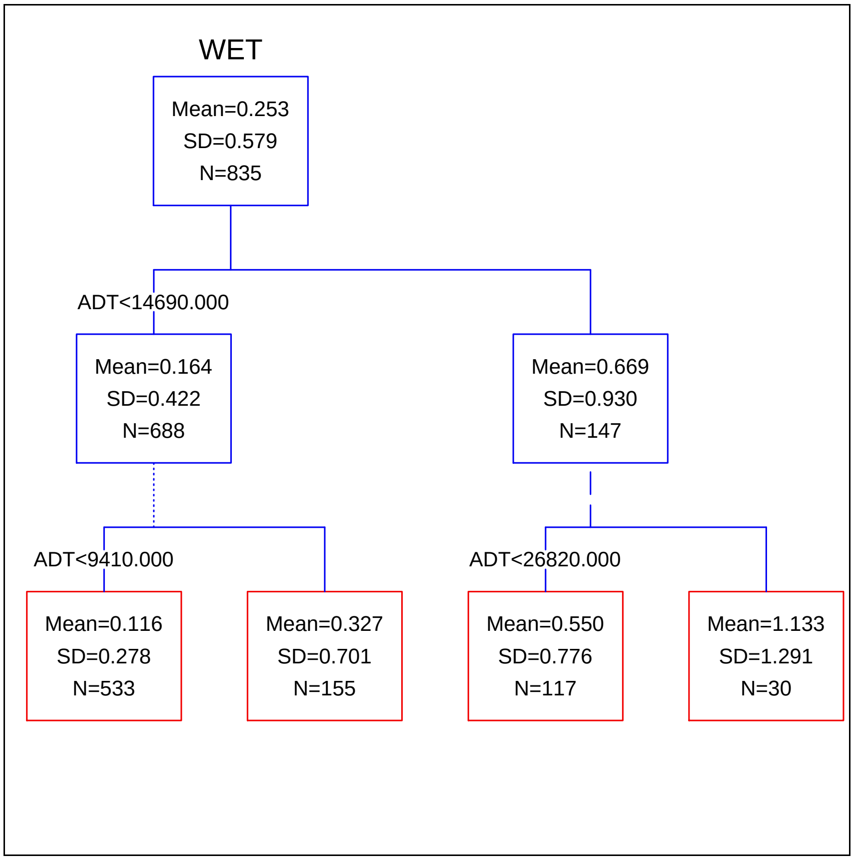


Figure 13. AID tree for Signalized Intersection Legs - Night Crashes

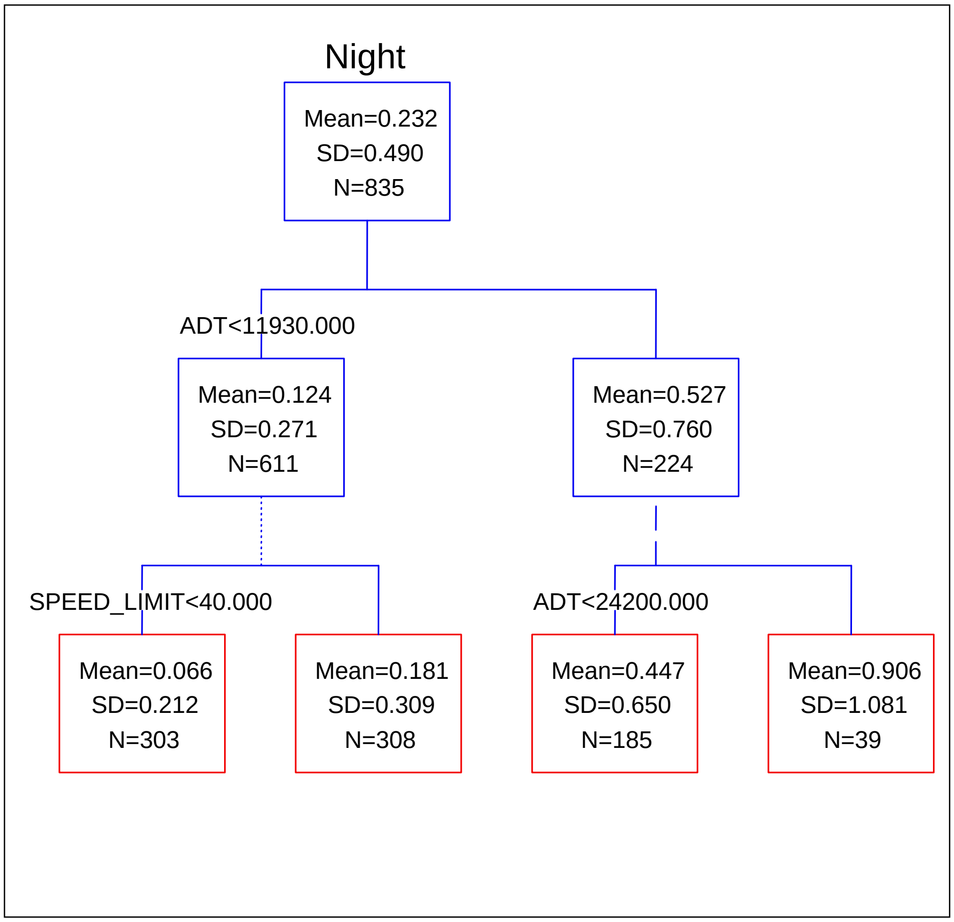


Figure 14. AID Tree for Signalized Intersection Legs – Rear End Crashes

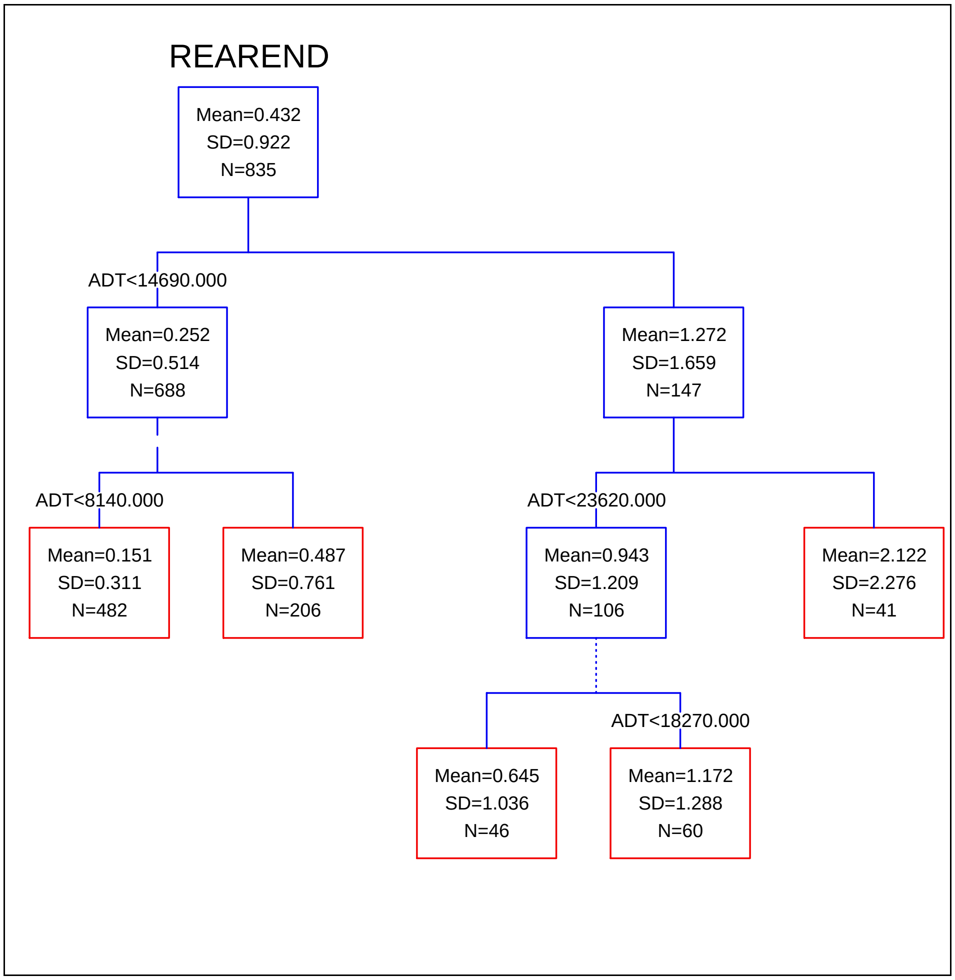


Figure 15. AID Tree for Signalized Intersection Legs - Sideswipe Crashes

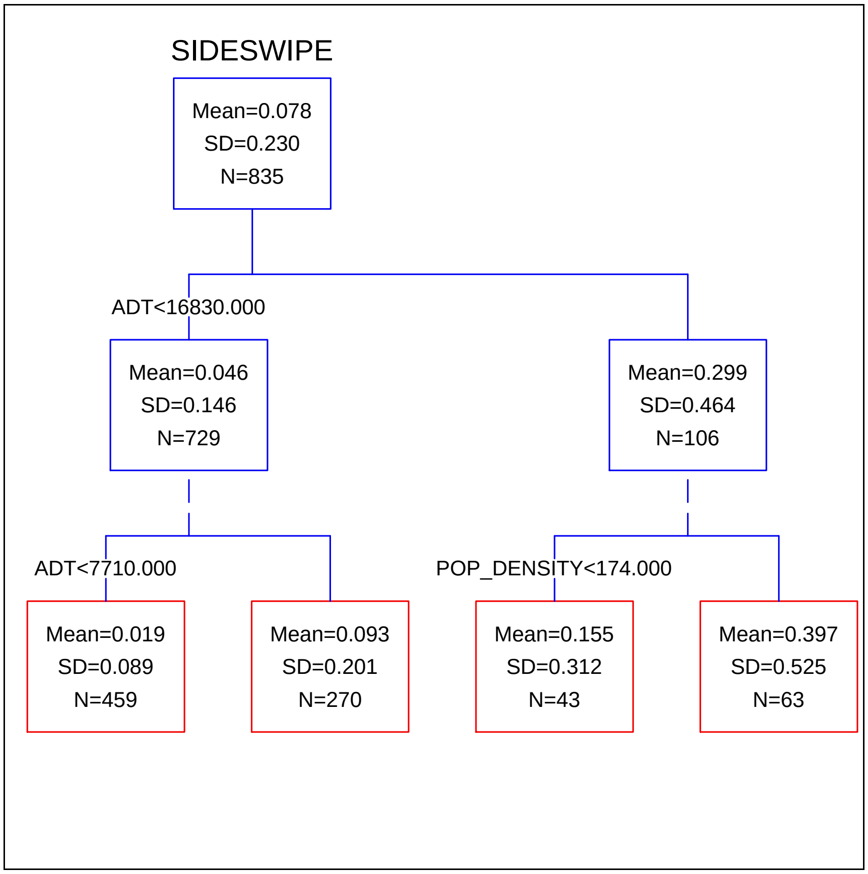
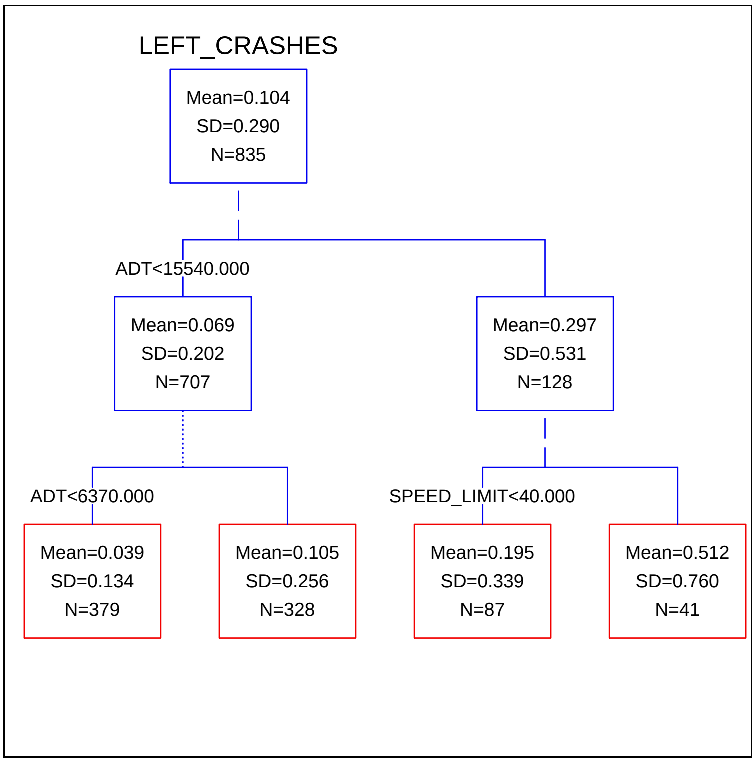


Figure 16. AID Tree for Signalized Intersection Legs - Left Turn Crashes



7.2 Regression Analysis

The purpose of multiple regression is to learn more about the relationship between more than one independent variable and a dependent variable. Each of the terminal cells from the AID runs is subjected to multiple regression analysis. Stepwise regression can be treated as an incremental approach where the order of entry of the independent variables is determined based on a statistic. It is a variation in multiple regression where an independent variable is added or removed from the equation at each step which results in the highest reduction in Sum of Squares due to Error (SSE). SSE is a measure of error if the regression model is used to estimate the dependent variable. It is computed as:

$$\text{SSE} = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

where
SSE = Sum of squares due to error
N = Number of observations
y_i= Value of the i^{th} dependent variable
$\hat{y}_i$= Predicted value of the i^{th} dependent variable

It allows for the generation of the best regression model using minimum number of variables. F statistic is the basis for selection to add or drop an independent variable at each step. The computed F value is compared with a user specified cutoff value $F_{\alpha.}$ In this research the cutoff value was set at 4. Hence a variable can enter the equation if F≥ 4.0 and a variable is removed if F < 4.0. Multiple coefficient of determination is a common measure of the goodness of fit for the estimated regression equation.

$$R^2 = \frac{SSR}{TSS}$$

where:
R^2 = multiple coefficient of determination

SSR = Sum of squares due to regression = $\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$

TSS = Total sum of squares = $\sum_{i=1}^{n}(y_i - \bar{y}_i)^2$

To avoid over estimating the impact of adding an independent variable on the amount of variability explained by the estimated regression equation, adjusted multiple coefficient of determination was used. Adjusted multiple coefficient of determination is calculated as follows:

$$R^2_{adj} = 1 - (1 - R^2)\frac{n-1}{n-p-1}$$

where n = number of observations
P = number of independent variables. R^2 and R^2_{adj} are provided by SYSTAT in the output.

The aim of the model building process is to reduce the unexplained variance. R^2_{adj} and R^2 are a measure of the reduction, values close to 1 show good reduction and R^2_{adj} is a measure of how well the equation fits the data.

Standard Error of Estimate (SSE) is an estimate of the variation likely to be encountered in making predictions from the regression equation. It is used to assess the absolute unexplained variance, which is calculated as follows:

$$SEE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n-2}}$$

where:

y_i = observed value of i^{th} dependent variable

$\hat{y}_i$ = predicted value of i^{th} dependent variable.

n = sample size (number of observations)

The master database was split into two sets with 2/3 data for model development and 1/3 data for model validation. The larger data set for model building was split into 196 subsets commensurate with the AID terminal cells. Multiple regression was performed on the subgroups using SYSTAT 11.0.

In order to make the independent variables consistent, for the coefficients to be significant, the units for ADT, population density and speed limits were modified as ADT per 1000 veh per day, population density per 100 persons per area of 1 mile radius, and speed limit per 10 mph.

The R^2_{adj} and SEE values of the regression runs are shown in the tables. The R^2_{adj} values ranged from 0 to 1.00. A value closer to 1.00 indicates stronger relationship between the dependent and independent variables. Most of them ranged 0 to 0.4.

The key to read the candidate models is:

X_1 = Number of Left turn lanes
X_2 = Number of Left & Through lanes
X_3 = Number of Through lanes
X_4 = Number of Right/Through lanes
X_5 = Number of Right turn lanes
X_6 = Number of Right and Left turn lanes
X_7 = Number of Right/Through/Left turn lanes
X_8 = Population Density
X_9 = Speed posted
X_{10} = ADT

Table 6. Crash Models for T intersections With One Way Stop Control: No Control Legs

T intersection with One Way Stop Control: No Control Legs						
Crash Type	Mean	Standard Deviation	AID terminal Cells	Sample Size	Linear regression	
					R^2_{adj}	SEE
Injury	0.10	0.25	Condition 1 $X_{10} < 3500$	274	0.135	0.097
			Condition 2 $X_{10} \geq 3500$ & $X_9 < 45$	51	0.605	0.031
			Condition 3 $X_{10} \geq 3500$ & $X_9 \geq 45$	164	0.000	0.335
PDO	0.21	0.38	Condition 1 $X_{10} < 3760$	287	0.089	0.199
			Condition 2 $X_{10} \geq 3760$ & $74 \leq X_8 < 153$	30	0.152	0.200
			Condition 3 $X_{10} \geq 3760$ & $X_8 \geq 153$	58	0.000	0.424
			Condition 4 $X_{10} \geq 3760$ & $X_8 < 74$	114	0.000	0.491
Total	0.55	0.55	Condition 1 $X_{10} < 3760$	287	0.048	0.249
			Condition 2 $X_{10} \geq 3760$ & $X_9 < 45$	48	0.179	0.462
			Condition 3 $X_{10} \geq 3760$ & $X_9 \geq 45$	154	0.028	0.636
Wet	0.07	0.20	Condition 1 $X_{10} < 3530$	277	0.027	0.080
			Condition 2 $X_{10} \geq 3530$ & $X_9 < 45$	51	1.000	0.000
			Condition 3 $X_{10} \geq 3530$ & $X_9 \geq 45$	161	0.000	0.272
Night	0.10	0.24	Condition 1 $X_{10} < 2240$	194	0.129	0.106
			Condition 2 $X_{10} \geq 2240$ & $X_9 < 45$	60	0.661	0.037
			Condition 3 $X_{10} \geq 2240$ & $X_9 \geq 45$	235	0.051	0.259
Rear end	0.07	0.2	Condition 1 $X_{10} < 3760$	287	0.044	0.110
			Condition 2 $X_{10} \geq 3760$ & $X_2 < 1$	128	0.000	0.219
			Condition 3 $3760 \leq X_{10} < 7120$ & $X_2 < 1$	44	0.117	0.382
			Condition 4 $X_{10} \geq 7120$ & $X_2 < 1$	30	0.000	0.375
Sideswipe	0.005	0.04	Condition 1 $X_{10} < 4380$	309	0.000	0.019
			Condition 2 $X_{10} \geq 4380$ & $X_8 \geq 77$	79	-	-
			Condition 3 $X_{10} \geq 4380$ & $X_8 < 29$	64	0.000	0.042
			Condition 4 $X_{10} \geq 4380$ & $29 \leq X_8 < 77$	37	0.000	0.116

Fixed object	0.067	0.18	Condition 1 $X_{10} < 1370$	105	0.059	0.111
			Condition 2 $X_{10} \geq 1370$ & $X_9 < 45$	76	0.431	0.029
			Condition 3 $X_{10} \geq 1370$ & $X_9 \geq 45$ & $X_3 \geq 1$	42	0.133	0.081
			Condition 4 $X_{10} \geq 1370$ & $X_9 < 77$ & $X_3 < 1$	266	0.000	0.221
Left turn	0.005	0.04	Condition 1 $X_8 < 471$	454	0.008	0.035
			Condition 2 $X_8 \geq 471$	35	0.000	0.079

Table 7. Crash Models for T Intersections with One Way Stop Control: Stop Controlled Legs

T intersection with One Way Stop Control: Stop Controlled legs						
Crash Type	Mean	Standard Deviation	AID terminal Cells	Sample Size	Linear regression	
					R^2_{adj}	SEE
Injury	0.026	0.113	Condition 1 $X_8 \geq 4.244$ & $X_{10} < 3000$	177	0.000	0.035
			Condition 2 $X_8 \geq 4.244$ & $X_{10} \geq 3000$	31	0.000	0.206
			Condition 3 $X_8 < 4.244$	32	0.000	0.197
PDO	0.075	0.278	Condition 1 $X_{10} < 3140$	209	0.000	0.175
			Condition 2 $X_{10} \geq 3140$	31	0.000	0.619
Total	0.103	0.356	Condition 1 $X_{10} < 3140$ & $X_8 \geq 5$	179	0.000	0.172
			Condition 2 $X_{10} < 3140$ & $X_8 < 5$	30	0.000	0.335
			Condition 3 $X_{10} \geq 3140$	31	0.000	0.812
Wet	0.017	0.079	Condition 1 $X_8 \geq 6.024$ & $X_{10} < 2660$	164	0.000	0.037
			Condition 2 $X_8 \geq 6.024$ & $X_{10} \geq 2660$	36	0.000	0.093
			Condition 3 $X_8 < 6.024$	40	0.385	0.044
Night	0.032	0.120	Condition 1 $X_8 \geq 4.244$ & $X_{10} < 2070$	145	0.000	0.077
			Condition 2 $X_8 \geq 4.244$ & $X_{10} \geq 2070$	63	0.000	0.140
			Condition 3 $X_8 < 4.244$	32	0.000	0.194
Rear end	0.031	0.198	Condition 1 $X_{10} < 3190$	210	0.015	0.064
			Condition 2 $X_{10} \geq 3190$	30	0.000	0.516
Sideswipe	0.004	0.048	Condition 1 $X_{10} < 3190$	210	0.000	0.023
			Condition 2 $X_{10} \geq 3190$	30	0.000	0.122
Fixed object	0.029	0.112	Condition 1 $X_8 \geq 4$ & $X_{10} < 1520$	125	0.000	0.073
			Condition 2 $X_8 \geq 110$ & $X_{10} \geq 1520$	35	0.000	0.056
			Condition 3 $4 \leq X_8 < 110$ & $X_{10} \geq 1520$	50	0.000	0.141
			Condition 4 $X_8 < 4$	30	0.000	0.194
Left turn	0.001	0.022	Condition 1 $X_{10} < 3190$	210	-	-
			Condition 2 $X_{10} \geq 3190$	30	0.000	0.061

Table 8. Crash Models for Two Way Stop Controlled Intersection: No Control Legs

Two Way Stop Controlled Intersections: No Control Legs						
Crash Type	Mean	Standard Deviation	AID terminal Cells	Sample Size	Linear regression	
					R^2_{adj}	SEE
Injury	0.332	0.636	Condition 1 $X_{10} < 3070$	161	0.000	0.405
			Condition 2 $X_{10} \geq 3070$ & $X_8 < 18$	65	0.234	0.540
			Condition 3 $X_{10} \geq 3070$ & $X_8 \geq 18$	87	0.000	0.891
PDO	0.299	0.604	Condition 1 $X_{10} < 2870$	151	0.102	0.192
			Condition 2 $X_{10} \geq 2870$ & $X_8 < 88$	109	0.000	0.453
			Condition 3 $X_{10} \geq 2870$ & $X_8 \geq 88$	53	0.327	0.915
Total	0.637	1.126	Condition 1 $X_{10} < 2870$	151	0.051	0.438
			Condition 2 $X_{10} \geq 2870$ & $X_8 < 18$	69	0.000	0.780
			Condition 3 $X_{10} \geq 2870$ & $X_8 \geq 18$	93	0.274	1.53
Wet	0.096	0.233	Condition 1 $X_{10} < 2590$	140	0.058	0.098
			Condition 2 $X_{10} \geq 6300$ & $X_8 < 67$	31	0.000	0.132
			Condition 3 $2590 \leq X_{10} < 6300$ & $X_8 < 67$	80	0.000	0.272
			Condition 4 $X_{10} \geq 2590$ & $X_8 \geq 67$	62	0.000	0.322
Night	0.119	0.242	Condition 1 $X_{10} < 2870$	151	0.066	0.098
			Condition 2 $X_{10} \geq 4220$ & $X_7 \geq 1$	78	0.000	0.233
			Condition 3 $X_{10} \geq 4220$ & $X_7 < 1$	32	0.000	0.343
			Condition 4 $2870 \leq X_{10} < 4220$	52	0.000	0.313
Rear end	0.066	0.277	Condition 1 $X_{10} < 4770$	231	0.000	0.103
			Condition 2 $4770 \leq X_{10} < 7210$	52	0.065	0.143
			Condition 3 $X_{10} \geq 7210$	30	0.223	0.701
Sideswipe	0.010	0.090	Condition 1 $X_{10} < 7210$	283	0.000	0.052
			Condition 2 $X_{10} \geq 7210$	30	0.286	0.206
Fixed Object	0.027	0.091	Condition 1 $5 \leq X_8 < 21$	86	-	-
			Condition 2 $X_8 < 5$	58	0.481	0.033
			Condition 3 $X_8 \geq 163.265$	71	0.652	0.024

			Condition 4 $21 \le X_8 < 55$	64	0.746	0.022
			Condition 5 $55 \le X_8 < 163.265$	34	0.000	0.149
Left Turn	0.022	0.099	Condition 1 $X_{10} < 6170$	260	0.018	0.067
			Condition 2 $X_{10} \ge 6170$	53	0.000	0.186

Table 9. Crash Models for Two Way Stop Controlled Intersections: Stop Controlled Legs

Two Way Stop Controlled Intersection: Stop Controlled legs						
Crash Type	Mean	Standard Deviation	AID terminal Cells	Sample Size	Linear regression	
					R^2_{adj}	SEE
Injury	0.084	0.241	Condition 1 $X_{10} < 2120$	263	0.000	0.222
			Condition 2 $X_{10} \geq 2120$	50	0.000	0.310
PDO	0.141	0.304	Condition 1 $X_{10} <730$	61	0.000	0.092
			Condition 2 $730 \leq X_{10} < 2260$	210	0.000	0.289
			Condition 3 $X_{10} \geq 2260$	42	0.000	0.468
Total	0.227	0.487	Condition 1 $X_{10} < 730$	61	0.000	0.173
			Condition 2 $730 \leq X_{10} < 2100$	199	0.000	0.475
			Condition 3 $X_{10} \geq 2100$	53	0.000	0.665
Wet	0.042	0.149	Condition 1 $X_{10}< 1010$	115	0.079	0.071
			Condition 2 $X_{10} \geq 1010$ & $X_8 <21$	89	0.000	0.108
			Condition 3 $X_{10} \geq 1010$ & $X_8 \geq 51$	79	0.000	0.139
			Condition 4 $X_{10} \geq 1010$ & $21 \leq X_8 < 51$	30	0.000	0.336
Night	0.037	0.118	Condition 1 $X_{10} < 730$	61	0.000	0.043
			Condition 2 $730 \leq X_{10} < 2420$	219	0.000	0.109
			Condition 3 $X_{10} \geq 2420$	33	0.000	0.212
Rear end	0.044	0.179	Condition 1 $X_{10} < 2420$	280	0.067	0.028
			Condition 2 $X_{10} \geq 2420$	33	0.000	0.442
Sideswipe			*No trees*			
Fixed Object	0.020	0.080	Condition 1 $X_8 < 33$	178	0.000	0.050
			Condition 2 $X_8 \geq 33$	135	0.000	0.105
Left Turn			*No trees*			

Table 10. Crash Models for Flashing Beacon Controlled Intersections: No Control Legs

Flashing Beacon Controlled Intersections: No Control Legs						
Crash Type	Mean	Standard Deviation	AID terminal Cells	Sample Size	Linear regression	
					R^2_{adj}	SEE
Injury	0.527	0.809	Condition 1 $X_8 \geq 105$	46	0.103	0.521
			Condition 2 $X_8 < 21$	39	0.000	0.837
			Condition 3 $21 \leq X_8$ 105	34	0.635	0.058
PDO	0.499	0.760	Condition 1 $X_{10} < 4960$	69	0.000	0.591
			Condition 2 $X_{10} \geq 4960$	50	0.000	0.919
Total	1.036	1.447	Condition 1 $X_{10} < 5310$	76	0.000	1.164
			Condition 2 $X_{10} \geq 5310$	43	0.000	1.558
Wet	0.190	0.329	Condition 1 $X_{10} < 5310$	76	0.000	0.217
			Condition 2 $X_{10} \geq 5310$	43	0.000	0.344
Night	0.193	0.408	Condition 1 $X_{10} < 5310$	76	0.000	0.189
			Condition 2 $X_{10} \geq 5310$	43	0.000	0.425
Rear end	0.092	0.256	Condition 1 $X_{10} < 5840$	83	0.000	0.121
			Condition 2 $X_{10} \geq 5840$	36	0.120	0.382
Sideswipe	0.017	0.073	Condition 1 $X_{10} < 6310$	89	0.000	0.050
			Condition 2 $X_{10} \geq 6310$	30	0.000	0.115
Fixed object	0.034	0.133	Condition 1 $X_9 < 50$	32	0.442	0.045
			Condition 2 $X_9 \geq 50$	87	1.000	0.000
Left turn	0.022	0.094	Condition 1 $X_{10} < 6310$	89	0.635	0.058
			Condition 2 $X_{10} \geq 6310$	30	0.578	0.105

Table 11. Crash Models for Flashing Beacon Controlled Intersections: Stop Controlled Legs

Flashing Beacon Controlled Intersections: Stop Controlled Legs						
Crash Type	Mean	Standard Deviation	AID terminal Cells	Sample Size	Linear regression	
					R^2_{adj}	SEE
Injury	0.127	0.274	Condition 1 $X_{10} < 2420$	93	0.000	0.121
			Condition 2 $X_{10} \geq 2420$	59	0.000	0.241
PDO	0.322	0.477	Condition 1 $X_{10} < 2050$	65	0.000	0.304
			Condition 2 $X_{10} \geq 2050$ & $X_9 \geq 50$	53	0.000	0.391
			Condition 3 $X_{10} \geq 2050$ & $X_9 < 50$	34	0.000	0.682
Total	0.452	0.657	Condition 1 $X_{10} < 2030$	61	0.000	0.363
			Condition 2 $2030 \leq X_{10} < 2420$	32	0.205	0.334
			Condition 3 $X_{10} \geq 2420$	59	0.000	0.690
Wet	0.086	0.208	Condition 1 $X_{10} < 2420$	93	0.000	0.127
			Condition 2 $X_{10} \geq 2420$	59	0.000	0.227
Night	0.088	0.198	Condition 1 $X_{10} < 3100$ & $X_8 \geq 387.763$	31	-	-
			Condition 2 $X_{10} < 3100$ & $X_8 < 17$	32	0.000	0.082
			Condition 3 $X_{10} < 3100$ & $17 \leq X_8 < 387.763$	46	0.000	0.125
			Condition 4 $X_{10} \geq 3100$	43	0.000	0.274
Rear end	0.081	0.176	Condition 1 $X_{10} < 2030$	61	0.000	0.083
			Condition 2 $2030 \leq X_{10} < 3140$	49	0.000	0.152
			Condition 3 $X_{10} \geq 3140$	42	0.000	0.246
Sideswipe	0.009	0.054	Condition 1 $X_{10} < 2920$	102	-	-
			Condition 2 $X_{10} \geq 2920$	50	0.084	0.087
Fixed Object	0.022	0.091	Condition 1 $X_9 \geq 50$ & $X_8 \geq 26$	65	-	-
			Condition 2 $X_9 \geq 50$ & $X_8 < 26$	37	0.175	0.085
			Condition 3 $X_9 < 50$	50	0.000	0.092
Left Turn			*No trees*		-	-

Table 12. Crash Models for Signalized Intersections (Four Way)

Signalized Intersections (Four Way)						
Crash Type	Mean	Standard Deviation	AID terminal Cells	Sample Size	Linear regression	
					R^2_{adj}	SEE
Injury	0.324	0.691	Condition 1 $X_{10} < 11800$ & $X_9 < 45$	317	0.055	0.161
			Condition 2 $11800 \leq X_{10} < 14580$ & $X_9 < 45$	65	0.078	0.253
			Condition 3 $X_{10} < 6130$ & $X_9 \geq 45$	173	0.034	0.350
			Condition 4 $6130 \leq X_{10} < 14580$ & $X_9 \geq 45$	131	0.000	0.813
			Condition 5 $14580 \leq X_{10} < 23620$	108	0.000	0.815
			Condition 6 $X_{10} \geq 23620$	41	0.074	1.010
PDO	0.793	1.443	Condition 1 $X_{10} < 7040$	427	0.127	0.466
			Condition 2 $7040 \leq X_{10} < 14690$	261	0.074	1.028
			Condition 3 $14690 \leq X_{10} < 23620$	106	0.000	1.975
			Condition 4 $X_{10} \geq 23620$	41	0.068	3.141
Total	1.135	2.052	Condition 1 $X_{10} < 7040$	427	0.140	0.678
			Condition 2 $7040 \leq X_{10} < 14690$	261	0.071	0.295
			Condition 3 $14690 \leq X_{10} < 23620$	106	0.000	2.742
			Condition 4 $X_{10} \geq 23620$	41	0.000	3.498
Wet	0.253	0.579	Condition 1 $X_{10} < 9410$	533	0.062	0.209
			Condition 2 $9410 \leq X_{10} < 14690$	155	0.020	0.378
			Condition 3 $14690 \leq X_{10} < 26820$	117	0.000	0.776
			Condition 4 $X_{10} \geq 26820$	30	0.106	1.221
Night	0.232	0.490	Condition 1 $X_{10} < 11930$ & $X_9 < 40$	303	0.079	0.203
			Condition 2 $X_{10} < 11930$ & $X_9 \geq 40$	308	0.027	0.280
			Condition 3 $11930 \leq X_{10} < 24200$	185	0.000	0.650
			Condition 4 $X_{10} \geq 24200$	39	0.000	1.081
Rear end	0.432	0.922	Condition 1 $X_{10} < 8140$	482	0.145	0.288
			Condition 2 $8140 \leq X_{10} < 14690$	206	0.034	0.584

			Condition 3 $18270 \le X_{10} < 23620$	46	0.107	1.094
			Condition 4 $14690 \le X_{10} < 18270$	60	0.107	1.094
			Condition 5 $X_{10} \ge 23620$	41	0.119	2.138
Sideswipe	0.078	0.230	Condition 1 $X_{10} < 7710$	459	0.017	0.088
			Condition 2 $7710 \le X_{10} < 16830$	270	0.052	0.196
			Condition 3 $X_{10} \ge 16830$ & $X_8 < 174$	43	0.361	0.076
			Condition 4 $X_{10} \ge 16830$ & $X_8 \ge 174$	63	0.000	0.525
Fixed Object			*No trees*			
Left turn	0.104	0.290	Condition 1 $X_{10} < 6370$	379	0.017	0.133
			Condition 2 $6370 \le X_{10} < 15540$	328	0.044	0.165
			Condition 3 $X_{10} \ge 15540$ & $X_9 < 40$	87	0.090	0.249
			Condition 4 $X_{10} \ge 15540$ & $X_9 \ge 40$	41	0.000	0.760

Table 13. Crash Models for Signalized T Intersections

Signalized T Intersections						
Crash Type	Mean	Standard Deviation	AID terminal Cells	Sample Size	Linear regression	
					R^2_{adj}	SEE
Injury	0.204	0.514	Condition 1 $X_{10} < 10700$	49	0.250	0.115
			Condition 2 $X_{10} \geq 10700$	41	0.000	0.717
PDO	0.541	1.122	Condition 1 $X_{10} < 13070$	60	0.000	0.394
			Condition 2 $X_{10} \geq 13070$	30	0.000	1.721
Total	0.763	1.579	Condition 1 $X_{10} < 13070$	60	0.166	0.457
			Condition 2 $X_{10} \geq 13070$	30	0.000	2.447
Wet	0.185	0.527	Condition 1 $X_{10} < 13070$	60	0.000	0.172
			Condition 2 $X_{10} \geq 13070$	30	0.000	0.823
Night	0.174	0.469	Condition 1 $X_{10} < 13070$	60	0.119	0.091
			Condition 2 $X_{10} \geq 13070$	30	0.000	0.722
Rear end	0.348	0.932	Condition 1 $X_{10} < 13070$	60	0.101	0.147
			Condition 2 $X_{10} \geq 13070$	30	0.000	1.487
Sideswipe	0.041	0.110	Condition 1 $X_{10} < 9540$	38	-	-
			Condition 2 $X_{10} \geq 9540$	52	0.000	0.137
Fixed object	0.044	0.114	Condition 1 $X_5 < 1$	60	0.000	0.093
			Condition 2 $X_5 \geq 1$	30	0.302	0.120
Left turn	0.048	0.162	Condition 1 $X_{10} < 13070$	60	0.103	0.134
			Condition 2 $X_{10} \geq 13070$	30	0.291	0.164

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8. Model validation

The final step of the research was to validate the crash estimation models. The 1/3 data set created by random selection method from the master database was further split according to the conditions of the AID terminal cells. The candidate models were tested against the observations in the validation data. The mean of the sample and the mean of estimated crashes were calculated. The difference between the estimated and observed means and Standard Error of Estimate (SEE) were also calculated for each model. The summaries of observed means, estimated means, and SEEs are shown in the tables.

The following key should be used to read the tables:

X_1 = Number of Left turn lanes
X_2 = Number of Left & Through lanes
X_3 = Number of Through lanes
X_4 = Number of Right/Through lanes
X_5 = Number of Right turn lanes
X_6 = Number of Right/Left turn lanes
X_7 = Number of Right/Through/Left turn lanes
X_8 = Population Density
X_9 = Speed posted
X_{10} = ADT

Table 14. Summary of Model Validation for T Intersections with One Way Stop Control: No Control Legs

T Intersections with One Way Stop Control: No Control Legs						
Crash Type	AID terminal Cells	Sample Size	Sample mean	Estimated Mean	Difference	SEE
Injury	Condition 1 $X_{10} < 3500$	130	0.054	0.031	42.429	0.172
	Condition 2 $X_{10} \geq 3500$ & $X_9 < 45$	28	0.107	0.050	53.333	0.284
	Condition 3 $X_{10} \geq 3500$ & $X_9 \geq 45$	84	0.159	0.179	12.77	0.274
PDO	Condition 1 $X_{10} < 3760$	138	0.118	0.102	13.890	0.248
	Condition 2 $X_{10} \geq 3760$ & $74 \leq X_8 < 153$	11	0.152	0.161	6.080	0.323
	Condition 3 $X_{10} \geq 3760$ & $X_8 \geq 153$	33	0.222	0.293	31.850	0.353
	Condition 4 $X_{10} \geq 3760$ & $X_8 < 74$	63	0.302	0.368	22.021	0.526
Total	Condition 1 $X_{10} < 3760$	138	0.176	0.135	23.365	0.337
	Condition 2 $X_{10} \geq 3760$ & $X_9 < 45$	28	0.262	3.674	1302	4.218
	Condition 3 $X_{10} \geq 3760$ & $X_9 \geq 45$	80	0.471	0.508	7.940	0.703
Wet	Condition 1 $X_{10} < 3530$	135	0.035	0.021	38.350	0.131
	Condition 2 $X_{10} \geq 3530$ & $X_9 < 45$	28	0.060	0.048	19.960	0.217
	Condition 3 $X_{10} \geq 3530$ & $X_9 \geq 45$	83	0.092	0.133	43.987	0.216
Night	Condition 1 $X_{10} < 2240$	92	0.065	0.040	39.700	0.206
	Condition 2 $X_{10} \geq 2240$ & $X_9 < 45$	37	0.054	0.423	681.980	0.422
	Condition 3 $X_{10} \geq 2240$ & $X_9 \geq 45$	103	0.175	0.175	0.341	0.331
Rear end	Condition 1 $X_{10} < 3760$	139	0.024	0.021	13.510	0.108
	Condition 2 $X_{10} \geq 3760$ & $X_2 < 1$	57	0.129	0.100	23.050	0.318
	Condition 3 $3760 \leq X_{10} < 7120$ & $X_2 < 1$	33	0.071	0.380	495	0.421
	Condition 4 $X_{10} \geq 7120$ & $X_2 < 1$	14	0.119	0.267	113.100	0.706
Sideswipe	Condition 1 $X_{10} < 4380$	143	0	0.001		0.001
	Condition 2 $X_{10} \geq 4380$ & $X_8 \geq 77$		No eq			

	Condition 3 $X_{10} \geq 4380$ & $X_8 < 29$	34	0.009	0.005	49.000	0.058
	Condition 4 $X_{10} \geq 4380$ & $29 \leq X_8 < 77$	43	0	0.045		0.046
Fixed object	Condition 1 $X_{10} < 1370$	57	0.041	0.029	29.150	0.111
	Condition 2 $X_{10} \geq 1370$ & $X_9 < 45$	26	0.013	0.019	49.334	0.077
	Condition 3 $X_{10} \geq 1370$ & $X_9 \geq 45$ & $X_3 \geq 1$	18	0.130	0.032	75.657	0.350
	Condition 4 $X_{10} \geq 1370$ & $X_9 < 77$ & $X_3 < 1$	129	0.111	0.102	8.900	0.245
Left turn	Condition 1 $X_8 < 471$	225	0.010	0.004	66.180	0.059
	Condition 2 $X_8 \geq 471$	21	0.111	0.019	82.900	0.245

Table 15. Summary of Model Validation for T Intersections with One Way Stop Control: Stop Controlled Legs

T Intersections with One Way Stop Control: Stop Controlled Legs						
Crash Type	AID terminal Cells	Sample Size	Sample mean	Estimate Mean	Difference	SEE
Injury	Condition 1 $X_8 \geq 4.244$ & $X_{10} < 3000$	76	0.018	0.004	77.200	0.077
	Condition 2 $X_8 \geq 4.244$ & $X_{10} \geq 3000$	18	0.093	0.075	19.00	0.231
	Condition 3 $X_8 < 4.244$	24	0.029	0.104	258.00	0.123
PDO	Condition 1 $X_{10} < 3140$	98	0.058	0.053	1.424	0.180
	Condition 2 $X_{10} \geq 3140$	19	0.368	0.204	44.628	0.227
Total	Condition 1 $X_{10} < 3140$ & $X_8 \geq 5$	76	0.023	0.052	122.300	0.070
	Condition 2 $X_{10} < 3140$ & $X_8 < 5$	22	0.091	0.189	107.900	0.281
	Condition 3 $X_{10} \geq 3140$	19	0.509	0.312	38.670	0.291
Wet	Condition 1 $X_8 \geq 6.024$ & $X_{10} < 2660$	65	0.015	0.004	74.000	0.072
	Condition 2 $X_8 \geq 6.024$ & $X_{10} \geq 2660$	22	0.061	0.028	53.800	0.175
	Condition 3 $X_8 < 6.024$	13	0.077	0.020	74.080	0.069
Night	Condition 1 $X_8 \geq 4.244$ & $X_{10} < 2070$	62	0.022	0.014	34.900	0.084
	Condition 2 $X_8 \geq 4.244$ & $X_{10} \geq 2070$	32	0.041	0.042	0.800	0.114
	Condition 3 $X_8 < 4.244$	23	0.087	0.094	8.100	0.211
Rear end	Condition 1 $X_{10} < 3190$	88	0.019	0.011	43.715	0.078
	Condition 2 $X_{10} \geq 3190$	19	0.211	0.178	15.450	0.476
Sideswipe	Condition 1 $X_{10} < 3190$	99	0	0.002		0.002
	Condition 2 $X_{10} \geq 3190$	19	0.035	0.022	37.300	0.251
Fixed object	Condition 1 $X_8 \geq 4$ & $X_{10} < 1520$	54	0.006	0.011	78.200	0.046
	Condition 2 $X_8 \geq 110$ & $X_{10} \geq 1520$	16	0.042	0.010	73.600	0.123
	Condition 3 $4 \leq X_8 < 110$ & $X_{10} \geq 1520$	29	0.023	0.053	130.550	0.130
	Condition 4 $X_8 < 4$	18	0.074	0.089	20.150	0.189
Left turn	Condition 1 $X_{10} < 3190$	98	0.010	No eqn		
	Condition 2 $X_{10} \geq 3190$	19	0.123	0.011	91.042	0.263

Table 16. Summary of Model Validation for Two Way Stop Controlled Intersections: No Control Legs

Two Way Stop Control Intersections: No Control Legs						
Crash Type	AID terminal Cells	Sample Size	Sample mean	Estimate Mean	Difference	SEE
Injury	Condition 1 $X_{10}< 3070$	77	0.338	0.207	39.696	0.572
	Condition 2 $X_{10}\geq 3070$ & $X_8 < 18$	33	0.343	0.371	7.929	0.547
	Condition 3 $X_{10} \geq 3070$ & $X_8 \geq 18$	47	0.532	0.567	6.596	0.860
PDO	Condition 1 $X_{10}< 2870$	71	0.305	0.104	65.957	0.546
	Condition 2 $X_{10}\geq 2870$ & $X_8 < 88$	58	0.270	0.033	23.280	0.478
	Condition 3 $X_{10} \geq 2870$ & $X_8 \geq 88$	28	0.440	0.444	0.765	0.724
Total	Condition 1 $X_{10}< 2870$	71	0.653	0.276	57.773	0.988
	Condition 2 $X_{10}\geq 2870$ & $X_8 < 18$	35	0.628	0.596	5.181	0.963
	Condition 3 $X_{10} \geq 2870$ & $X_8 \geq 18$	46	0.761	1.055	38.721	1.301
Wet	Condition 1 $X_{10} < 2590$	65	0.092	0.032	65.333	0.184
	Condition 2 $X_{10} \geq 6300$ & $X_8 < 67$	14	0.214	0.032	49.330	1.220
	Condition 3 $2590 \leq X_{10} < 6300$ & $X_8 < 67$	46	0.138	0.125	9.211	0.218
	Condition 4 $X_{10} \geq 2590$ & $X_8 \geq 67$	32	0.104	0.194	86.240	0.237
Night	Condition 1 $X_{10} < 2870$	71	0	0.031		0.319
	Condition 2 $X_{10} \geq 4220$ & $X_7 \geq 1$	34	0.176	0.115	34.833	0.261
	Condition 3 $X_{10} \geq 4220$ & $X_7 < 1$	19	0.263	0.229	12.977	0.336
	Condition 4 $2870 \leq X_{10} < 4220$	33	0.121	0.231	90.594	0.248
Rear end	Condition 1 $X_{10} < 4770$	118	0.040	0.032	19.080	0.132
	Condition 2 $4770 \leq X_{10} < 7210$	22	0.121	0.097	20.050	0.248
	Condition 3 $X_{10} \geq 7210$	10	0	0.356		0.475
Sideswipe	Condition 1 $X_{10} < 7210$	140	0.011	0.006	49.600	0.074
	Condition 2 $X_{10} \geq 7210$	17	0.020	0	100.00	0.086
Fixed Object	Condition 1 $5 \leq X_8 < 21$			No eq		
	Condition 2 $X_8 < 5$	16	0.042	0	100.00	0.045
	Condition 3 $X_8 \geq 163.265$	13	0.103	0.014	86.420	0.242

	Condition 4 $21 \leq X_8 < 55$	34	0.020	0.013	31.300	0.097
	Condition 5 $55 \leq X_8 < 163.265$	20	0.033	0.088	164.00	0.120
Left Turn	Condition 1 $X_{10} < 6170$	131	0.010	0.015	46.700	0.074
	Condition 2 $X_{10} \geq 6170$	26	0.038	0.063	63.800	0.119

Table 17. Summary of Model Validation for Two Way Stop Controlled Intersections: Stop Controlled Legs

Two Way Stop Control Intersections: Stop Controlled Legs						
Crash Type	AID terminal Cells	Sample Size	Sample mean	Estimate Mean	Difference	SEE
Injury	Condition 1 $X_{10} < 2120$	134	0.077	0.066	14.413	0.201
	Condition 2 $X_{10} \geq 2120$	23	0.145	0.180	24.200	0.503
PDO	Condition 1 $X_{10} < 730$	29	0.034	0.027	21.700	0.106
	Condition 2 $730 \leq X_{10} < 2260$	108	0.130	0.140	8.000	0.296
	Condition 3 $X_{10} \geq 2260$	20	0.667	0.310	11.420	0.573
Total	Condition 1 $X_{10} < 730$	29	0.092	0.071	22.788	0.180
	Condition 2 $730 \leq X_{10} < 2100$	104	0.212	0.211	0.255	0.433
	Condition 3 $X_{10} \geq 2100$	24	0.458	0.465	1.455	0.961
Wet	Condition 1 $X_{10} < 1010$	55	0.006	0.018	198.382	0.054
	Condition 2 $X_{10} \geq 1010$ & $X_8 < 21$	43	0.047	0.030	35.500	0.140
	Condition 3 $X_{10} \geq 1010$ & $X_8 \geq 51$	37	0.036	0.046	27.650	0.107
	Condition 4 $X_{10} \geq 1010$ & $21 \leq X_8 < 51$	22	0.061	0.156	157.400	0.198
Night	Condition 1 $X_{10} < 730$	29	0.034	0.001	85.500	0.1010
	Condition 2 $730 \leq X_{10} < 2420$	110	0.036	0.037	1.750	0.131
	Condition 3 $X_{10} \geq 2420$	18	0.056	0.101	81.800	0.140
Rear end	Condition 1 $X_{10} < 2420$	84	0.028	0.005	81.402	0.096
	Condition 2 $X_{10} \geq 2420$	18	0.167	0.182	9.200	0.318
Sideswipe	*No trees*					
Fixed Object	Condition 1 $X_8 < 33$	84	0.008	0.007	11.800	0.051
	Condition 2 $X_8 \geq 33$	73	0.018	0.037	102.575	0.097
Left Turn	*No trees*					

Table 18. Summary of Model Validation for Flashing Beacon Controlled Intersections: No Control Legs

Flashing Beacon Controlled Intersections: No Control Legs						
Crash Type	AID terminal Cells	Sample Size	Sample mean	Estimate Mean	Difference	SEE
Injury	Condition 1 $X_8 \geq 105$	8	1	0.297	0.710	1.575
	Condition 2 $X_8 < 21$	21	0.968	0.487	49.700	1.359
	Condition 3 $21 \leq X_8$ 105	16	0.583	0.010	98.286	1.298
PDO	Condition 1 $X_{10} < 4960$	37	0.604	0.362	40.020	0.967
	Condition 2 $X_{10} \geq 4960$	24	0.639	0.687	7.530	1.006
Total	Condition 1 $X_{10} < 5310$	41	1.383	0.816	41.012	1.873
	Condition 2 $X_{10} \geq 5310$	21	1.476	1.286	12.883	2.240
Wet	Condition 1 $X_{10} < 5310$	40	0.350	0.120	78.137	0.623
	Condition 2 $X_{10} \geq 5310$	21	0.270	0.236	12.541	0.429
Night	Condition 1 $X_{10} < 5310$	40	0.208	0.092	55.840	0.391
	Condition 2 $X_{10} \geq 5310$	21	0.206	0.257	24.540	0.354
Rear end	Condition 1 $X_{10} < 5840$	43	0.047	0.040	79.125	0.216
	Condition 2 $X_{10} \geq 5840$	18	0.278	0.179	35.600	0.494
Sideswipe	Condition 1 $X_{10} < 6310$	45	0.007	0.007	5.500	0.050
	Condition 2 $X_{10} \geq 6310$	16	0.063	0.044	29.600	0.139
Fixed object	Condition 1 $X_9 < 50$	8	0.083	0.136	63.284	0.208
	Condition 2 $X_9 \geq 50$	45	0.030	0.030	0.200	0.135
Left turn	Condition 1 $X_{10} < 6310$	45	0.007	0.017	131.900	0.071
	Condition 2 $X_{10} \geq 6310$	13	0.026	0.154	502.400	0.299

Table 19. Summary of Model Validation for Flashing Beacon Controlled Intersections: Stop Controlled Legs

Flashing Beacon Controlled Intersections: Stop Controlled Legs						
Crash Type	AID terminal Cells	Sample Size	Sample mean	Estimate Mean	Difference	SEE
Injury	Condition 1 $X_{10} < 2420$	44	0.136	0.052	61.867	0.297
	Condition 2 $X_{10} \geq 2420$	33	0.091	0.141	0.234	0.234
PDO	Condition 1 $X_{10} < 2050$	31	0.215	0.128	40.480	0.416
	Condition 2 $X_{10} \geq 2050$ & $X_9 \geq 50$	36	0.269	0.390	45.241	0.590
	Condition 3 $X_{10} \geq 2050$ & $X_9 < 50$	10	0.167	0.588	252.800	0.302
Total	Condition 1 $X_{10} < 2030$	31	0.333	0.186		0.561
	Condition 2 $2030 \leq X_{10} < 2420$	13	0.487	0.295	39.350	0.735
	Condition 3 $X_{10} \geq 2420$	33	0.313	0.695	121.950	0.721
Wet	Condition 1 $X_{10} < 2420$	44	0.053	0.029	45.314	0.282
	Condition 2 $X_{10} \geq 2420$	33	0.071	0.146	106.486	0.200
Night	Condition 1 $X_{10} < 3100$ & $X_8 \geq 387.763$			No eq		
	Condition 2 $X_{10} < 3100$ & $X_8 < 17$	19	0.070	0.021	70.075	0.191
	Condition 3 $X_{10} < 3100$ & $17 \leq X_8 < 387.763$	21	0.079	0.054	31.960	0.151
	Condition 4 $X_{10} \geq 3100$	22	0.091	0.194	113.400	0.241
Rear end	Condition 1 $X_{10} < 2030$	31	0.032	0.022	31.800	0.102
	Condition 2 $2030 \leq X_{10} < 3140$	25	0.080	0.068	15.000	0.178
	Condition 3 $X_{10} \geq 3140$	21	0.032	0.183	476.450	0.189
Sideswipe	Condition 1 $X_{10} < 2920$			No eqn		
	Condition 2 $X_{10} \geq 2920$	26	0.000	0.030		0.048
Fixed Object	Condition 1 $X_9 \geq 50$ & $X_8 \geq 26$			No eqn		
	Condition 2 $X_9 \geq 50$ & $X_8 < 26$	15	0.000	0.045		0.063
	Condition 3 $X_9 < 50$	17	0.012	0.027	37.700	0.084
Left Turn	*No trees*					

Table 20. Summary of Model Validation for Signalized Intersections (Four Way)

Signalized Intersections						
Crash Type	AID terminal Cells	Sample Size	Sample mean	Estimate Mean	Difference	SEE
Injury	Condition 1 $X_{10} < 11800$ & $X_9 < 45$	168	0.105	0.065	37.710	0.245
	Condition 2 $11800 \leq X_{10} < 14580$ & $X_9 < 45$	20	0.283	0.229	19.282	0.633
	Condition 3 $X_{10} < 6130$ & $X_9 \geq 45$	73	0.297	0.234	21.178	0.479
	Condition 4 $6130 \leq X_{10} < 14580$ & $X_9 \geq 45$	83	0.478	0.512	7.132	0.682
	Condition 5 $14580 \leq X_{10} < 23620$	48	0.618	0.583	5.671	1.029
	Condition 6 $X_{10} \geq 23620$	21	1.397	0.676	51.582	2.112
PDO	Condition 1 $X_{10} < 7040$	213	0.438	0.304	30.660	0.697
	Condition 2 $7040 \leq X_{10} < 14690$	137	0.873	0.624	28.550	1.299
	Condition 3 $14690 \leq X_{10} < 23620$	48	1.819	1.664	2.580	2.428
	Condition 4 $X_{10} \geq 23620$	21	3.730	2.581	30.814	5.390
Total	Condition 1 $X_{10} < 7040$	213	0.634	.511	19.375	0.935
	Condition 2 $7040 \leq X_{10} < 14690$	137	1.217	1.093	10.149	1.763
	Condition 3 $14690 \leq X_{10} < 23620$	48	2.465	2.321	5.852	3.419
	Condition 4 $X_{10} \geq 23620$	21	5.238	3.650	30.318	7.392
Wet	Condition 1 $X_{10} < 9410$	278	0.159	0.103	35.457	0.324
	Condition 2 $9410 \leq X_{10} < 14690$	66	0.288	0.252	12.400	0.635
	Condition 3 $14690 \leq X_{10} < 26820$	55	0.745	0.550	26.220	1.283
	Condition 4 $X_{10} \geq 26820$	14	1.500	0.795	47.021	2.850
Night	Condition 1 $X_{10} < 11930$ & $X_9 < 40$	162	0.113	0.071	36.970	0.264
	Condition 2 $X_{10} < 11930$ & $X_9 \geq 40$	156	0.259	0.170	34.434	0.404
	Condition 3 $11930 \leq X_{10} < 24200$	82	0.423	0.447	5.733	0.733
	Condition 4 $X_{10} \geq 24200$	19	1.456	0.906	37.780	2.388
Rear end	Condition 1 $X_{10} < 8140$	223	0.203	0.181	10.764	0.459
	Condition 2 $8140 \leq X_{10} < 14690$	97	0.581	0.451	22.343	0.936
	Condition 3 $18270 \leq X_{10} < 23620$	11	1.212	0.786	35.157	1.525

	Condition 4 $14690 \leq X_{10} < 18270$	37	1.090	0.749	31.331	1.791
	Condition 5 $X_{10} \geq 23620$	21	2.937	1.583	46.076	4.255
Sideswipe	Condition 1 $X_{10} < 7710$	223	0.031	0.020	35.110	0.103
	Condition 2 $7710 \leq X_{10} < 16830$	134	0.097	0.088	9.748	0.240
	Condition 3 $X_{10} \geq 16830$ & $X_8 < 174$	16	0.104	0.043	58.394	0.174
	Condition 4 $X_{10} \geq 16830$ & $X_8 \geq 174$	33	0.364	0.397	9.715	0.546
Fixed Object	*No trees*					
Left turn	Condition 1 $X_{10} < 6370$	181	0.057	0.037	34.852	0.140
	Condition 2 $6370 \leq X_{10} < 15540$	176	0.119	0.086	28.019	0.251
	Condition 3 $X_{10} \geq 15540$ & $X_9 < 40$	44	0.181	0.151	16.738	0.390
	Condition 4 $X_{10} \geq 15540$ & $X_9 \geq 40$	18	0.352	0.512	45.516	0.630

Table 21. Summary of Model Validation for Signalized T Intersections

Signalized T Intersections						
Crash Type	AID terminal Cells	Sample Size	Sample mean	Estimate Mean	Difference	SEE
Injury	Condition 1 $X_{10} < 10700$	16	0.313	0.103221	66.969	0.602
	Condition 2 $X_{10} \geq 10700$	24	0.458	0.341	25.600	0.787
PDO	Condition 1 $X_{10} < 13070$	30	0.322	0.233	27.690	0.646
	Condition 2 $X_{10} \geq 13070$	17	1.196	1.156	3.351	1.426
Total	Condition 1 $X_{10} < 13070$	30	0.552	0.074	86.613	1.154
	Condition 2 $X_{10} \geq 13070$	17	1.824	1.556	14.671	2.203
Wet	Condition 1 $X_{10} < 13070$	30	0.144	0.050	65.385	0.377
	Condition 2 $X_{10} \geq 13070$	17	0.608	0.456	24.981	1.130
Night	Condition 1 $X_{10} < 13070$	17	0.196	0.051	74.080	0.487
	Condition 2 $X_{10} \geq 13070$	17	0.588	0.333	43.390	0.839
Rear end	Condition 1 $X_{10} < 13070$	30	0.156	0.073	53.286	0.323
	Condition 2 $X_{10} \geq 13070$	17	1.078	0.789	26.838	1.349
Sideswipe	Condition 1 $X_{10} < 9540$					
	Condition 2 $X_{10} \geq 9540$	27	0.099	0.071	28.113	0.161
Fixed object	Condition 1 $X_5 < 1$	35	0.057	0.028	51.000	0.156
	Condition 2 $X_5 \geq 1$	12	0.167	0.051	69.600	0.532
Left turn	Condition 1 $X_{10} < 13070$	10	0.000	0.088		0.106
	Condition 2 $X_{10} \geq 13070$	17	0.078	0.104	32.825	0.228

9. Applications, Conclusions and Recommendations

9.1 Applications

For models that were developed with statistical analysis, a tolerance range should be used for applying the AID and regression models.

a) Standard Error of Estimate, a measure of accuracy of the estimated models, should be used for models developed using regression. In the case of regression models, SEE gives an idea of the error range of the estimation away from the observed values. The upper limit of the tolerance range is given by

$$Ev + n*SEE$$

where
Ev = Estimated base crash rate
n = Tolerance level
SEE = Standard Error of Estimate

The tolerance range can be adjusted by changing the tolerance level, n. As n increases, we find fewer abnormal legs. On the other hand, by decreasing n, we find more legs abnormal, as tolerance range decreases.

b) For AID terminal cell models, standard deviation can be used as unit of tolerance. Hence the upper limit is obtained by :

$$Ev + n*SD$$

where
Ev = Estimated base crash rate
n = Tolerance level
SD = Standard Deviation

If an observed crash rate agrees with the estimation within the tolerance range, it is statistically acceptable. If it is greater than the upper limit, then it can be considered as an outlier or statistically higher than the normal.

An example of the application of the tolerance range is demonstrated:

The recommended PDO model for signal controlled legs are:

PDO crashes	Condition 1	$Y = -0.476-0.146*X_1+0.120\ X_9+0.076X_{10}$
	Condition 2	$Y = -0.906+0.936*X_1+1.680*X_2+0.588*X_3+ 0.442*X_4+1.852*X_7$
	Condition 3	$Y = 1.664$
	Condition 4	$Y = -2.458+0.179*X_{10}$

Let us consider an intersection with the following data:

X_1	Number of left turn lanes	1
X_2	Number of left & through turn lanes	0

X_3	Number of through lanes	1
X_4	Number of Right & through lanes	1
X_5	Number of right turn lanes	1
X_6	Number of right & left turn lanes	0
X_7	Number of right & through & left turn lanes	0
X_8	Population density (100 persons per area of 1 mile radius)	0.47
X_9	Speed limit (10mph)	3.5
X_{10}	ADT (1000 veh/day)	12.860

The estimated values can be obtained by inputting the above values of the independent variables.

Refer to AID and regression tables, since $7040 \le 12860 < 14690$, i.e. $7040 \le ADT < 14690$, the leg falls under Condition 2.

Hence number of base crashes $= -0.906+0.936*X_1+1.680*X_2+0.588*X_3+ 0.442*X_4 +1.852*X_7$
$= -0.906+0.936*1 +1.68*0 +0.588*1 +0.442*1 +1.852*0 = 1.06$

(a) Let us assume the tolerance level as 2, and the Standard Error of Estimate for Condition 2 for PDO crashes for signal controlled legs is 1.03.
Hence, the upper limit of tolerance range is:

$Ev + n*SEE = 1.06+2*1.03= 3.12$.

The actual number of crashes is 3 per year. Since $3 < 3.12$, the number of crashes at this intersection is within the tolerance range, and hence it can be statistically accepted to be normal.

(b) The standard deviation for Condition 2 for PDO crashes for signal controlled legs is 1.208. If we consider 2 * standard deviation as the tolerance range, the upper limit of the tolerance range is:

$Ev + n*SD = 1.06+2*1.208 = 3.476$

The actual number of crashes is 3.00 per year. Since $3.00 < 3.476$, the crash rate is within the tolerance range and statistically accepted to be normal.

9.2. Conclusions

This study was conducted to develop base crash rates for intersections in Ohio. The base crash rate models were developed for the following crash types:

1. Injury crashes
2. PDO crashes
3. Total crashes
4. Wet crashes
5. Night Crashes
6. Rear end crashes
7. Sideswipe crashes
8. Fixed object crashes
9. Left turn crashes

Base crash rate models were developed for intersection legs (also called intersection approaches) as the crash behavior of different legs within the same intersection were likely to be different. The type of control for each intersection or leg plays an important role in the crash experience of the intersections and their respective legs. Considering the minimum sample size needed to develop models, base crash rates for the following leg types were modeled based on the type of control.

1. Signalized legs at four way signalized intersections
2. Signalized legs at three way signalized intersections
3. No control legs at one way stop controlled intersections
4. Stop controlled legs at one way stop controlled intersections
5. No control legs at two way stop controlled intersections
6. Stop controlled legs at two way stop controlled intersections
7. No control legs at intersections with flashing beacons
8. Stop controlled legs at intersections with flashing beacons

Intersections with four way stop control, yield control, and three way stop control were excluded from the analysis due to the lack of adequate sample size.

For each leg type as categorized above, the following independent variables were included in the analysis:

1. Number of left turn lanes
2. Number of left / through lanes
3. Number of through lanes
4. Number of right / through lanes
5. Number of right turn lanes
6. Number of right / left turn lanes
7. Number of right / through / left turn lanes
8. Population density (persons per area of 1 mile radius)
9. Speed limit (mph) per 10 mph
10. Average daily traffic (ADT) per 1000 veh per day

This study focused on intersections formed by two or more State or US routes. A master database was prepared by using data available from ODOT and data manually extracted from photologs by the researchers. The database was randomly split into two-third and one-third for model building and model validation respectively.

To evaluate the complex interaction among the dependent and independent variables, Automatic Interaction Detection (AID) technique was used. AID assisted in identifying a set of independent variables that have significant relationship with each dependent variable. The data was split into mutually exclusive groups such that data in the same group were similar to each other. After the completion of AID analysis, a stepwise multiple regression technique was used to develop mathematical models for the split groups. Finally, the models were validated with the one-third data set aside for validation. The R^2_{adj} values ranged between 0 and 1.0, but most of them had low R^2_{adj} values. However, like in many engineering applications, these models with low R^2_{adj} values may still carry considerable significance for identifying independent variables that can potentially be used for generation of countermeasures.

This is a macroscopic analysis, which can help in identifying intersection legs with "abnormal" crash rates, upon which further safety analysis at the micro level can be done to improve the efficiency of the intersection legs.

9.3 Recommendations

- Statewide base crash rates for intersections were developed in this study and can be used by ODOT for evaluating intersections and generating countermeasures. It is recommended that the means and standard deviations for different crash types and intersection types as provided by the AID analysis in Appendix II be used for calculating base crash rates. This recommendation is based on the fact that although AID analysis showed significant relationships between crash rates and independent variables, the R^2 values for individual regression equations were low. Initially, a tolerance level of n = 2 may be used as a default value, however, other values may be adopted in the future to maintain uniformity and consistency on a statewide basis.

- Regression equations may be used as an additional tool for estimating statewide base crash rates for each crash type and intersection type in Ohio. These equations are presented in Appendix III.

10. References

1. "National Agenda for Intersection Safety", U.S. Department of Transportation, Federal Highway Administration Publication, FHWA- SA-02-007, May 2002.

2. Intersection Safety Facts and Statistics, FHWA website http://safety.fhwa.dot.gov/intersections/inter_facts.htm

3. Ohio Traffic Crash Facts, Ohio Department of Public Safety website http://www.publicsafety.ohio.gov/publicat/HSY7606/HSY7606-2004.PDF

4. Pant,P.D., Y.Liu and G. Vasisht, " Rational Schedule of Base Crash Rates for Rural Highways in Ohio(Phase-I)", Final report submitted to the Ohio Department of Transportation, U.S. Department of Transportation, January 2000

5. Pant,P.D., Arudi S. Rajagopal, Yizong Cheng, " Rational Schedule of Base Crash Rates for Rural Highways in Ohio(Phase-II)", Final report submitted to the Ohio Department of Transportation, U.S. Department of Transportation, June 2003

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7. Sonquist, John A. and Mongan, N. James, "The Detection of Interaction Effects; A Report on a Computer Program for the Selection of Optimal Combinations of Explanatory Variables," Ann Arbor Survey Research Center, Institute for Social Research, University of Michigan, 1970

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APPENDIX I

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Table A1.1. Distribution of Intersections and Legs for District 1

Type of intersection	Number of legs	Number of intersections
Signalized	52	13
Two way stop	152	38
Four way stop	0	0
One way stop	72	24
Three way stop	0	0
Yield control	0	0
Flashing beacons	16	4
Unspecified	3	1
No control	0	0
Signalized T intersection	6	2
	301	82

Figure A1.1 Distribution of Intersections and Legs for District 1

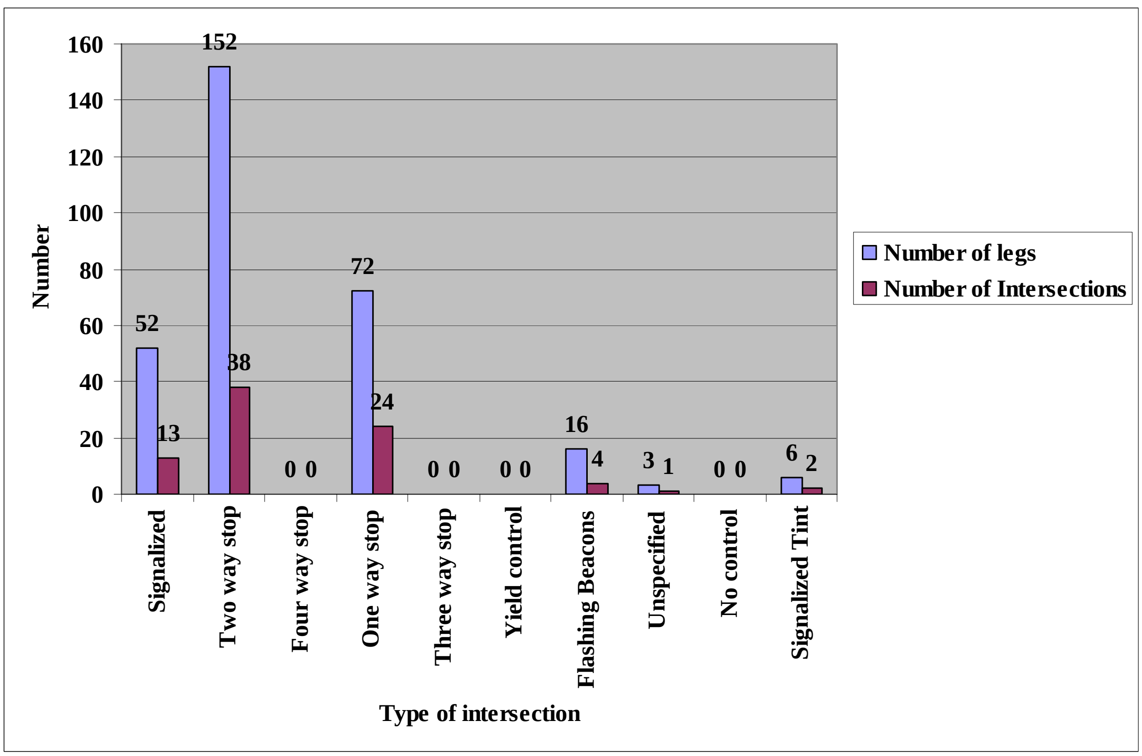


Table A1.2. Distribution of Intersections and Legs for District 2

Type of intersection	Number of legs	Number of intersections
Signalized	124	31
Two way stop	120	30
Four way stop	0	0
One way stop	60	20
Three way stop	3	1
Yield control	0	0
Flashing beacons	48	12
Unspecified	0	0
No control	0	0
Signalized T intersection	6	2
	361	96

Figure A1.2 Distribution of Intersections and Legs for District 2

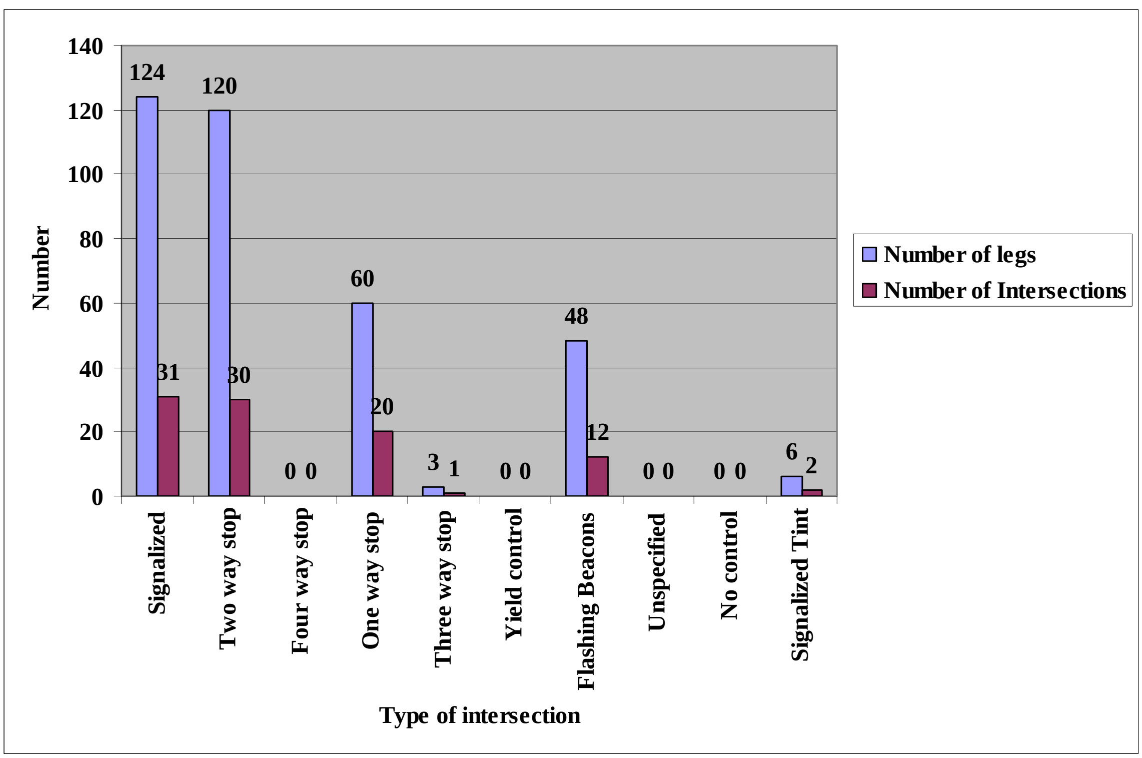


Table A1.3. Distribution of Intersections and Legs for District 3

Type of intersection	Number of legs	Number of intersections
Signalized	172	43
Two way stop	180	45
Four way stop	4	1
One way stop	99	33
Three way stop	0	0
Yield control	0	0
Flashing Beacons	39	10
Unspecified	8	2
No control	0	0
Signalized T intersection	9	3
	511	137

Figure A1.3. Distribution of number of intersections and legs for District 3

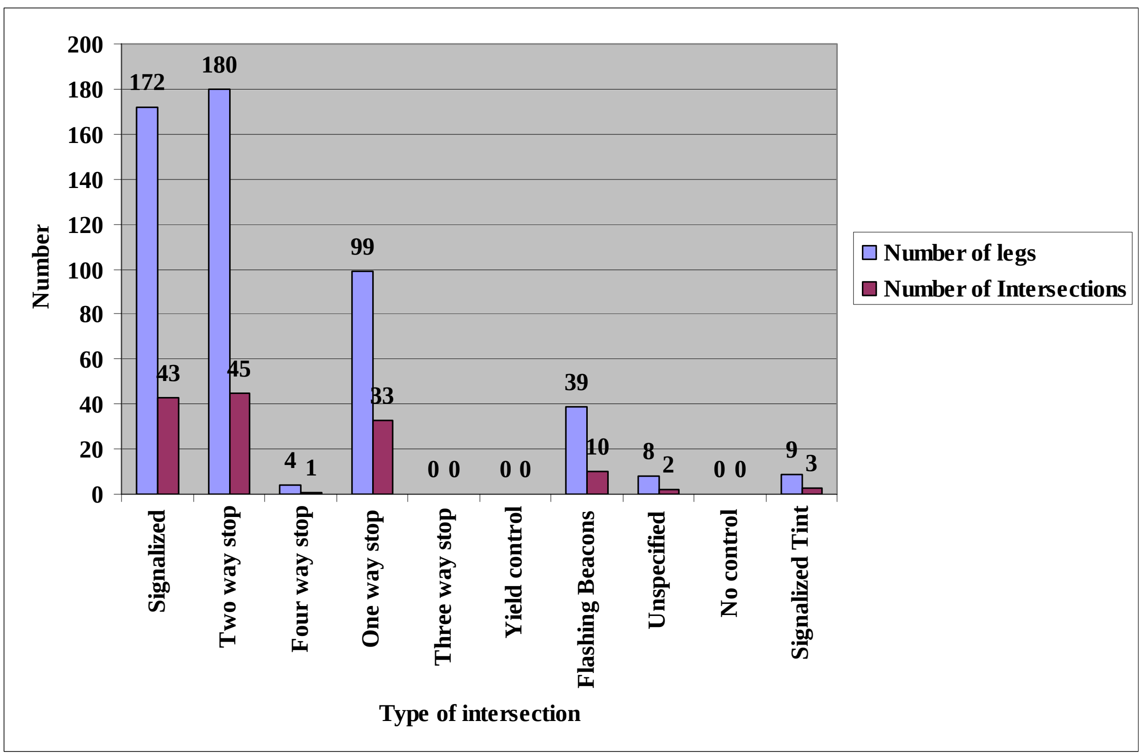


Table A1.4. Distribution of Intersections and Legs for District 4

Type of intersection	Number of legs	Number of intersections
Signalized	184	46
Two way stop	20	5
Four way stop	4	1
One way stop	21	7
Three way stop	0	0
Yield control	0	0
Flashing beacons	68	17
Unspecified	0	0
No control	0	0
Signalized T intersection	6	2
	303	78

Figure A1.4. Distribution of Intersections and Legs for District 4

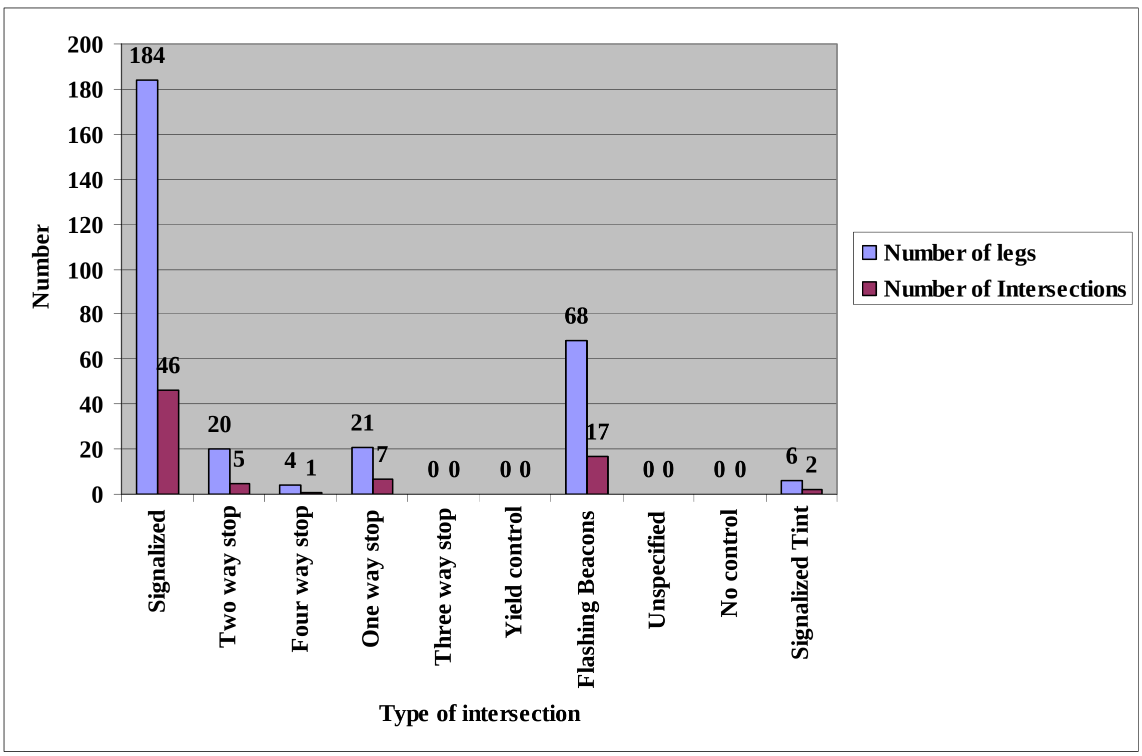


Table A1.5. Distribution Iintersections and Legs for District 5

Type of Intersection	Number of legs	Number of intersections
Signalized	64	16
Two way stop	64	16
Four way stop	20	5
One way stop	150	50
Three way stop	3	1
Yield control	0	0
Flashing Beacons	24	6
Unspecified	12	4
No control	0	0
Signalized Tint	18	6
	355	104

Figure A1.5. Distribution of Intersections and Legs for District 5

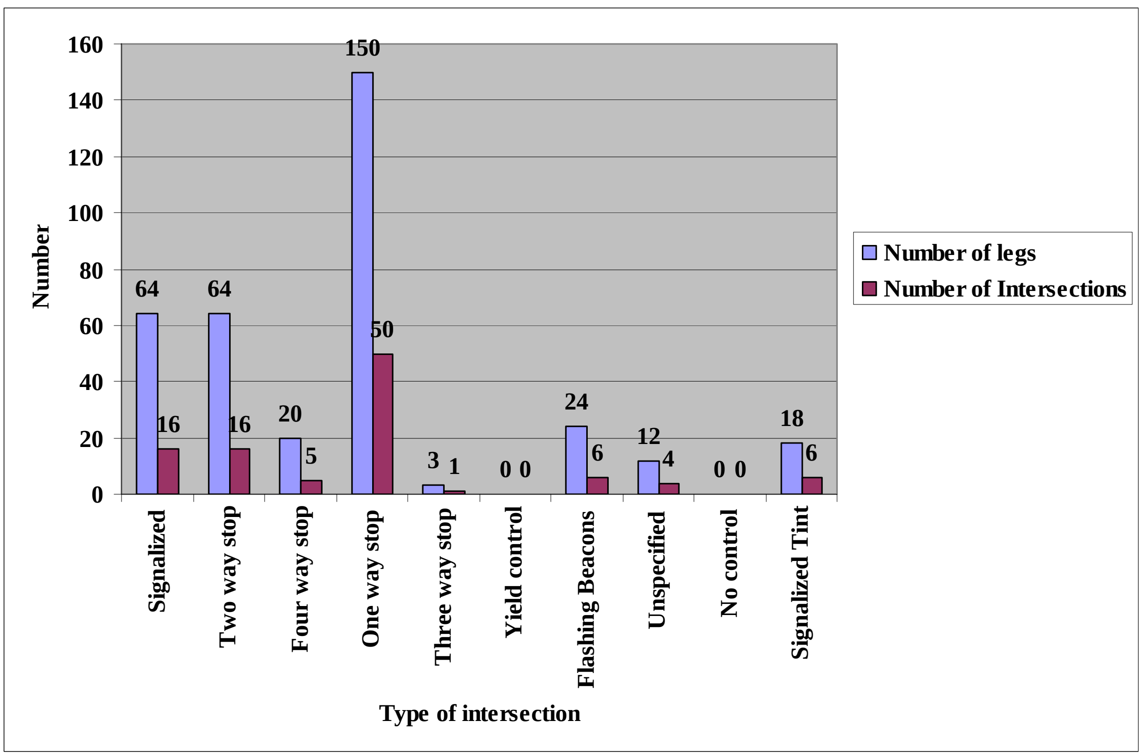


Table A1.6. Distribution of Intersections and Legs for District 6

Type of Intersection	Number of legs	Number of intersections
Signalized	124	31
Two way stop	68	17
Four way stop	8	2
One way stop	45	15
Three way stop	0	0
Yield control	0	0
Flashing Beacons	48	12
Unspecified	0	0
No control	0	0
Signalized Tint	6	2
	299	79

Figure A1.6. Distribution of Intersections and Legs for District 6

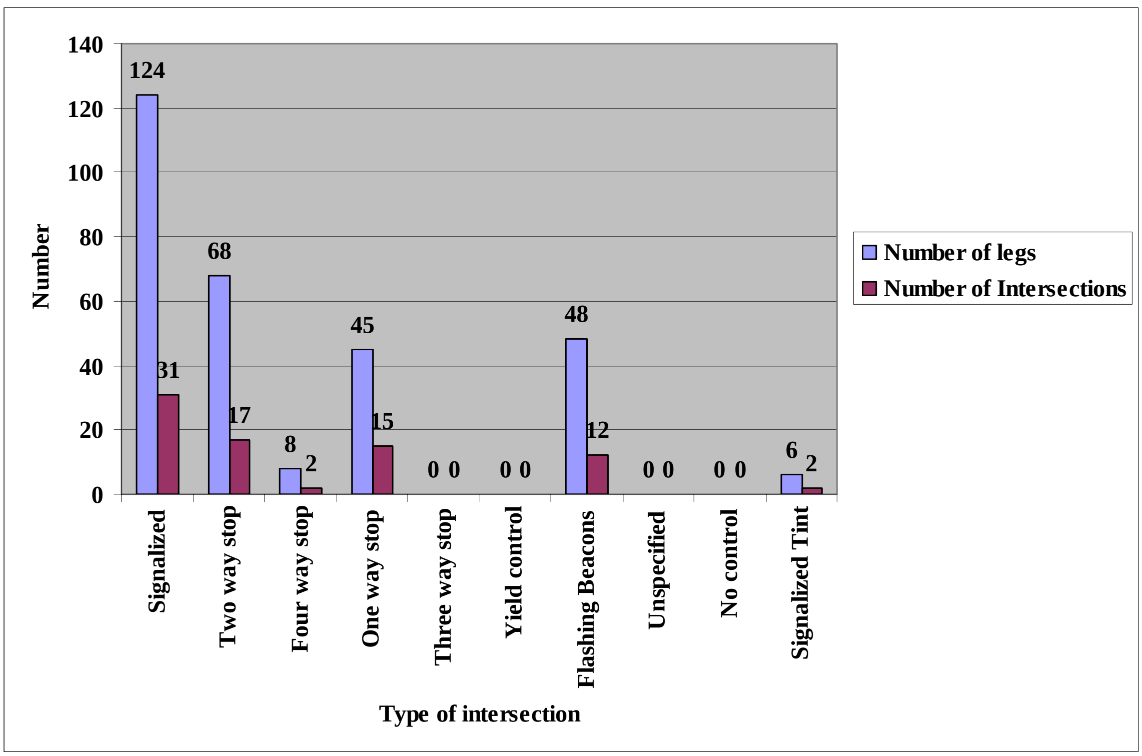


Table A1.7. Distribution of Intersections and Legs for District 7

Type of Intersection	Number of legs	Number of intersections
Signalized	124	31
Two way stop	156	39
Four way stop	12	3
One way stop	126	42
Three way stop	3	1
Yield control	0	0
Flashing Beacons	35	9
Unspecified	4	1
No control	0	0
Signalized Tint	12	4
	472	130

Figure A1.7. Distribution of Intersections and Legs for District 7

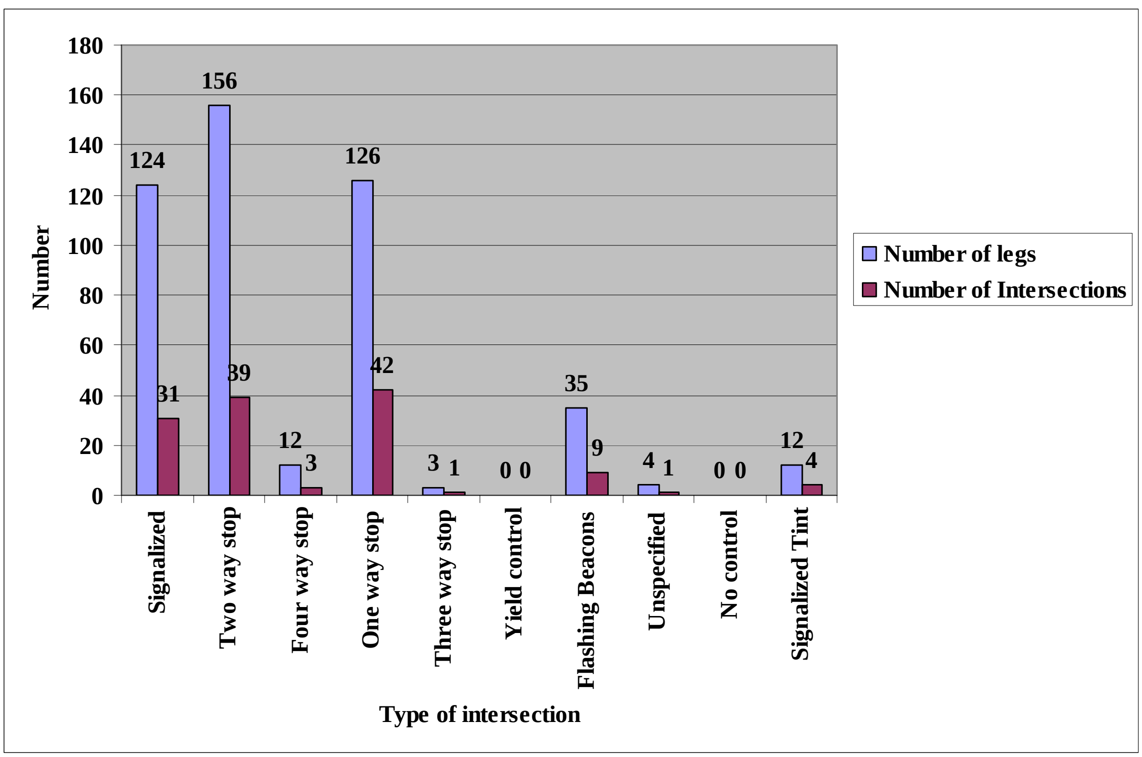


Table A1.8. Distribution of Intersections and Legs for District 8

Type of Intersection	Number of legs	Number of intersections
Signalized	116	29
Two way stop	48	12
Four way stop	0	0
One way stop	87	29
Three way stop	0	0
Yield control	0	0
Flashing Beacons	48	12
Unspecified	3	1
No control	0	0
Signalized Tint	33	11
	335	94

Figure A1.8. Distribution of Intersections and Legs for District 8

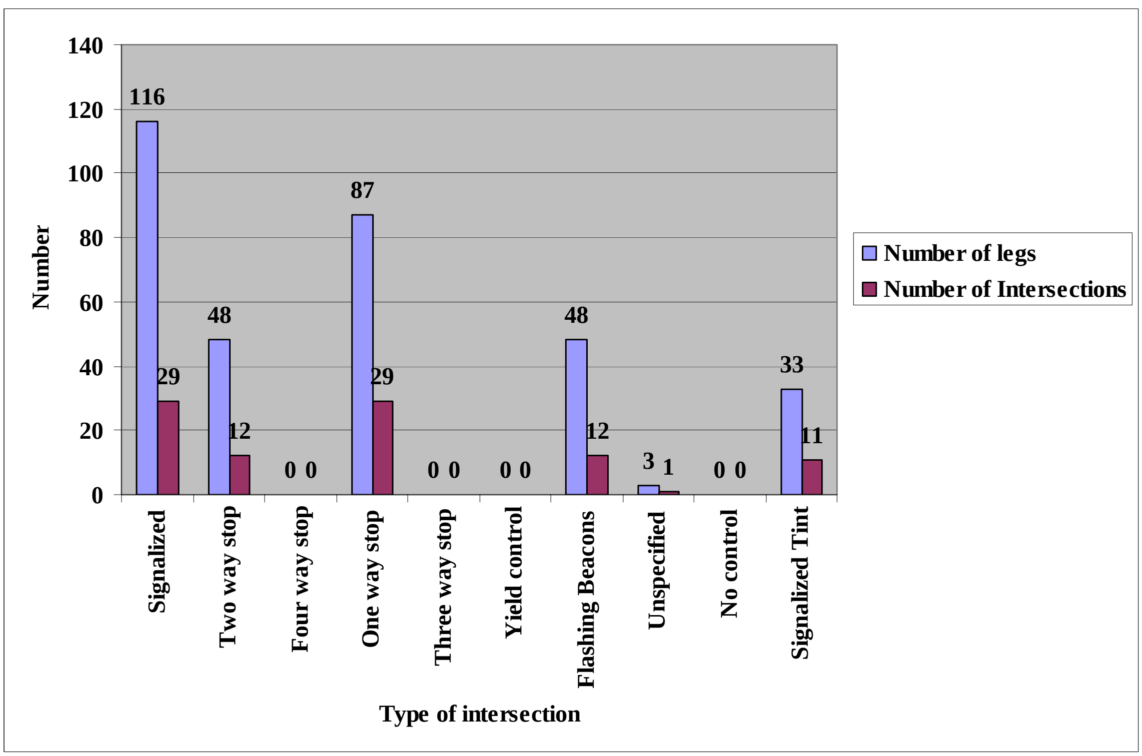


Table A1.9 Distribution of Intersections and Legs for District 9

Type of Intersection	Number of legs	Number of intersections
Signalized	48	12
Two way stop	56	14
Four way stop	4	1
One way stop	153	51
Three way stop	0	0
Yield control	0	0
Flashing Beacons	32	8
Unspecified	10	3
No control	0	0
Signalized Tint	3	1
	306	90

Figure A1.9. Distribution of Intersections and Legs for District 9

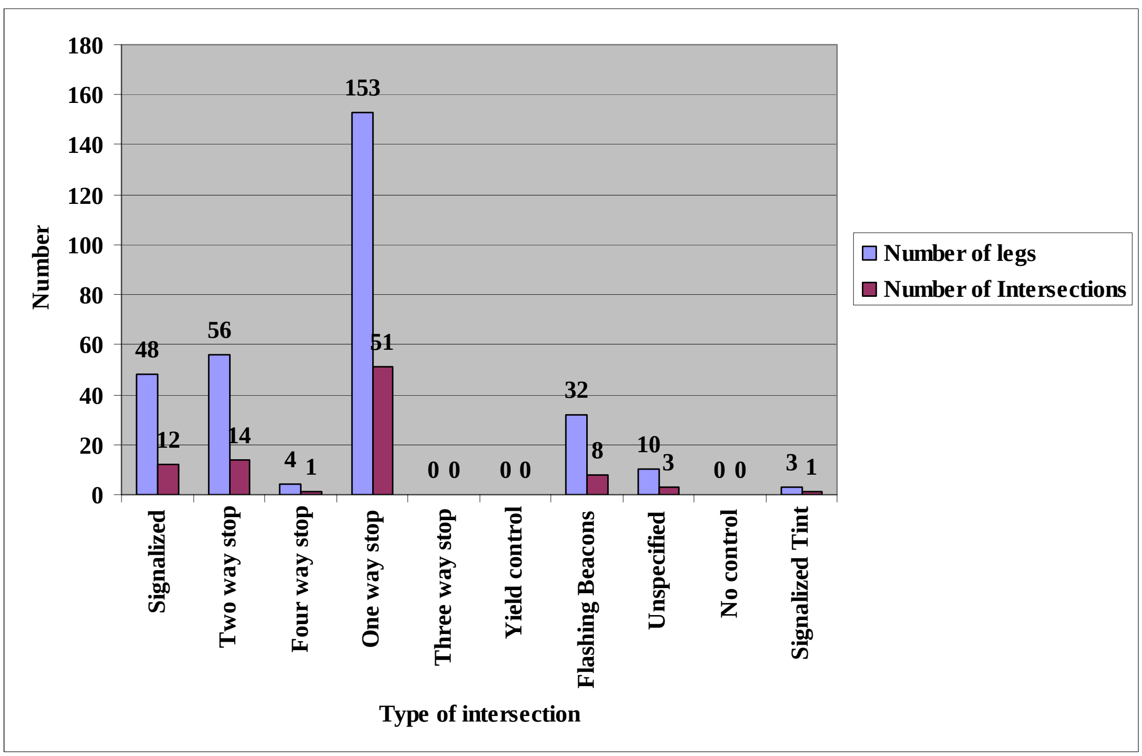


Table A1.10. Distribution of Intersections and Legs for District 10

Type of Intersection	Number of legs	Number of intersections
Signalized	20	5
Two way stop	16	4
Four way stop	0	0
One way stop	126	42
Three way stop	0	0
Yield control	0	0
Flashing Beacons	23	6
Unspecified	3	1
No control	3	1
Signalized Tint	6	2
	197	61

Figure A1.10. Distribution of Intersections and Legs for District 10

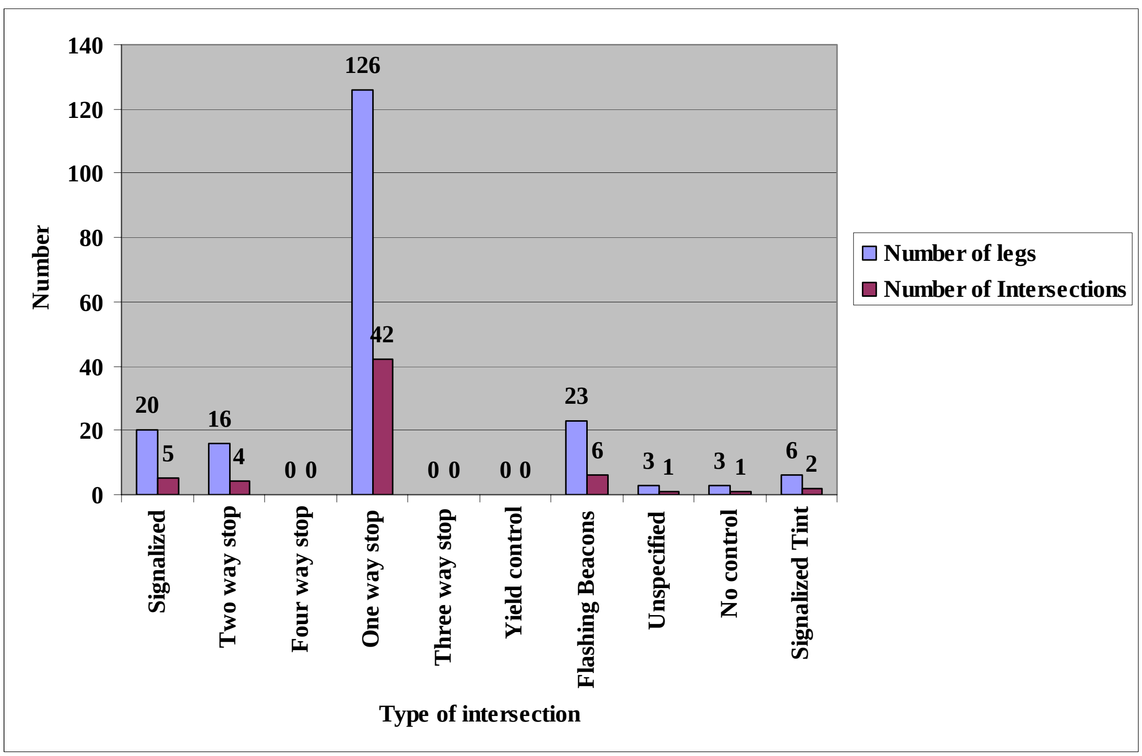


Table A1.1. Distribution of Intersections and Legs for District 11

Type of Intersection	Number of legs	Number of intersections
Signalized	64	16
Two way stop	48	12
Four way stop	8	2
One way stop	165	55
Three way stop	0	0
Yield control	0	0
Flashing Beacons	24	7
Unspecified	7	2
No control	0	0
Signalized Tint	9	3
	325	97

Figure A1.11. Distribution of Intersections and Legs for District 11

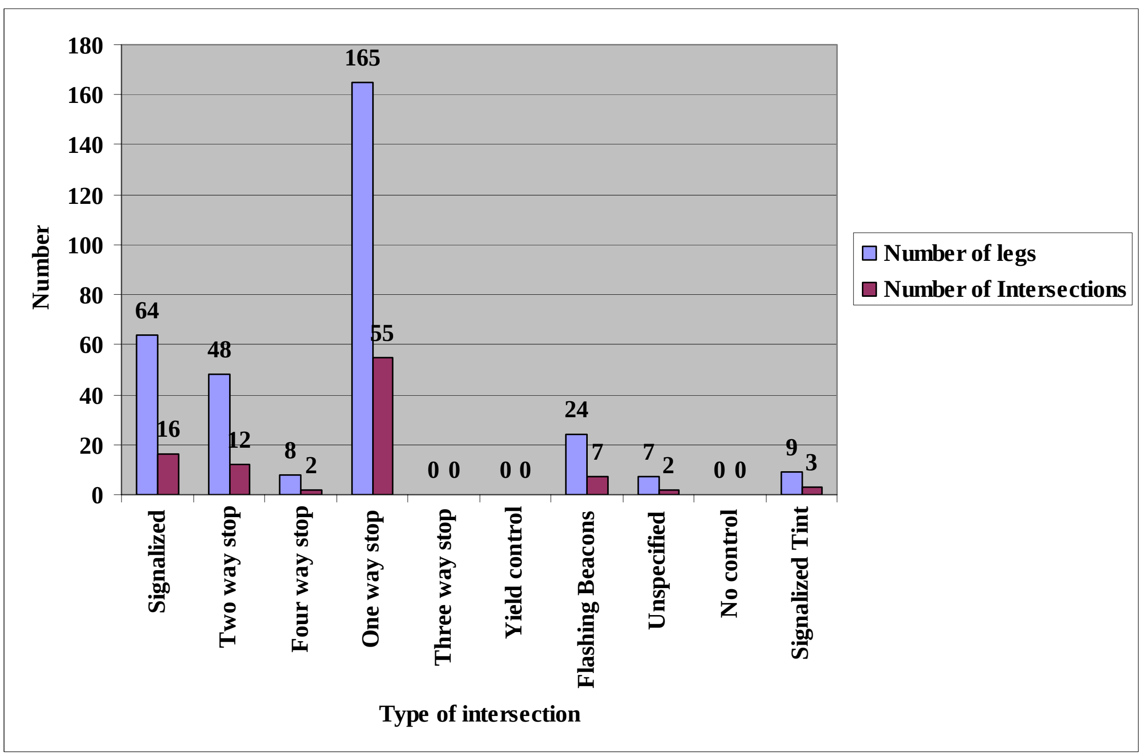
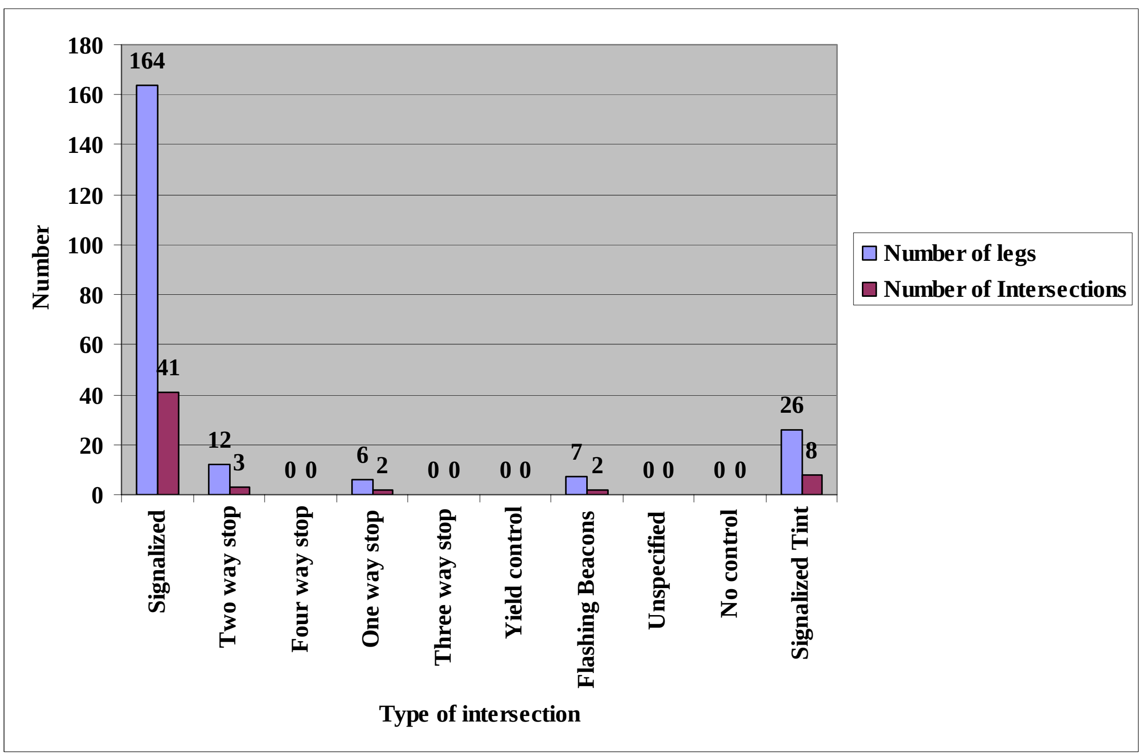


Table A1.12. Distribution of Intersections and Legs for District 12

Type of Intersection	Number of legs	Number of intersections
Signalized	164	41
Two way stop	12	3
Four way stop	0	0
One way stop	6	2
Three way stop	0	0
Yield control	0	0
Flashing Beacons	7	2
Unspecified	0	0
No control	0	0
Signalized Tint	26	8
	215	56

Figure A1.12. Distribution of Intersections and Legs for District 12



APPENDIX II-Recommended AID models

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Figure A2.1. AID Tree for T Intersections with One Way Stop Sign - No Control Legs-Injury Crashes

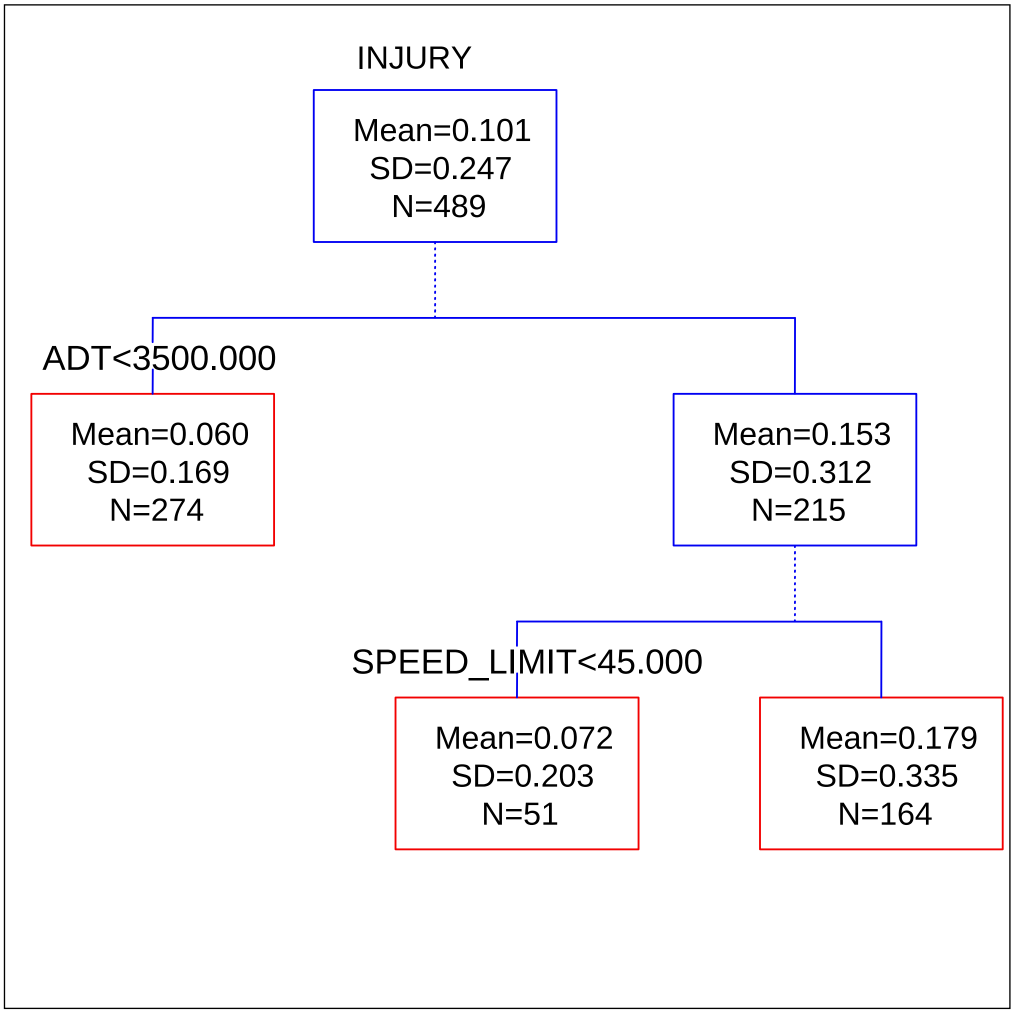


Figure A2.2 AID Tree for T Intersections with One Way Stop Sign - No Control Legs - PDO Crashes

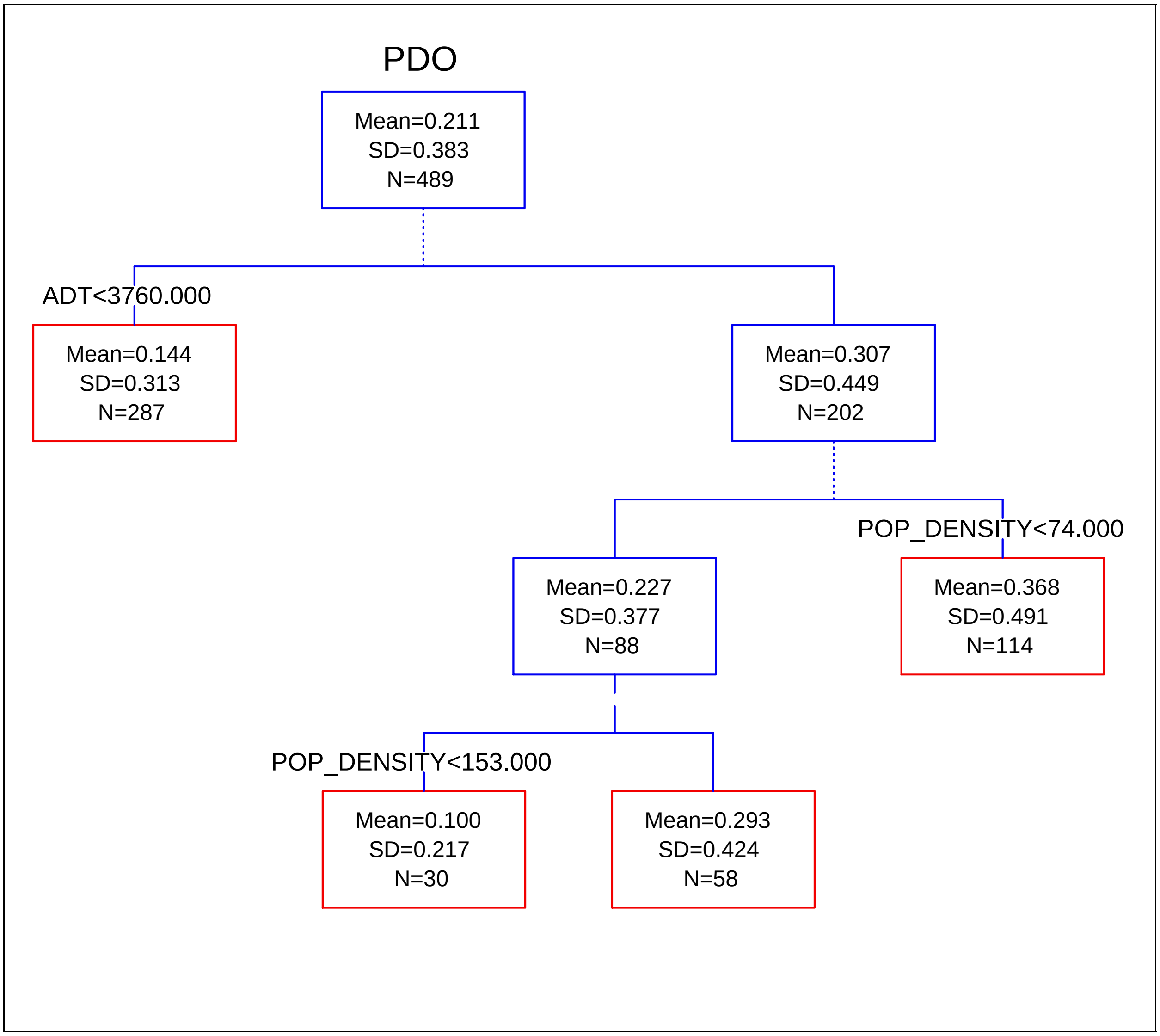


Figure A2.3. AID Tree for T Intersections with One Way Stop Sign - No Control Legs - Total Crashes

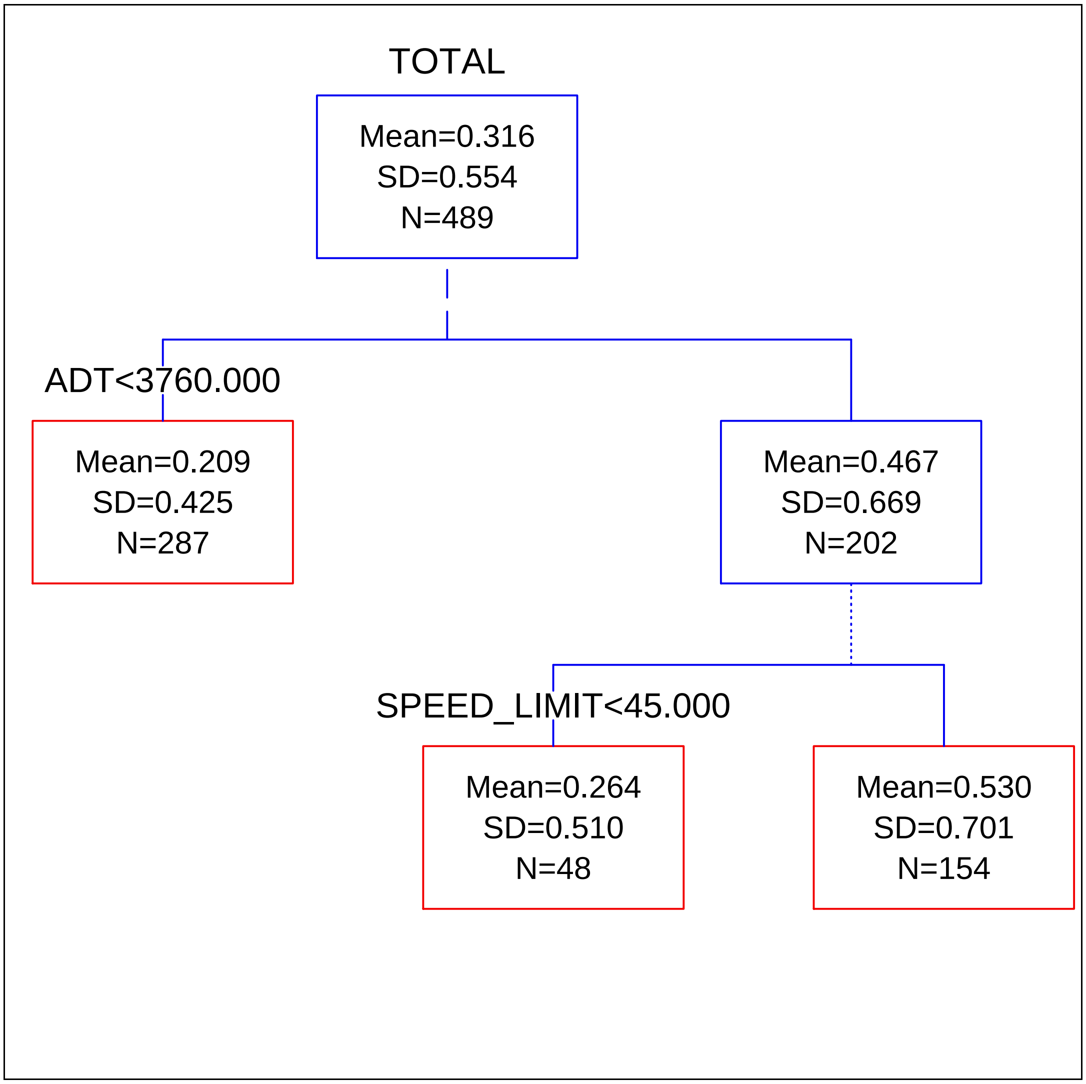


Figure A2.4 AID Tree for T Intersections with One Way Stop Sign - No Control Legs - Wet Pavement Crashes

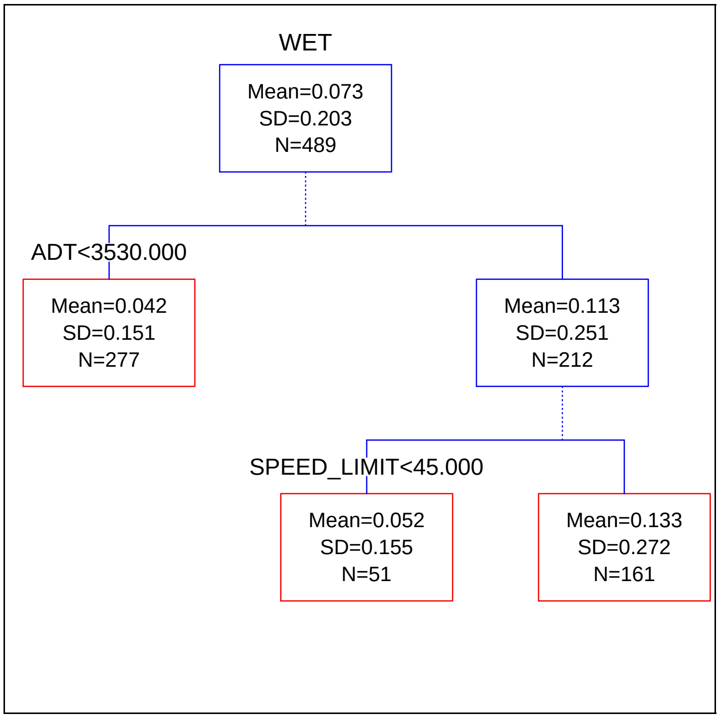


Figure A2.5. AID Tree for T Intersections with One Way Stop Sign - No Control Legs - Night Crashes

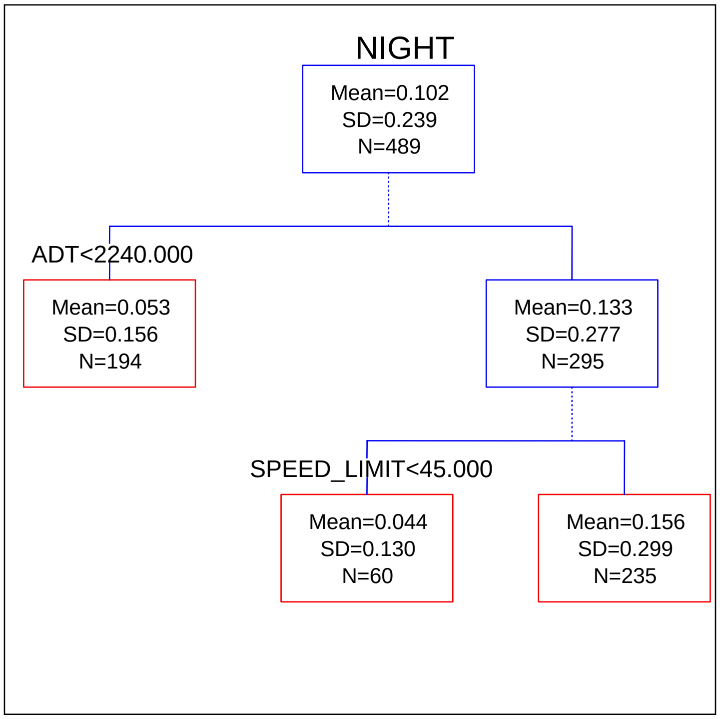


Figure A2.6. AID Tree For T Intersections With One Way Stop Sign - No Control Legs - Rear end Crashes

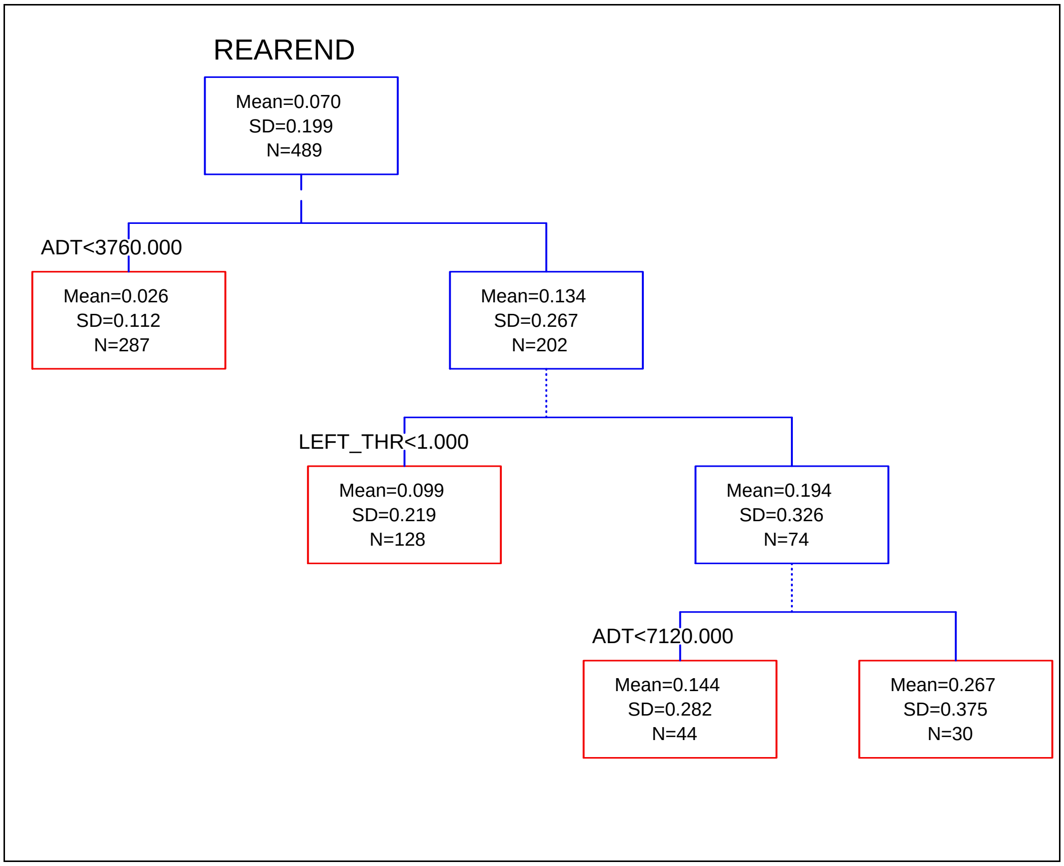


Figure A2.7. AID Tree For T Intersections With One Way Stop Sign - No Control Legs - Sideswipe Crashes

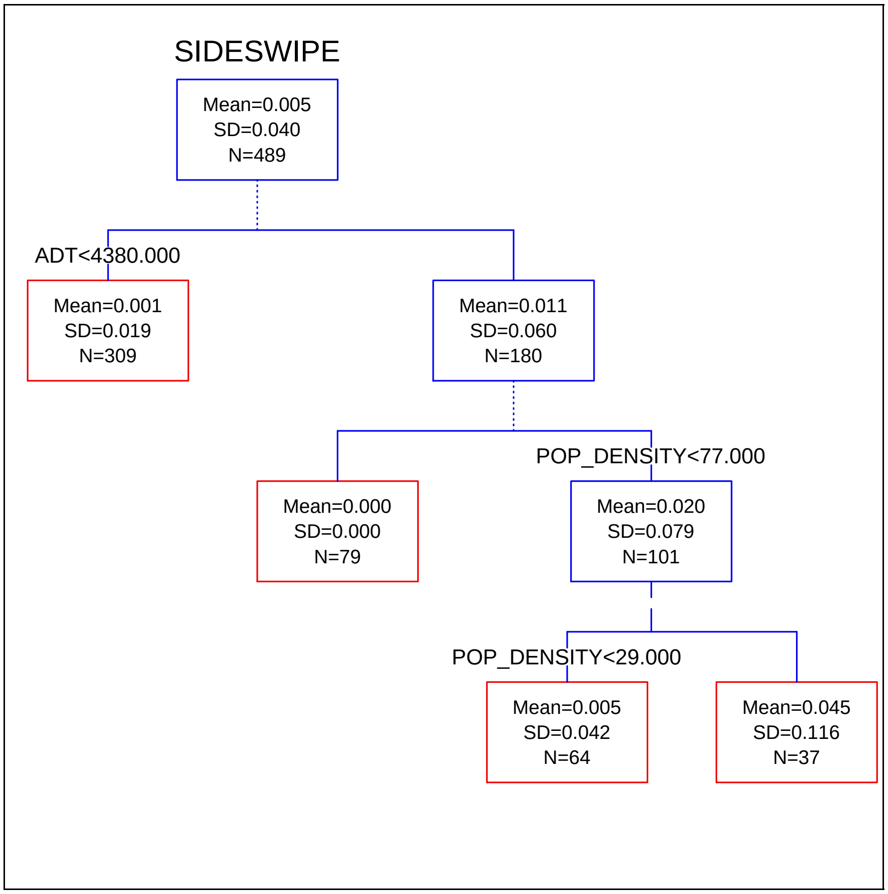


Figure A2.8. AID Tree For T Intersections With One Way Stop Sign - No Control Legs - Fixed Object Crashes

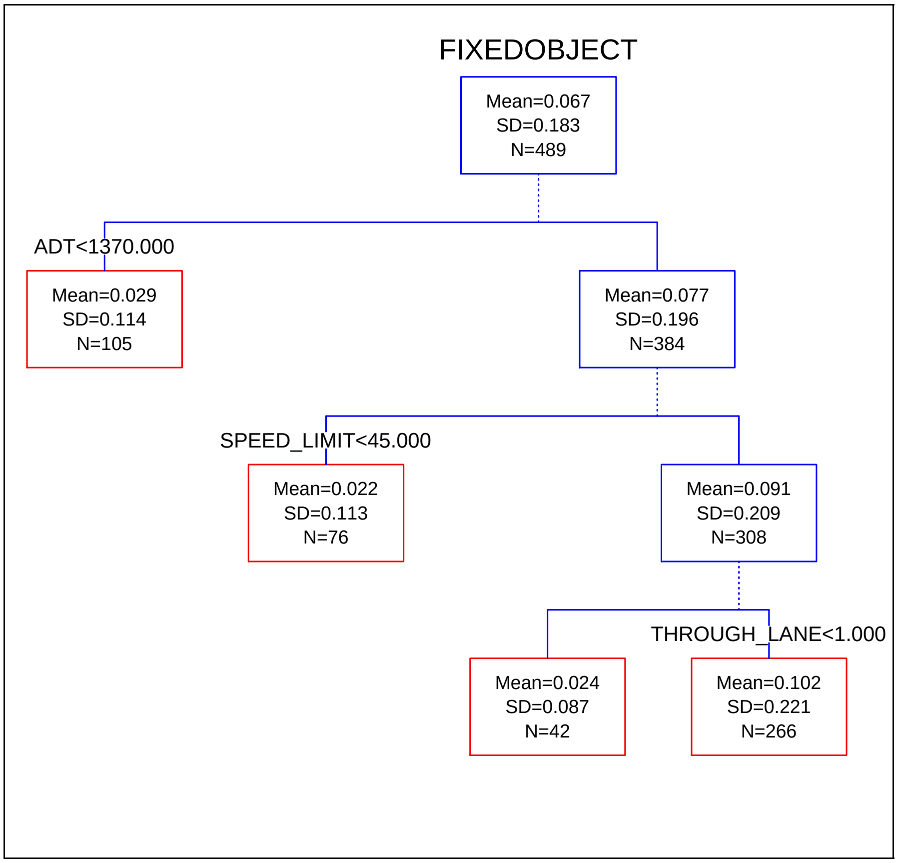


Figure A2.9. AID Tree For T Intersections With One Way Stop Sign - No Control Legs - Left Turn Crashes

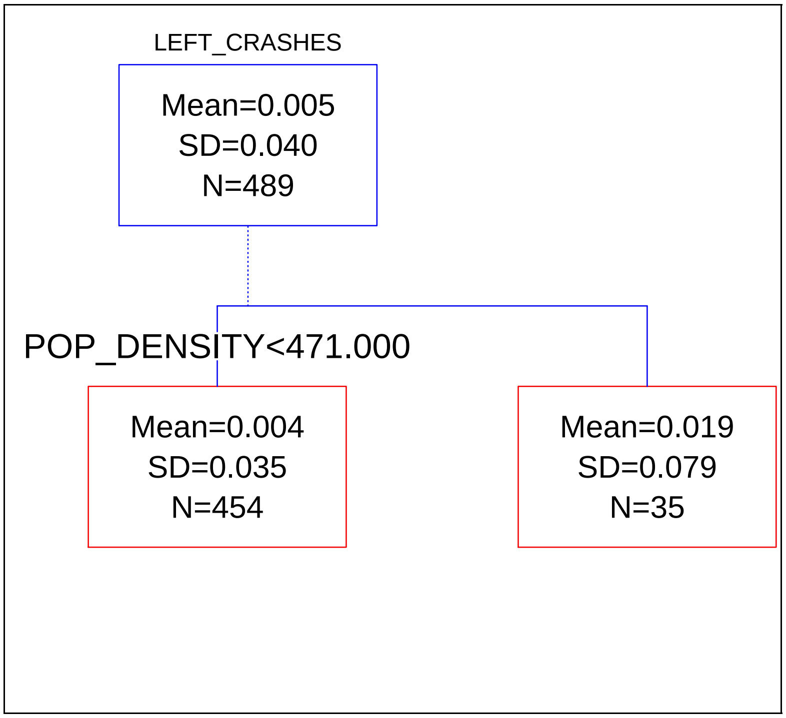


Figure A2.10. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - Injury Crashes

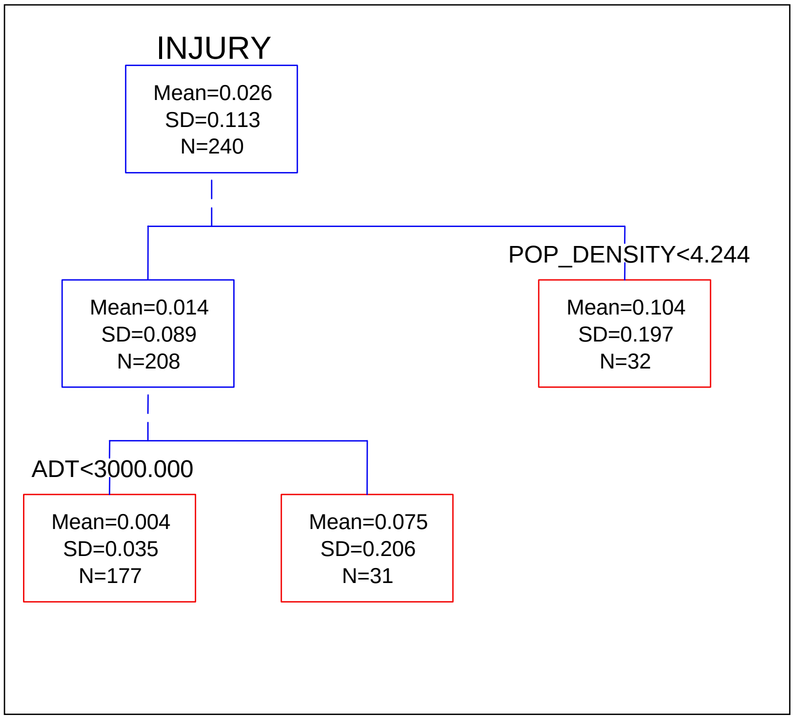


Figure A2.11. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - PDO Crashes

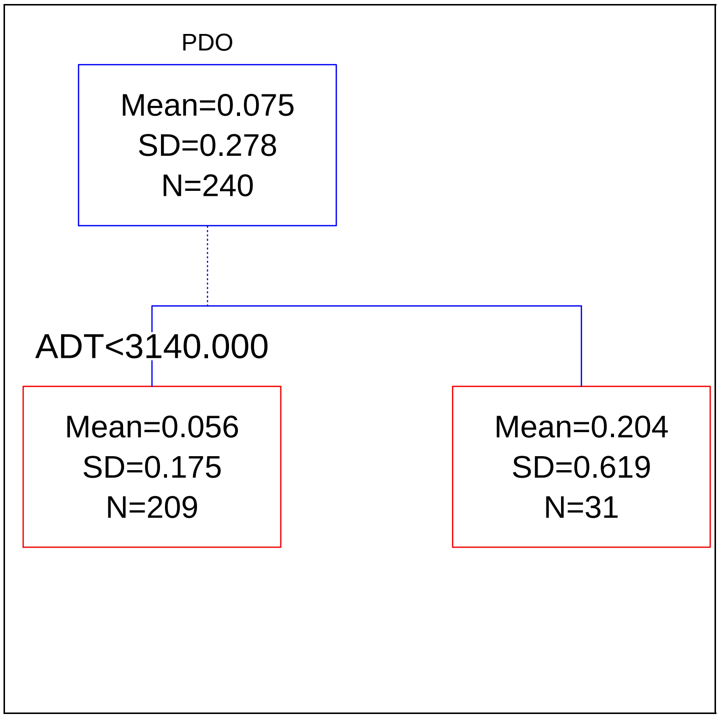


Figure A2.12. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - Total Crashes

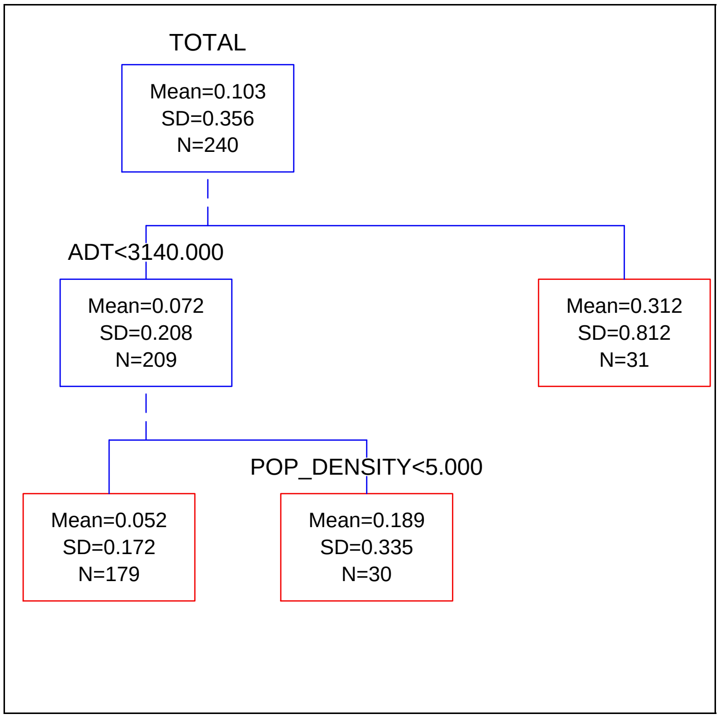


Figure A2.13. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - Wet Pavement Crashes

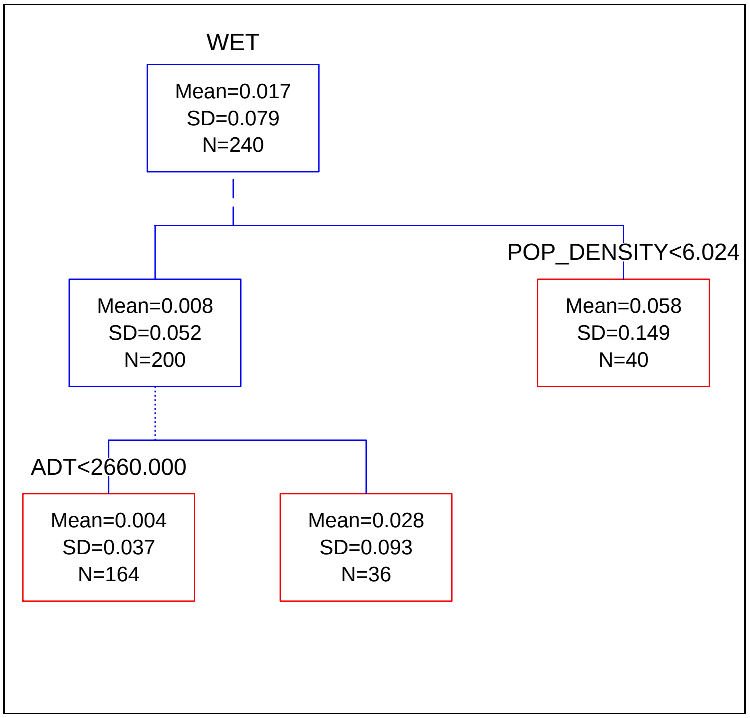


Figure A2.14. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - Night Crashes

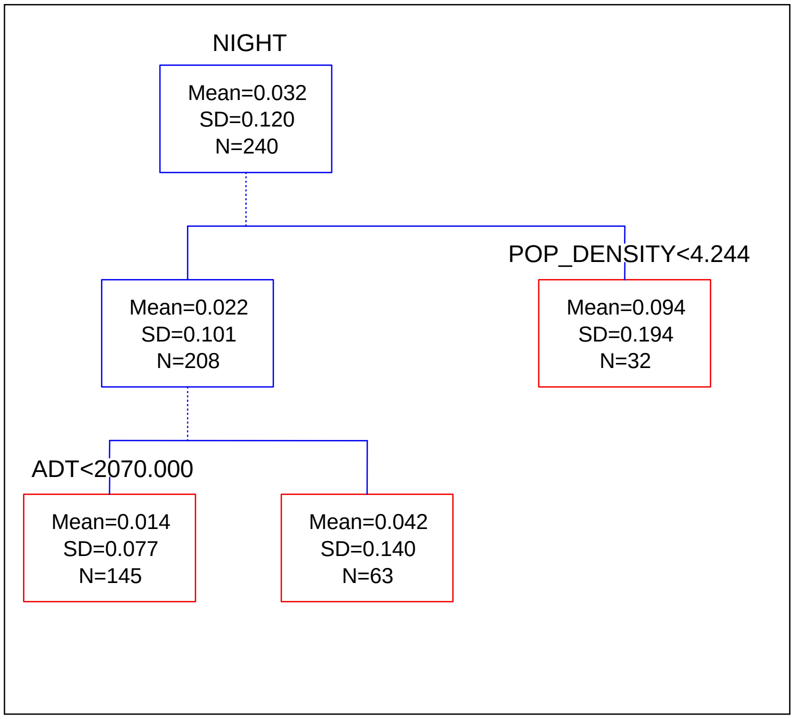


Figure A2.15. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - Rear end Crashes

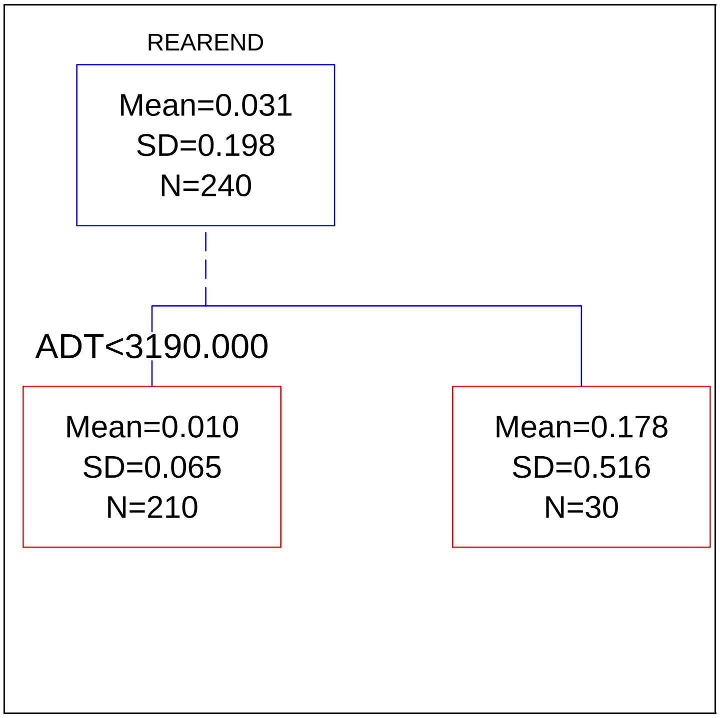


Figure A2.16. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - Sideswipe Crashes

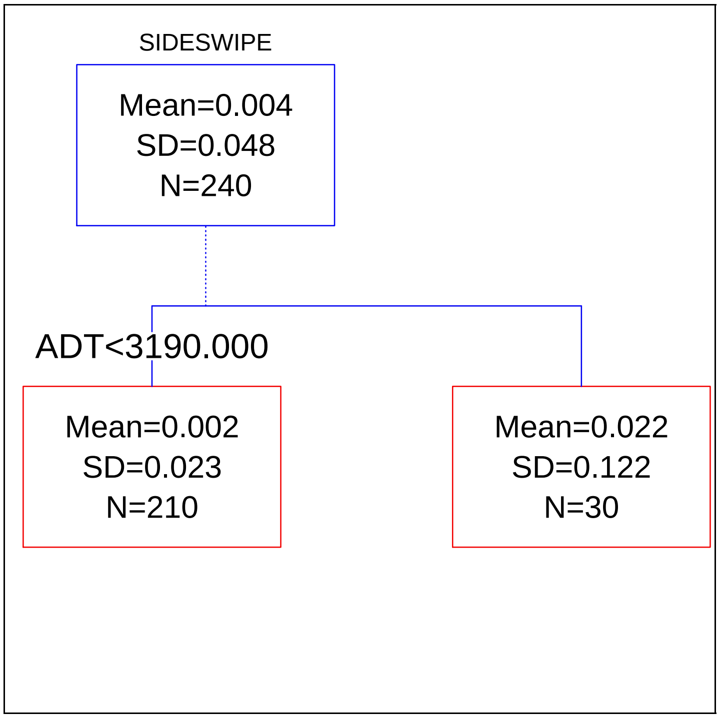


Figure A2.17. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - Fixed Object Crashes

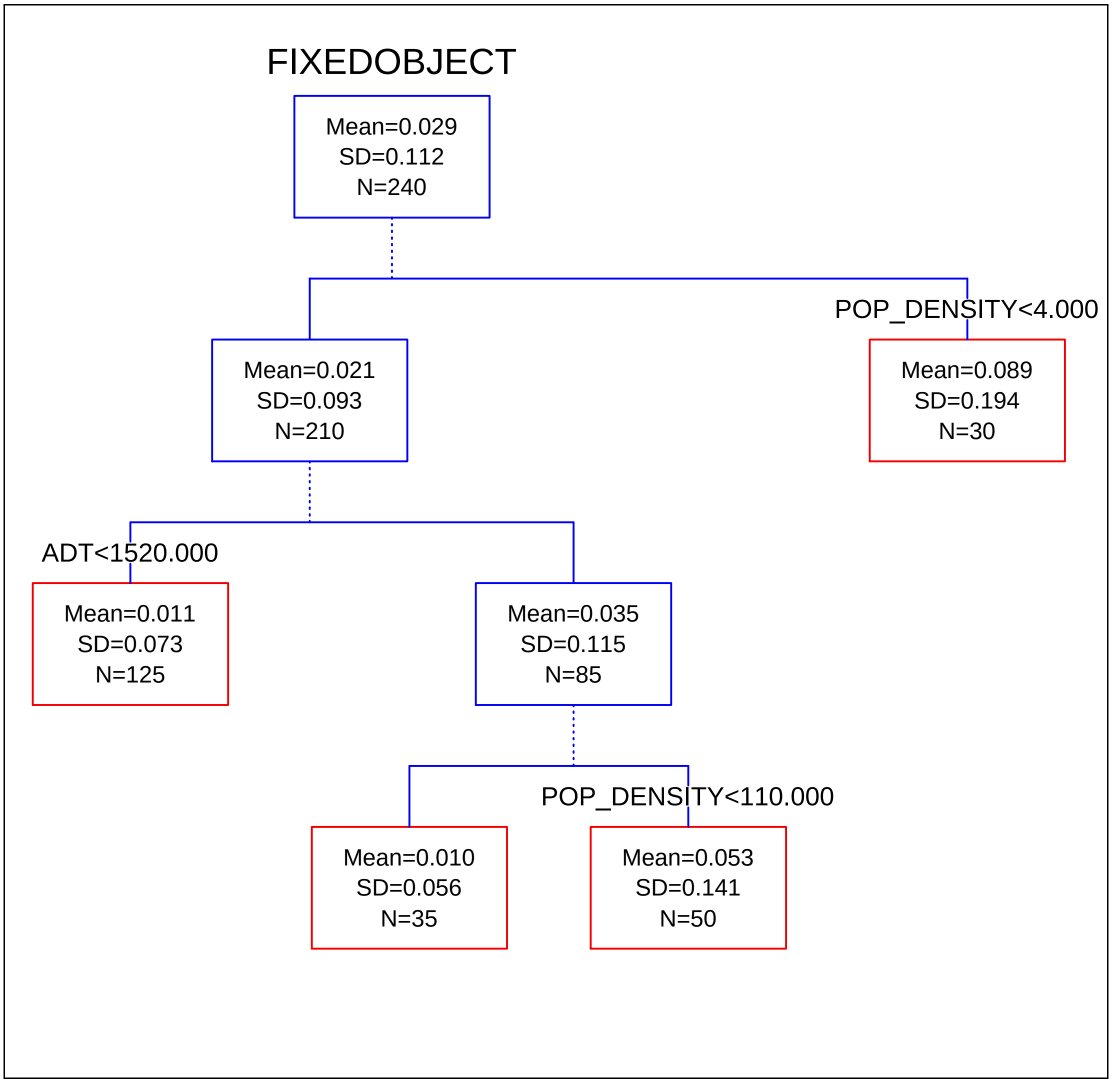


Figure A2.18. AID Tree For T Intersections With One Way Stop Sign - Stop Control Legs - Left Turn Crashes

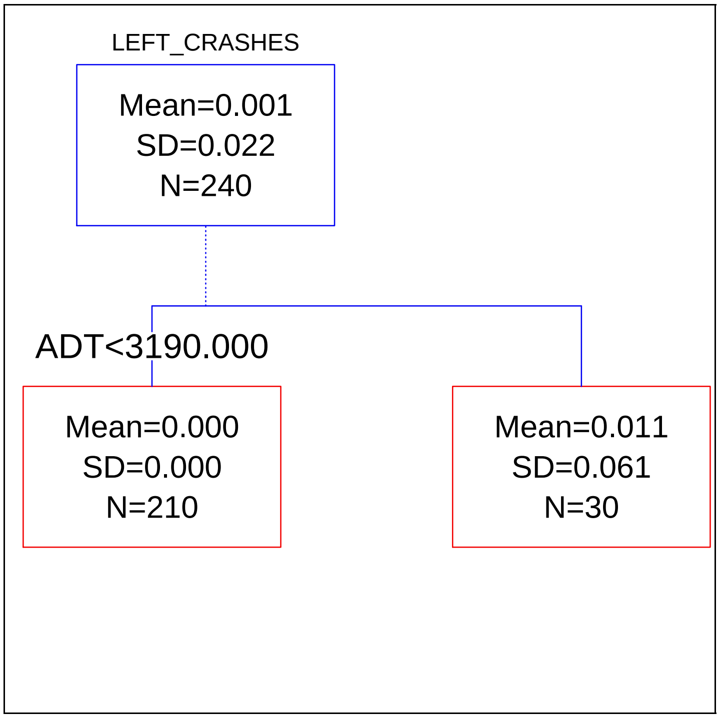


Figure A2.19. AID Tree For Two Way Stop Control Intersections- No Control Legs- Injury Crashes

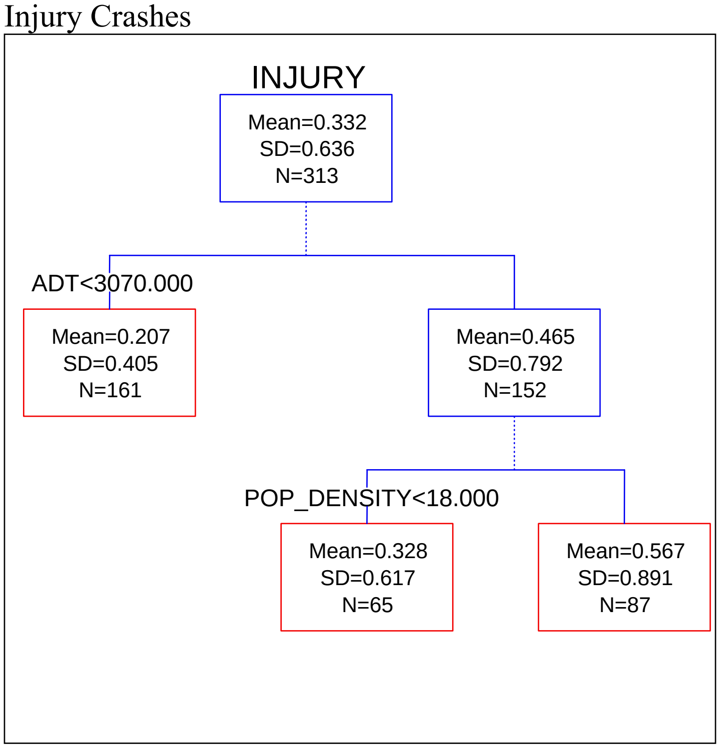


Figure A2.20. AID Tree For Two Way Stop Control Intersections- No Control Legs - PDO Crashes

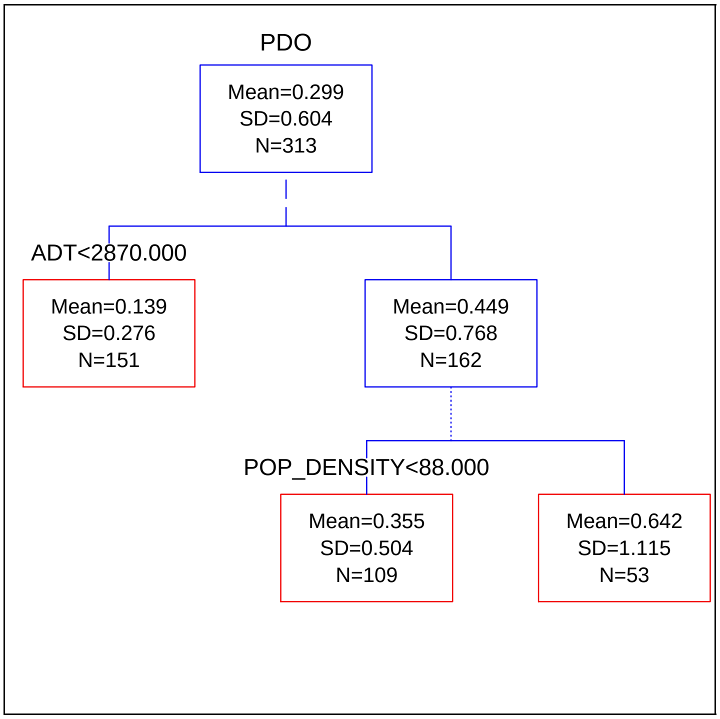


Figure A2.21. AID Tree For Two Way Stop Control Intersections- No Control Legs - Total Crashes

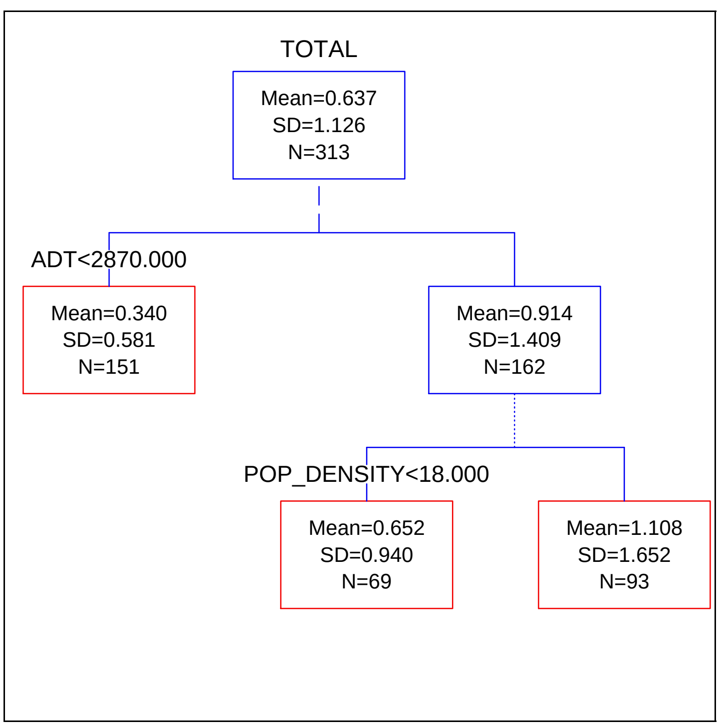


Figure A2.22. AID Tree For Two Way Stop Control Intersections- No Control Legs - Wet Pavement Crashes

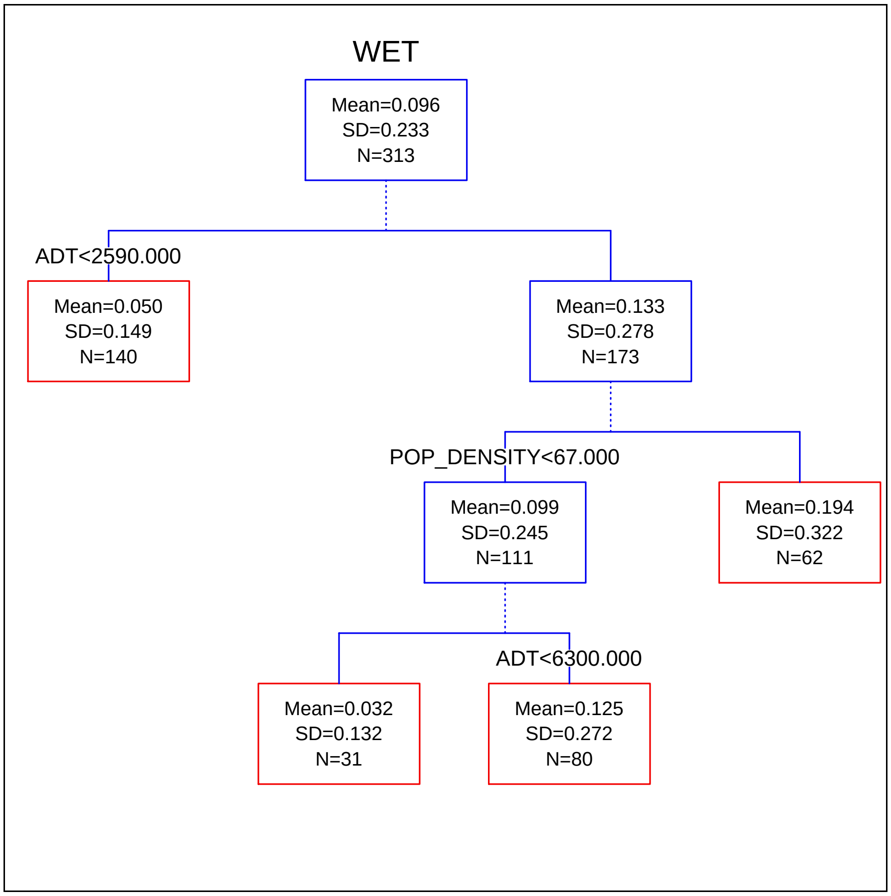


Figure A2.23. AID Tree For Two Way Stop Control Intersections- No Control Legs - Night Crashes

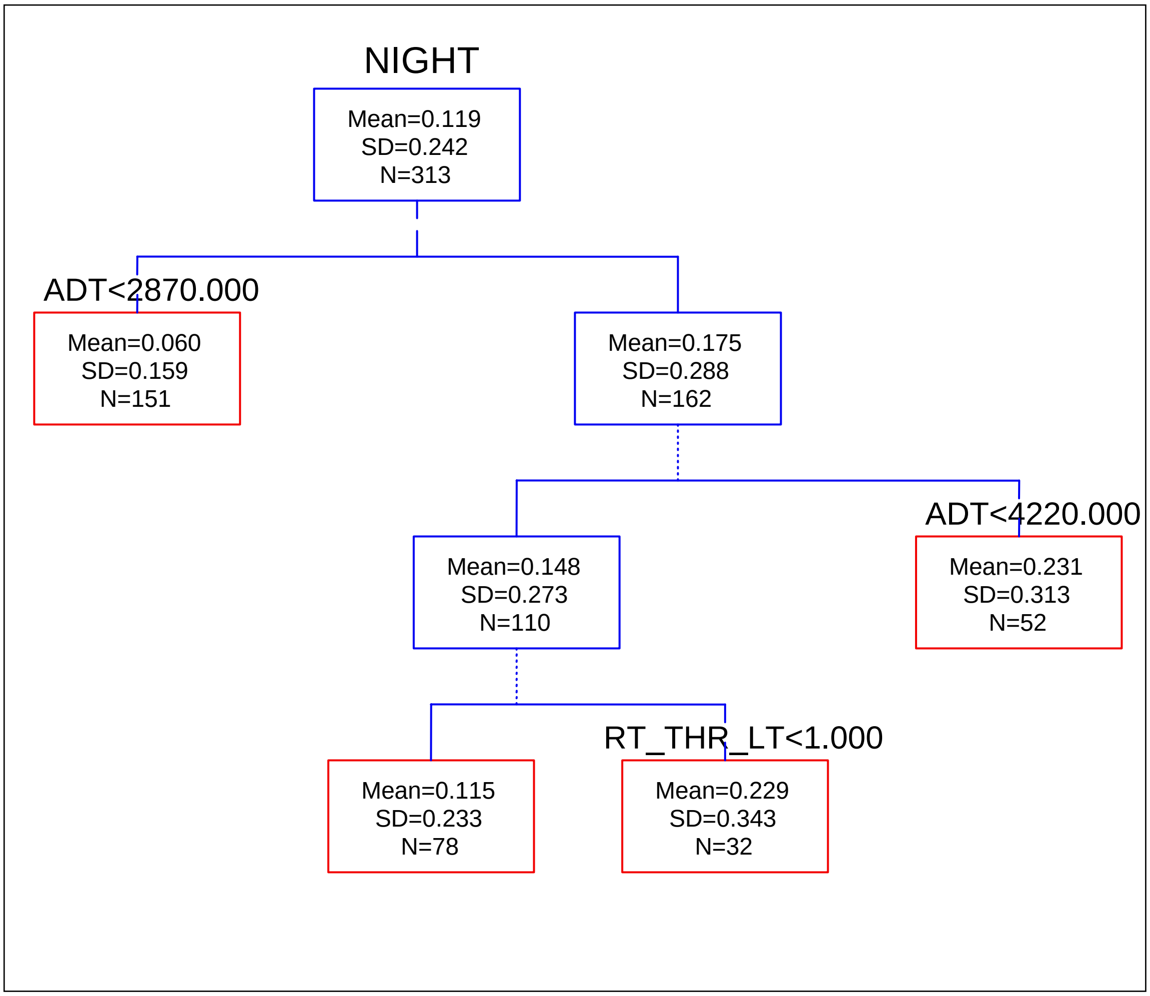


Figure A2.24. AID Tree For Two Way Stop Control Intersections- No Control Legs - Rear end Crashes

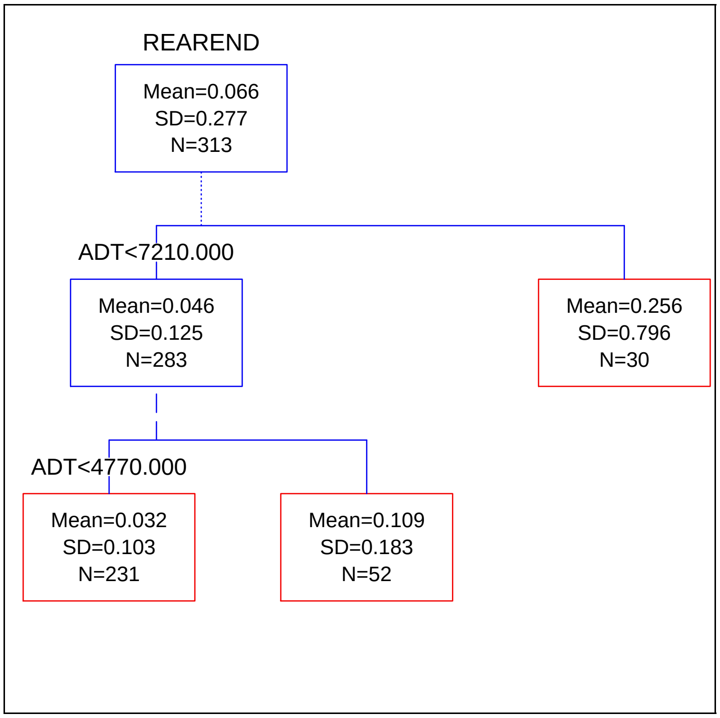


Figure A2.25. AID Tree For Two Way Stop Control Intersections- No Control Legs - Sideswipe Crashes

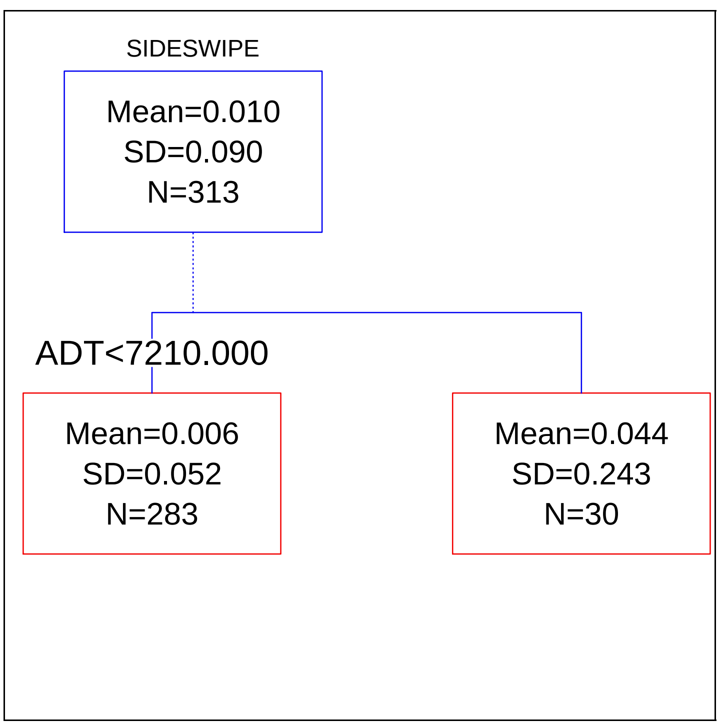


Figure A2.26. AID Tree For Two Way Stop Control Intersections- No Control Legs - Fixed Object Crashes

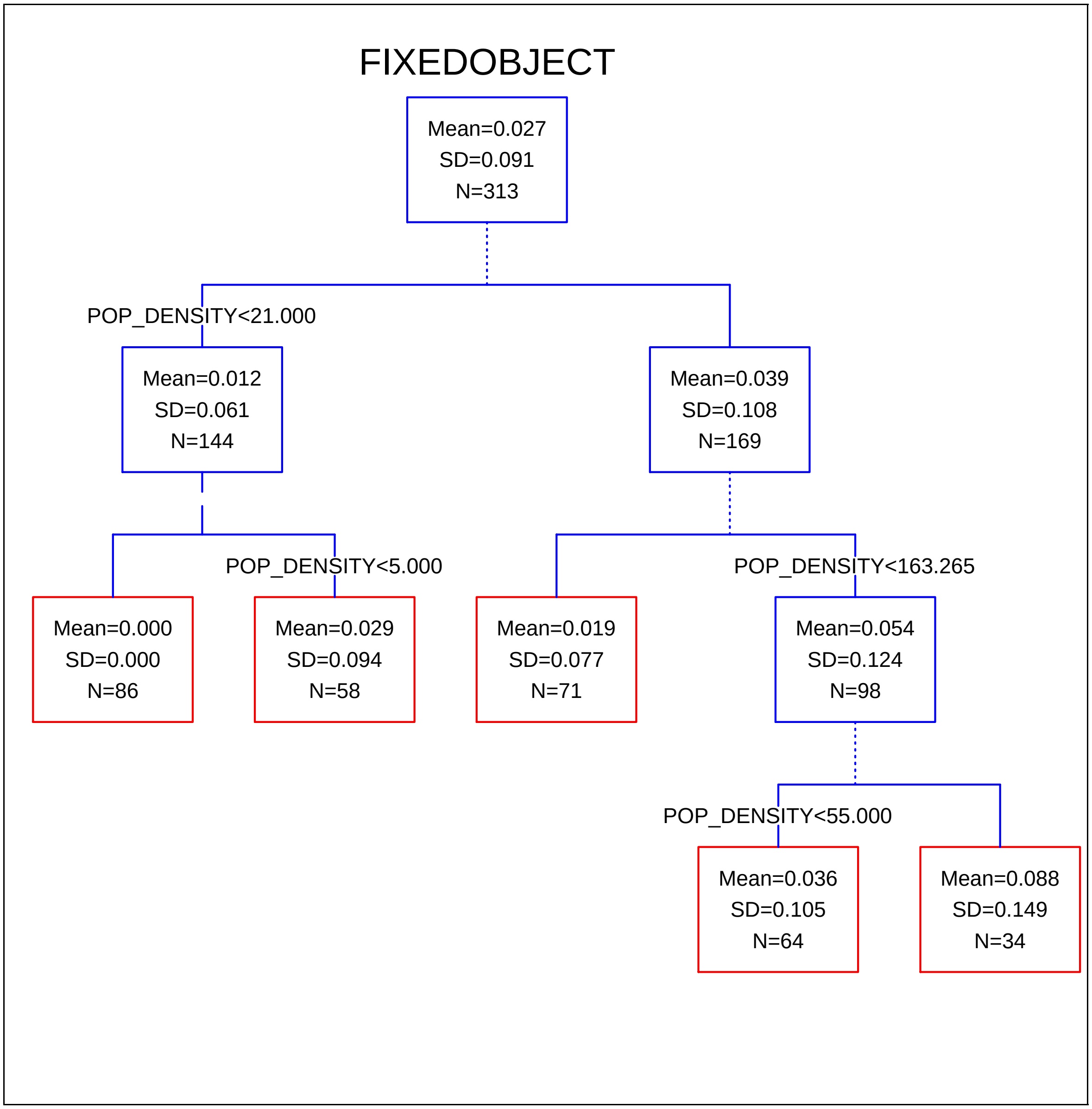


Figure A2.27. AID Tree For Two Way Stop Control Intersections- No Control Legs - Left Turn Crashes

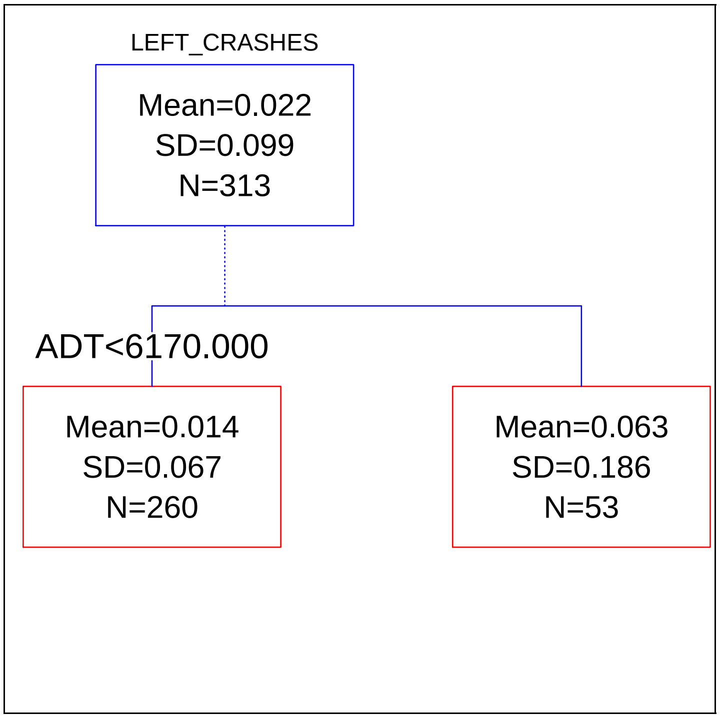


Figure A2.28.AID Tree For Two Way Stop Control Intersections- Stop Control Legs - Injury Crashes

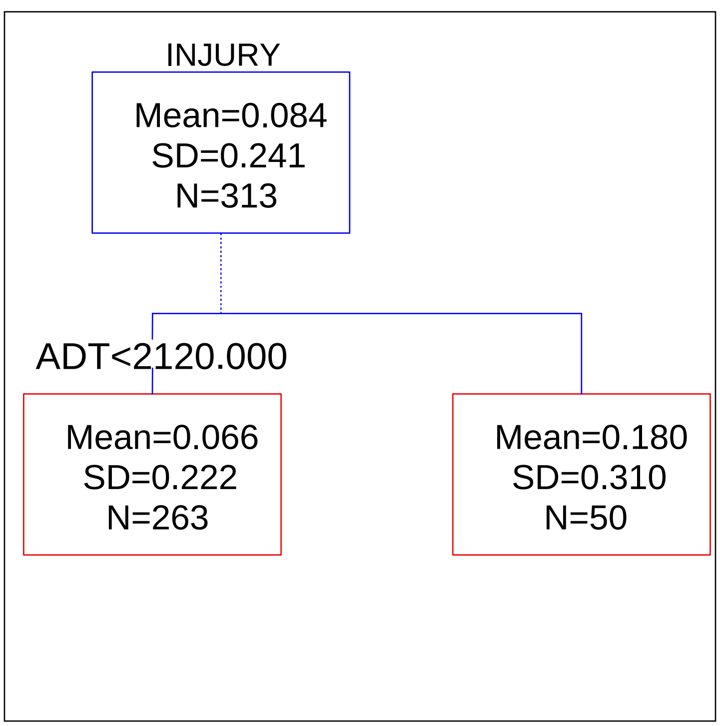


Figure A2.29. AID Tree For Two Way Stop Control Intersections- Stop Control Legs - PDO Crashes

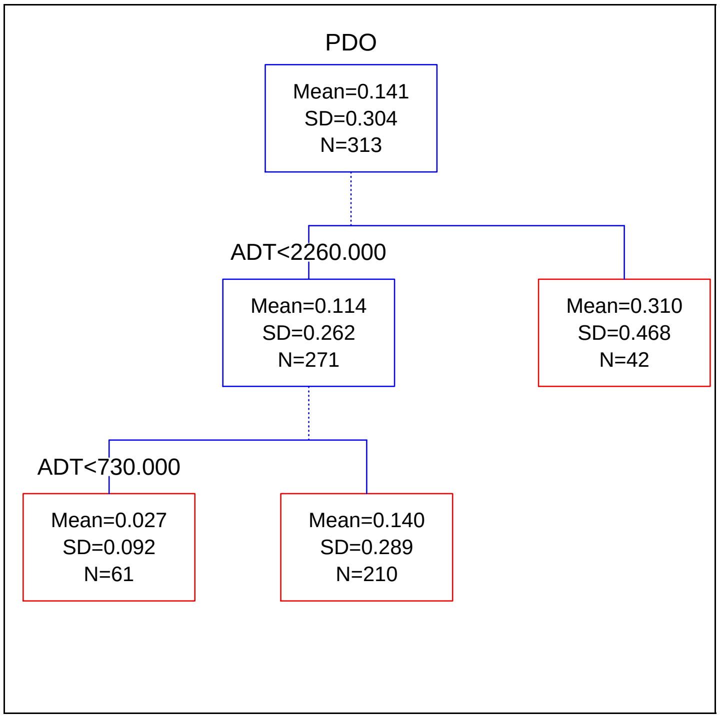


Figure A2.30. AID Tree For Two Way Stop Control Intersections- Stop Control Legs - Total Crashes

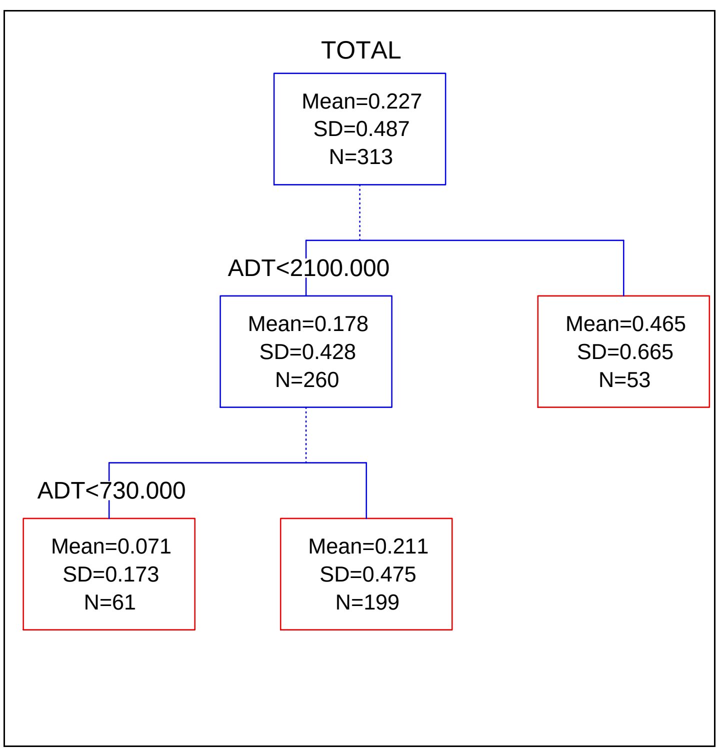


Figure A2.31. AID Tree For Two Way Stop Control Intersections- Stop Control Legs - Wet Pavement Crashes

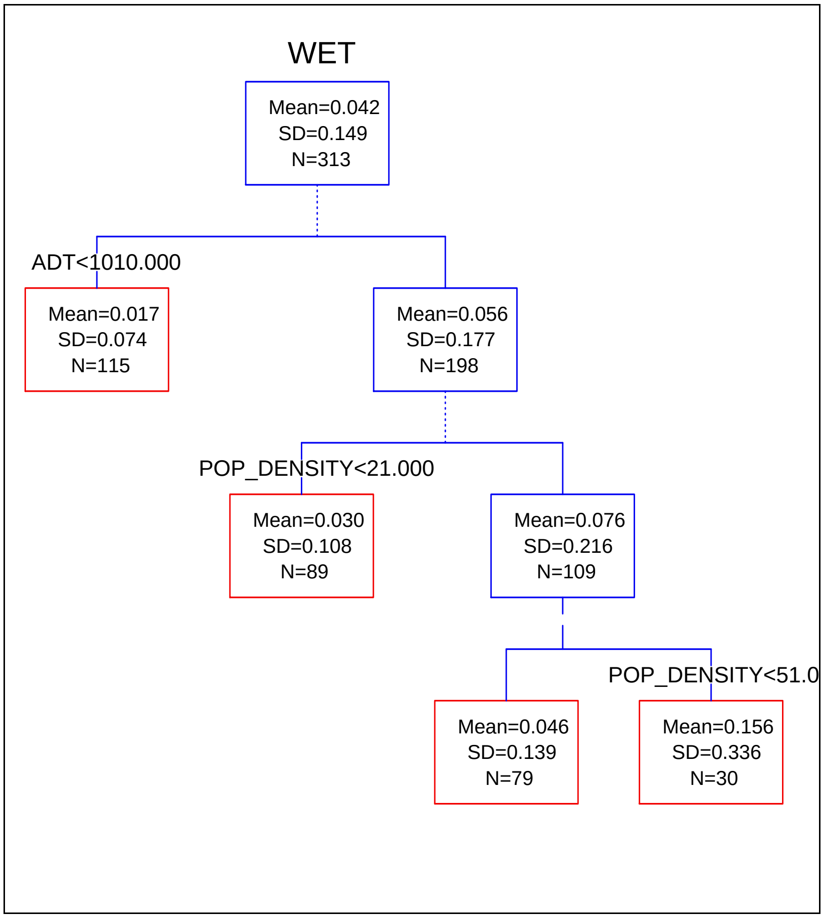


Figure A2.32. AID Tree For Two Way Stop Control Intersections- Stop Control Legs - Night Crashes

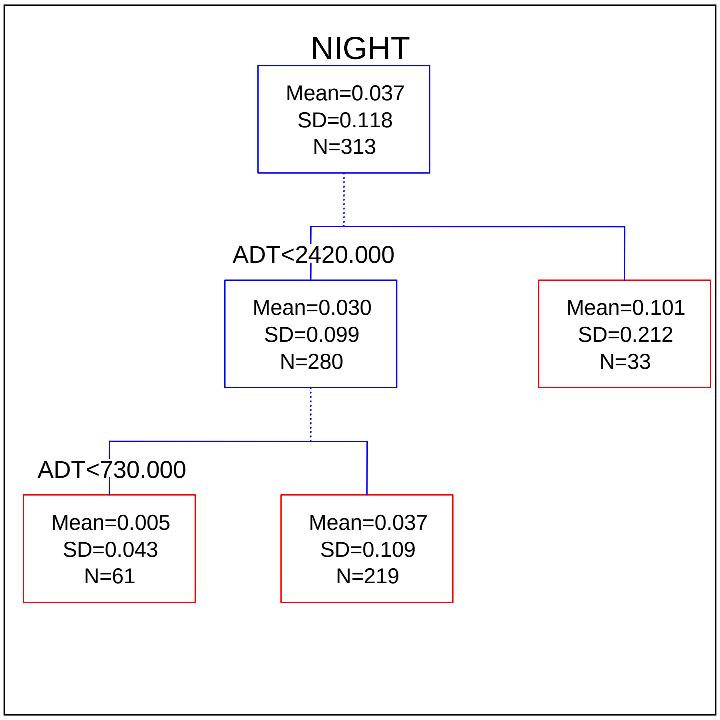


Figure A2.33. AID Tree For Two Way Stop Control Intersections- Stop Control Legs - Rear end Crashes

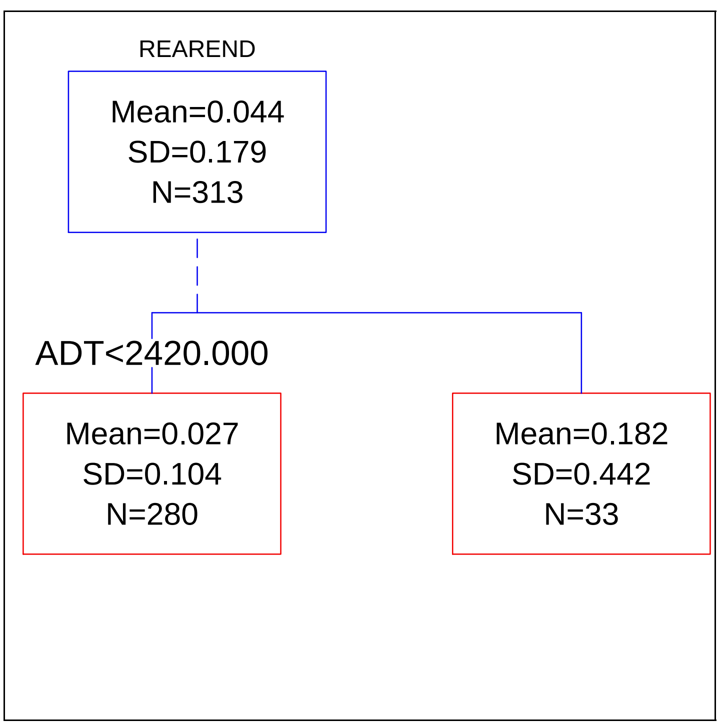


Figure A2.34. AID Tree For Two Way Stop Control Intersections- Stop Control Legs - Fixed Object Crashes

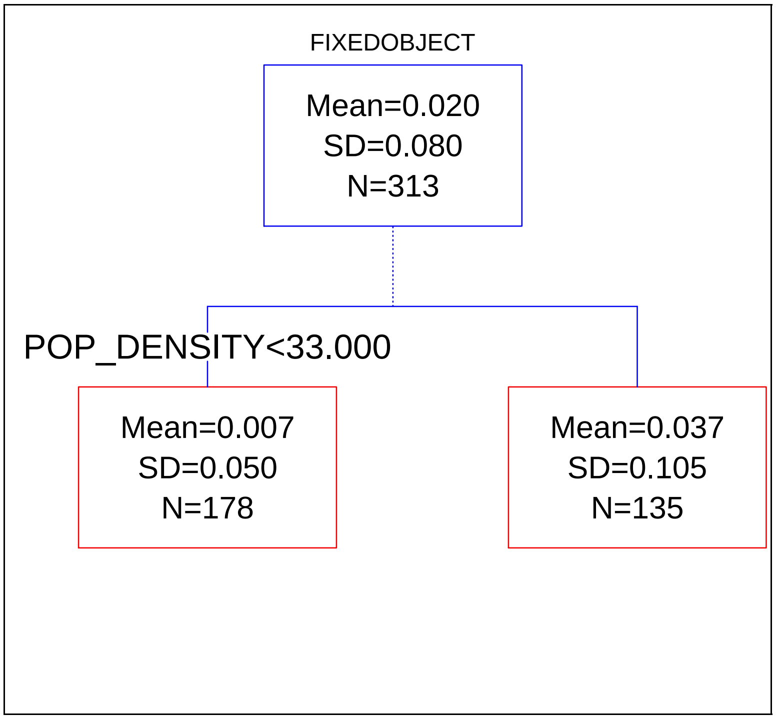


Figure A2.35. AID Tree For Flashing Beacon Control Intersections- No Control Legs- Injury Crashes

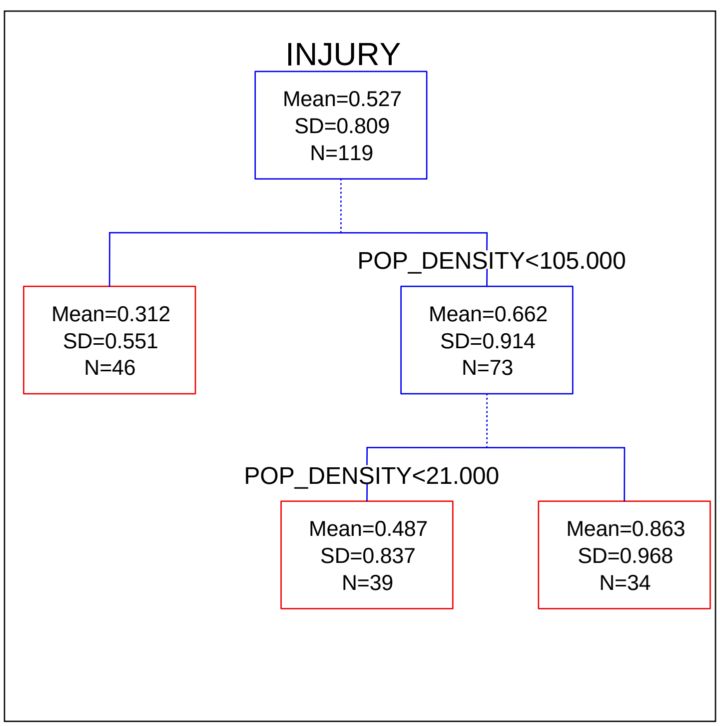


Figure A2.36. AID Tree For Flashing Beacon Control Intersections- No Control Legs - PDO Crashes

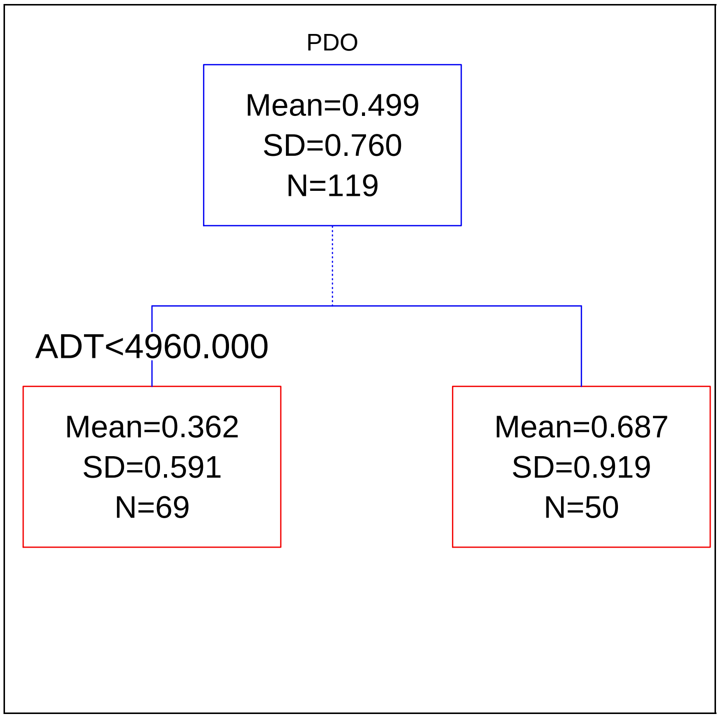


Figure A2.37. AID Tree For Flashing Beacon Control Intersections- No Control Legs - Total Crashes

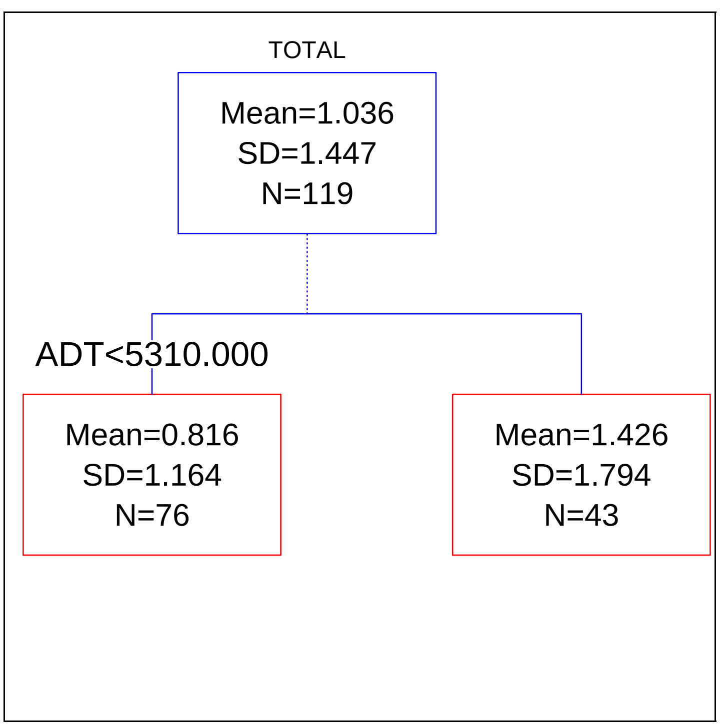


Figure A2.38. AID Tree For Flashing Beacon Control Intersections- No Control Legs - Wet Pavement Crashes

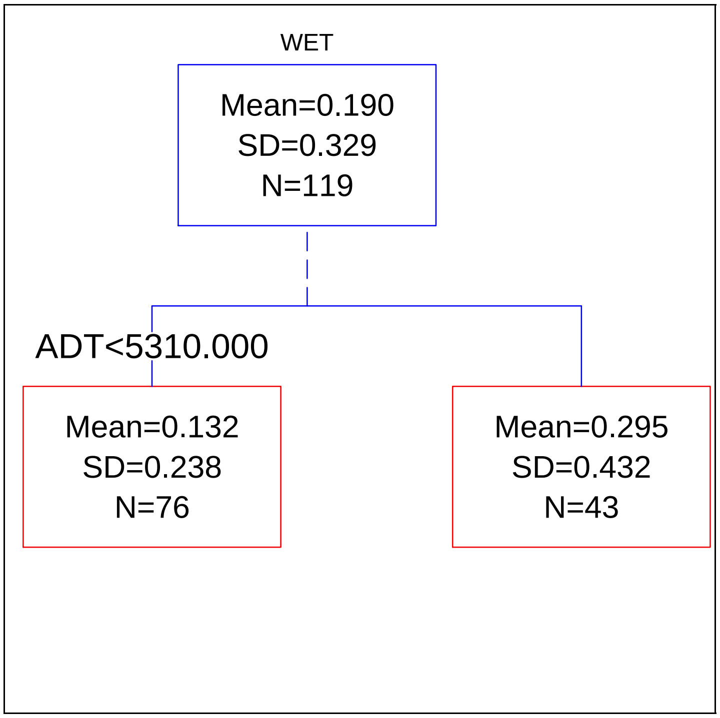


Figure A2.39. AID Tree For Flashing Beacon Control Intersections- No Control Legs - Night Crashes

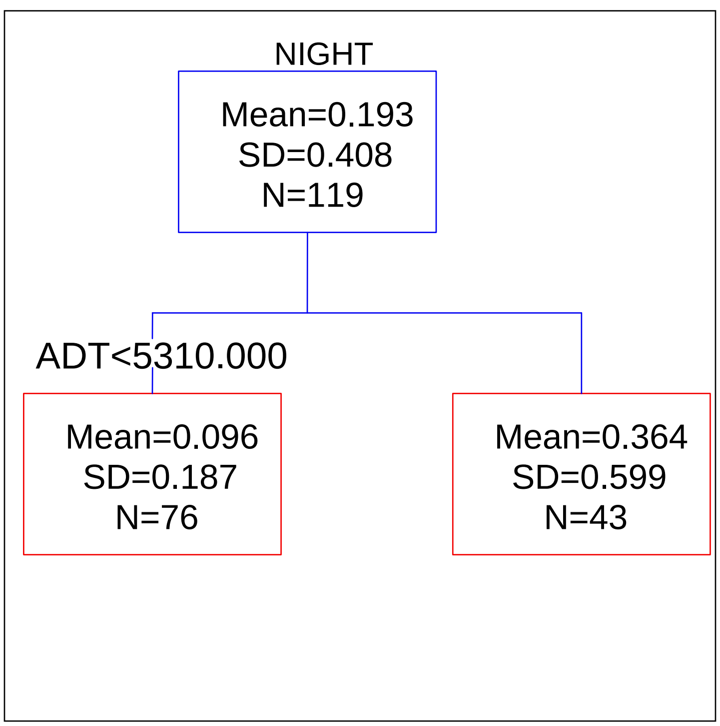


Figure A2.40. AID Tree For Flashing Beacon Control Intersections- No Control Legs - Rear end Crashes

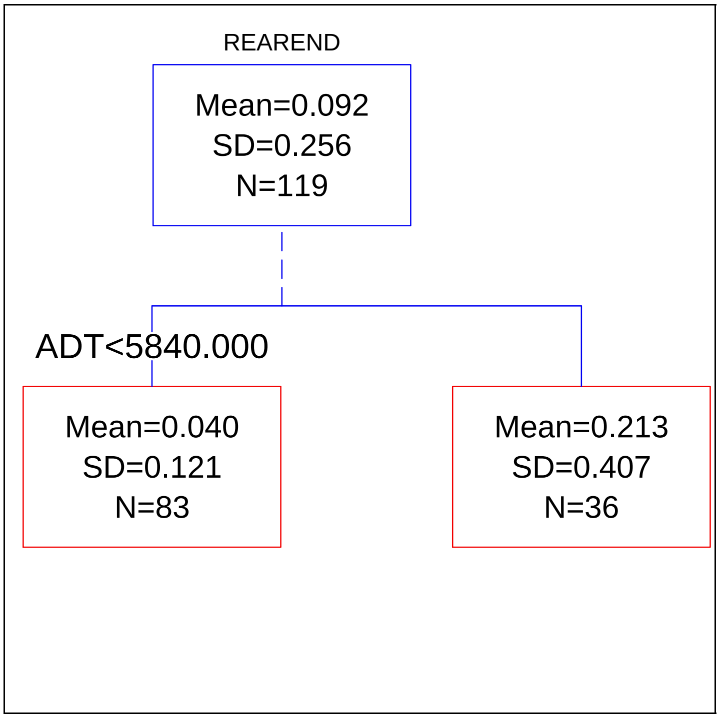


Figure A2.41. AID Tree For Flashing Beacon Control Intersections- No Control Legs - Sideswipe Crashes

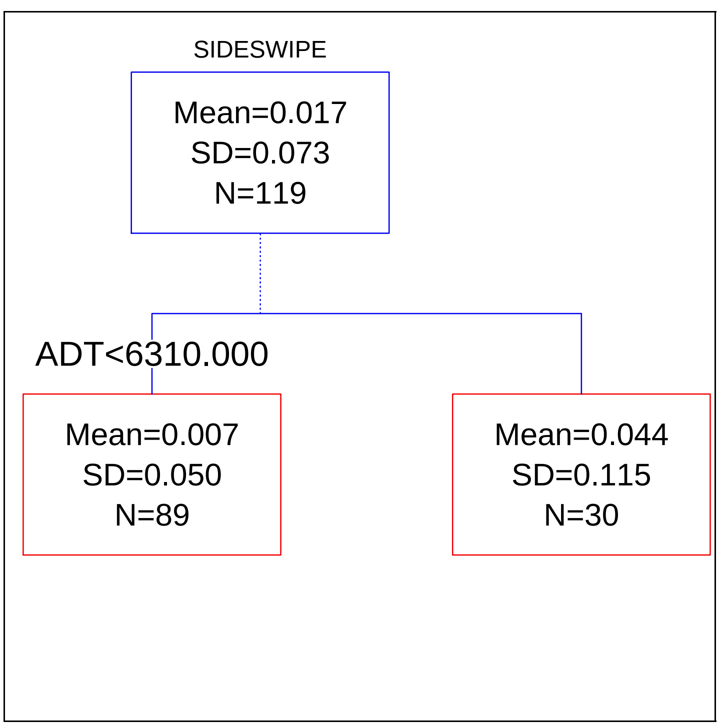


Figure A2.42. AID Tree For Flashing Beacon Control Intersections- No Control Legs - Fixed Object Crashes

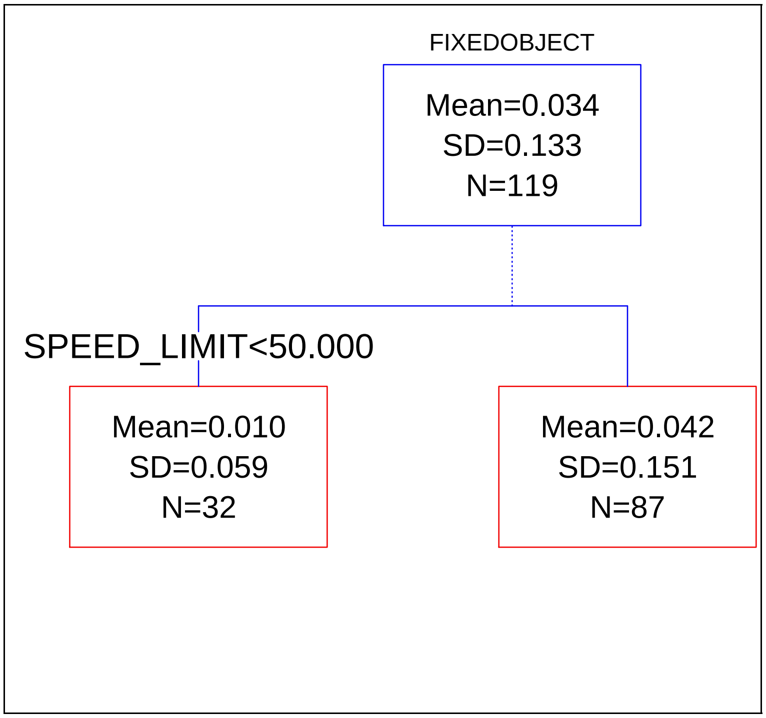


Figure A2.43. AID Tree For Flashing Beacon Control Intersections- No Control Legs - Left Turn Crashes

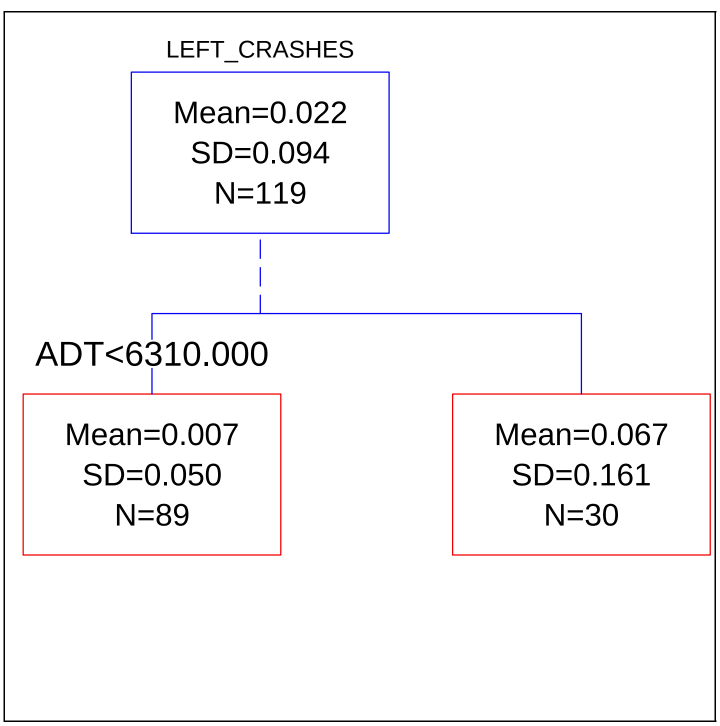


Figure A2.44. AID Tree For Flashing Beacon Control Intersections- Stop Control Legs - Injury Crashes

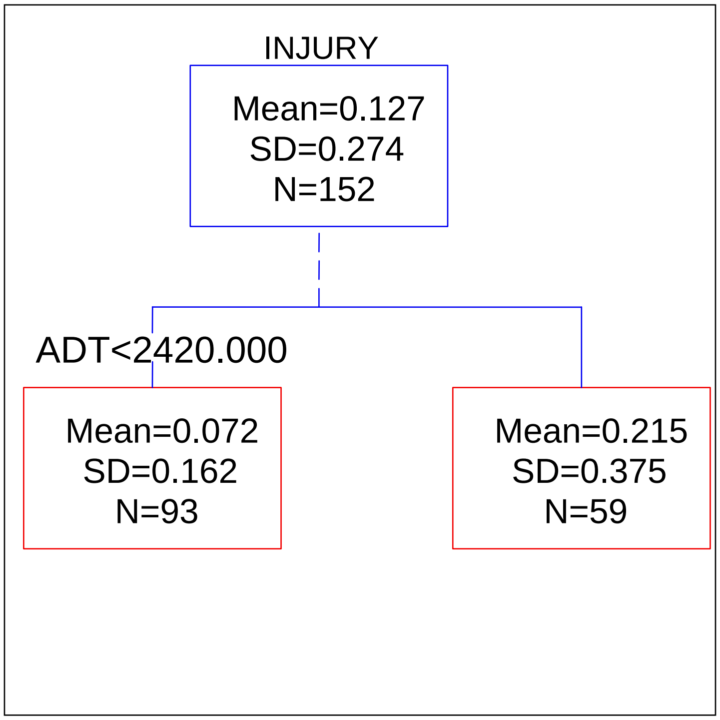


Figure A2.45. AID Tree For Flashing Beacon Control Intersections- Stop Control Legs - PDO Crashes

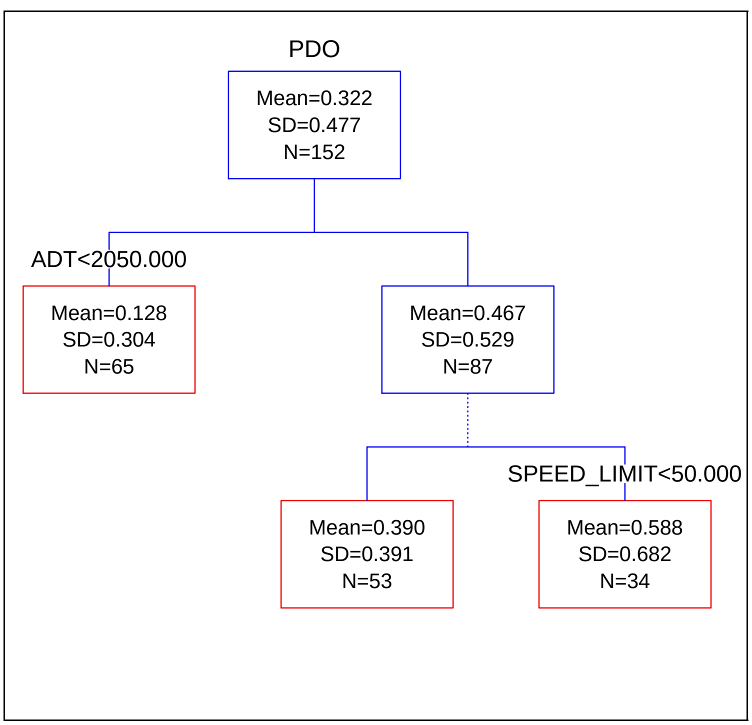


Figure A2.46. AID Tree For Flashing Beacon Control Intersections- Stop Control Legs - Total Crashes

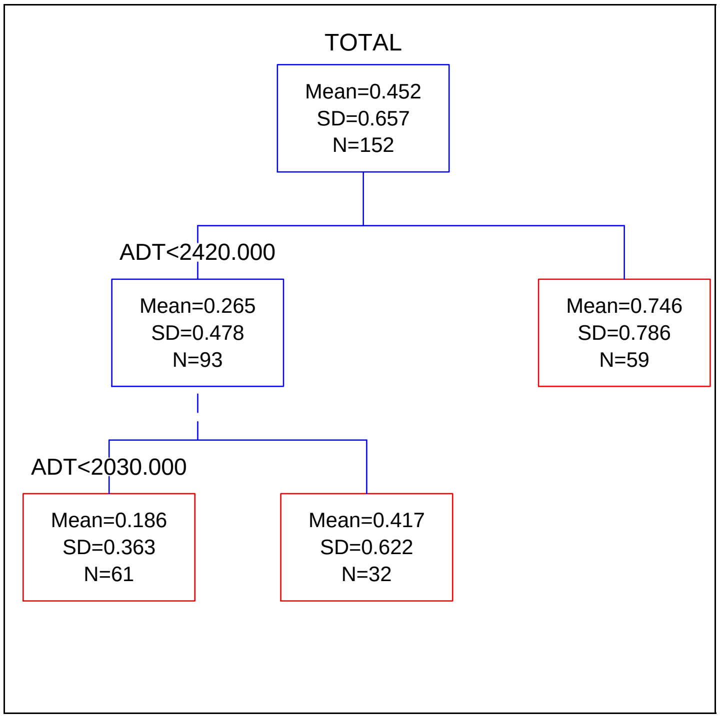


Figure A2.47. AID Tree For Flashing Beacon Control Intersections- Stop Control Legs - Wet Pavement Crashes

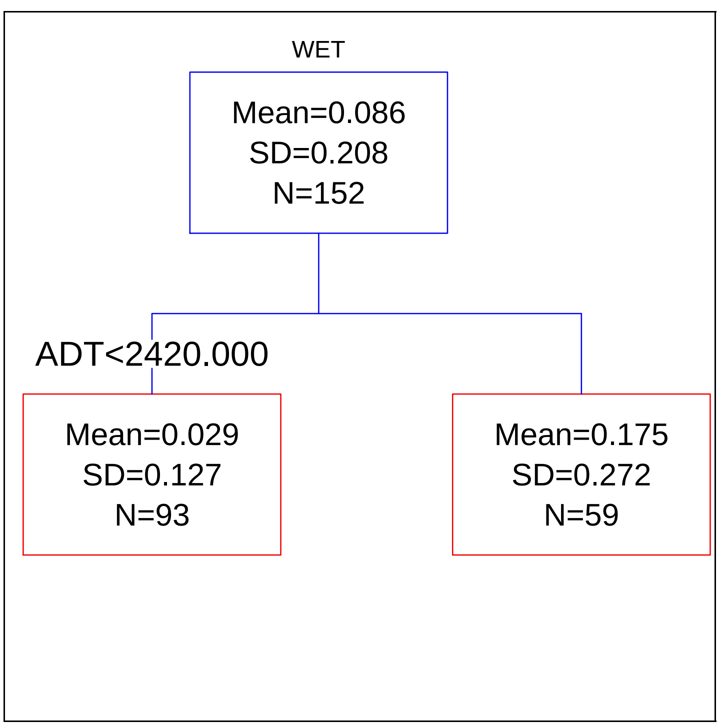


Figure A2.48. AID Tree For Flashing Beacon Control Intersections- Stop Control Legs - Night Crashes

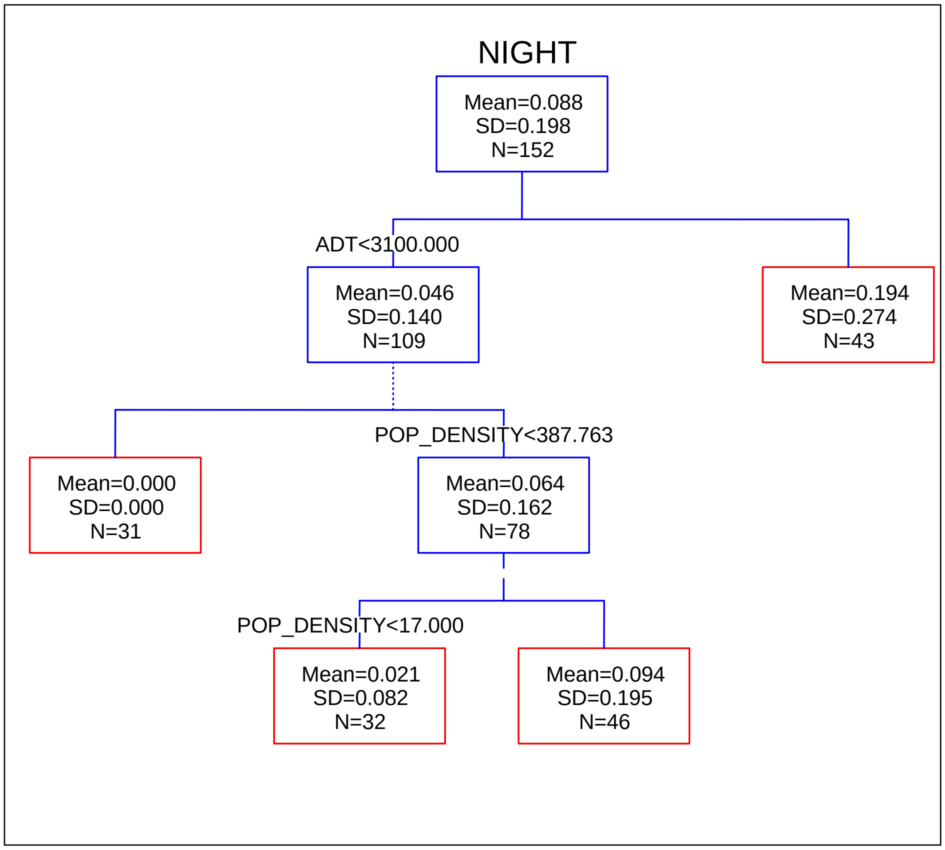


Figure A2.49. AID Tree For Flashing Beacon Control Intersections- Stop Control Legs - Rear end Crashes

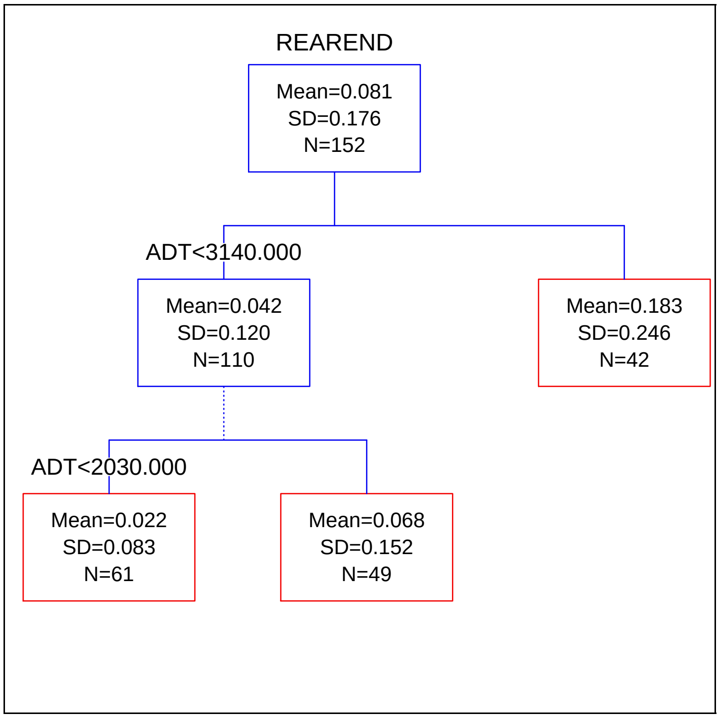


Figure A2.50. AID Tree For Flashing Beacon Control Intersections- Stop Control Legs - Sideswipe Crashes

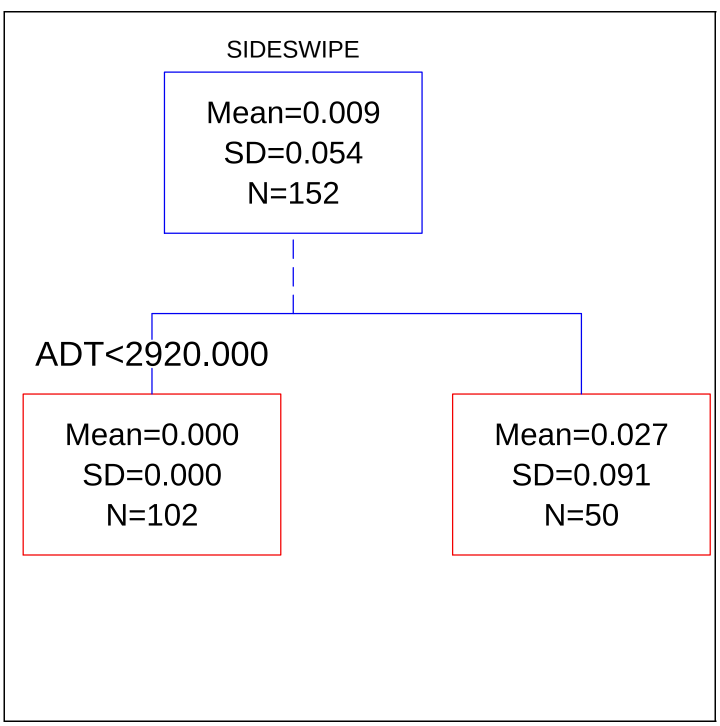


Figure A2.51. AID Tree For Flashing Beacon Control Intersections- Stop Control Legs - Fixed Object Crashes

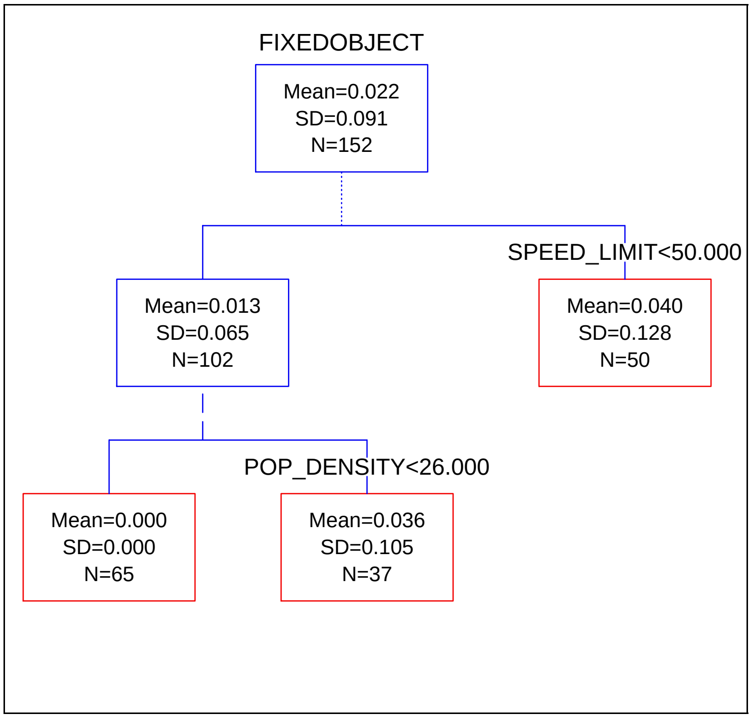


Figure A2.52. AID Tree For Signalized Intersection Legs - Injury Crashes

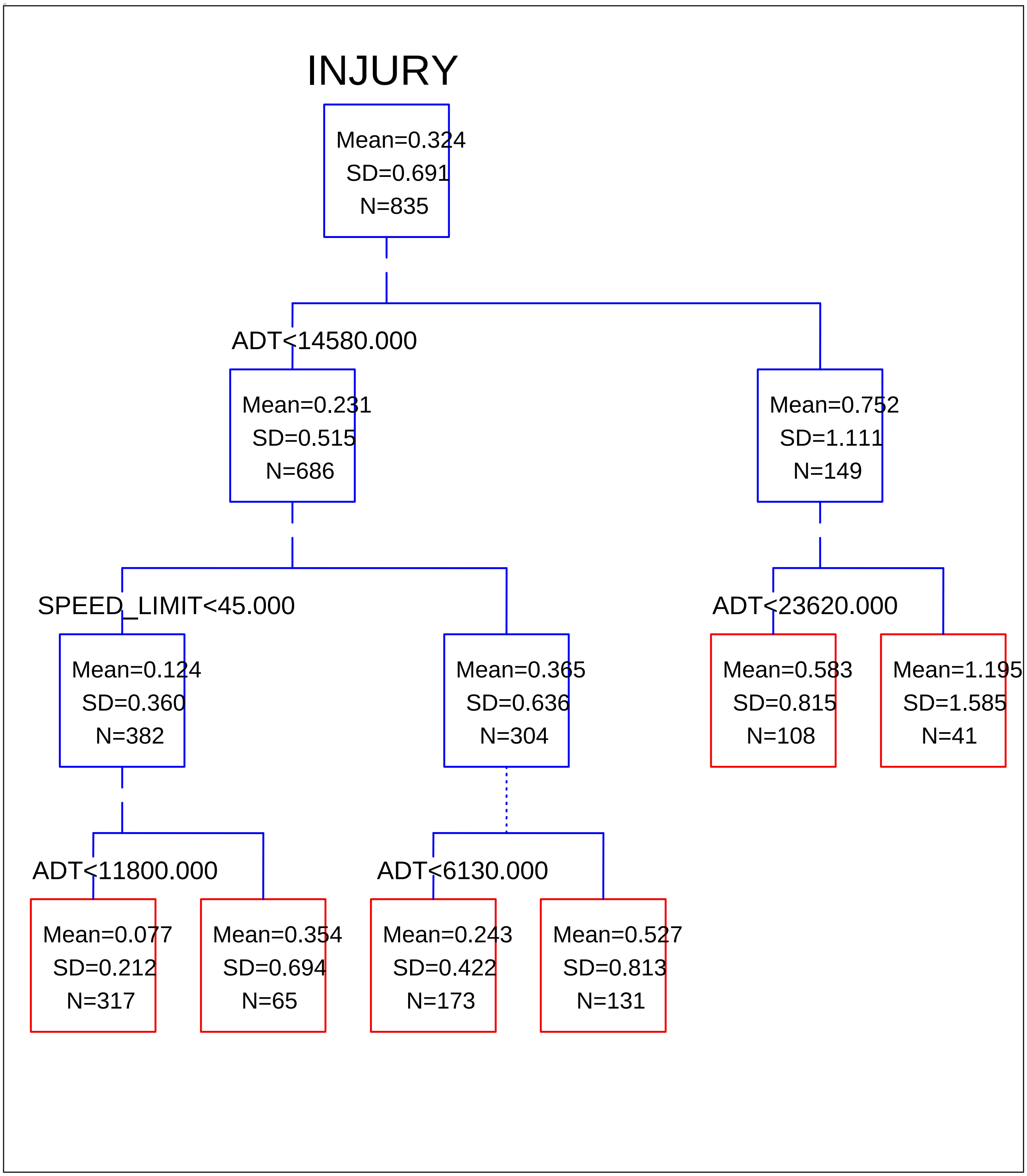


Figure A2.53. AID Tree For Signalized Intersection Legs - PDO Crashes

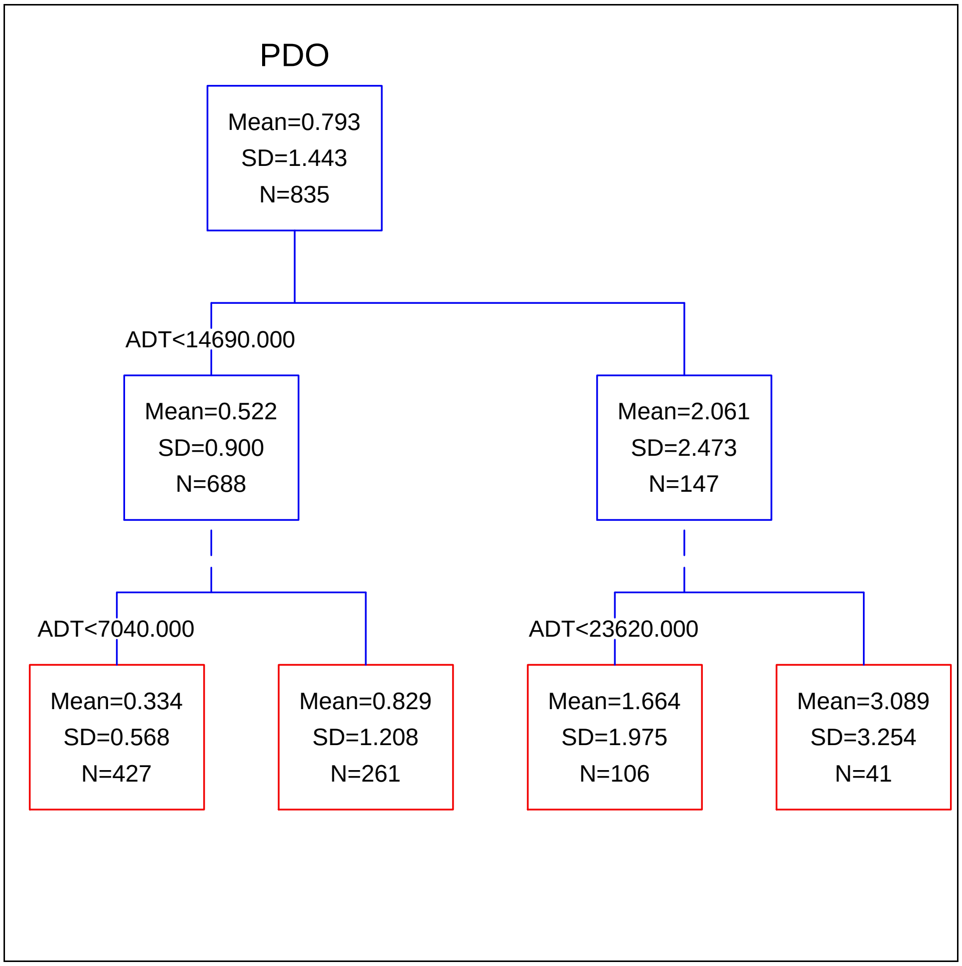


Figure A2.54. AID Tree For Signalized Intersection Legs- Total Crashes

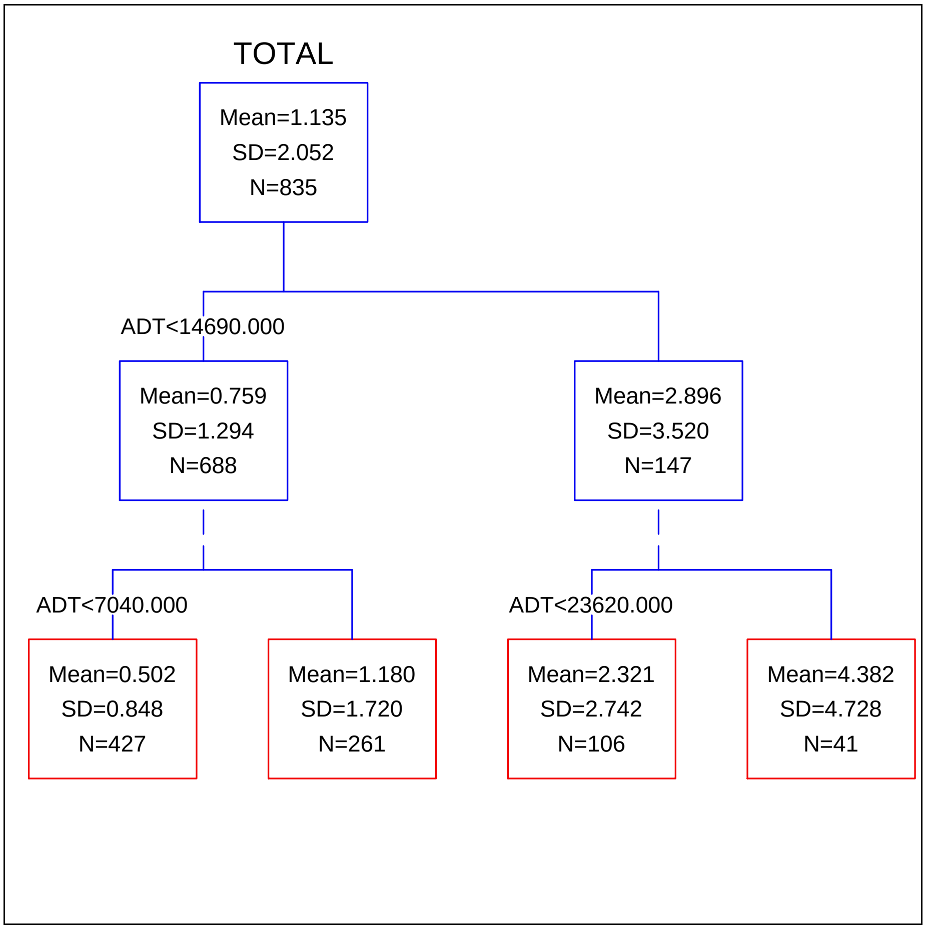


Figure A2.55. AID Tree For Signalized Intersection Legs - Wet Pavement Crashes

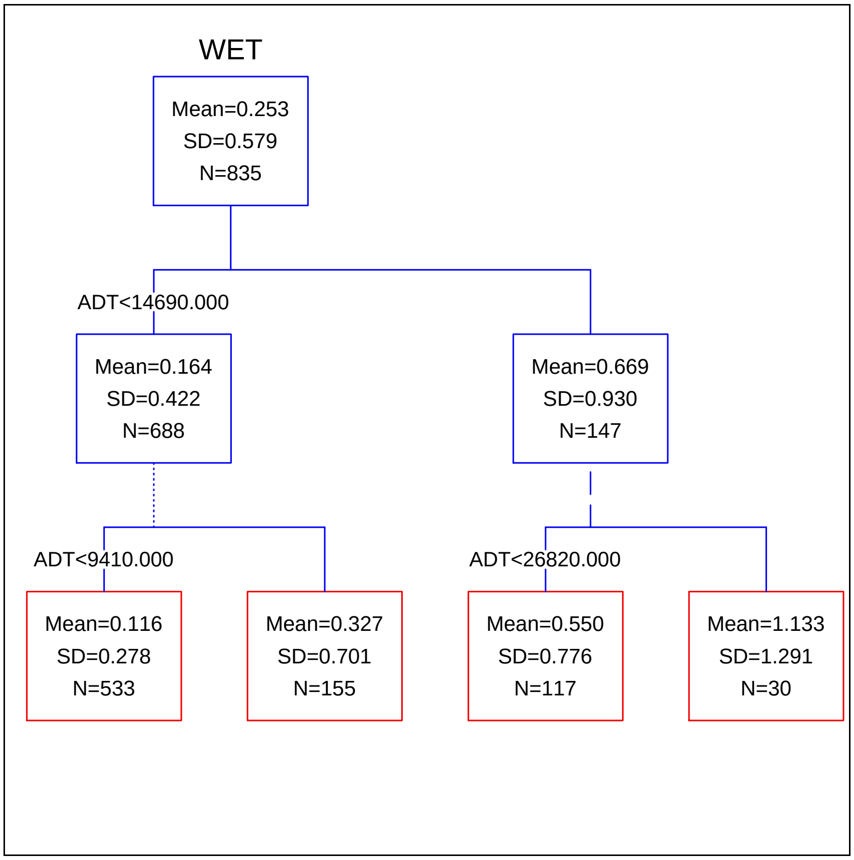


Figure A2.56. AID Tree For Signalized Intersection Legs - Night Crashes

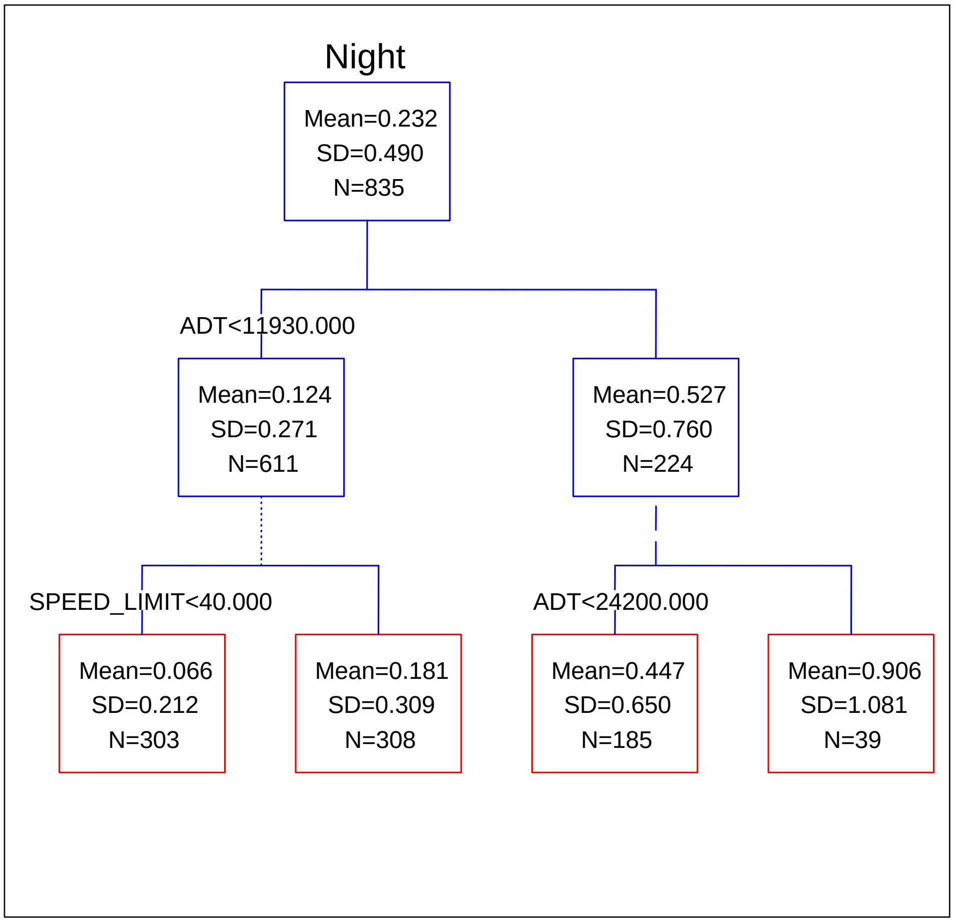


Figure A2.57. AID Tree For Signalized Intersection Legs - Rear end Crashes

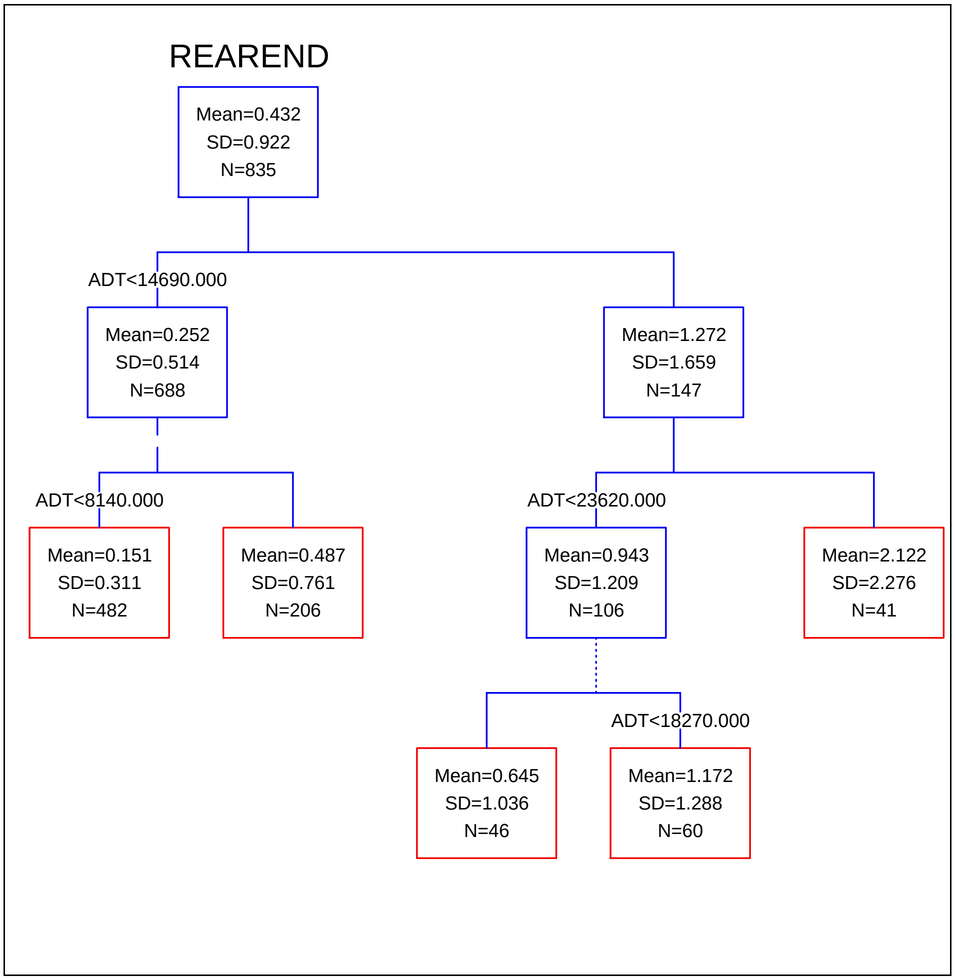


Figure A2.58. AID Tree For Signalized Intersection Legs - Sideswipe Crashes

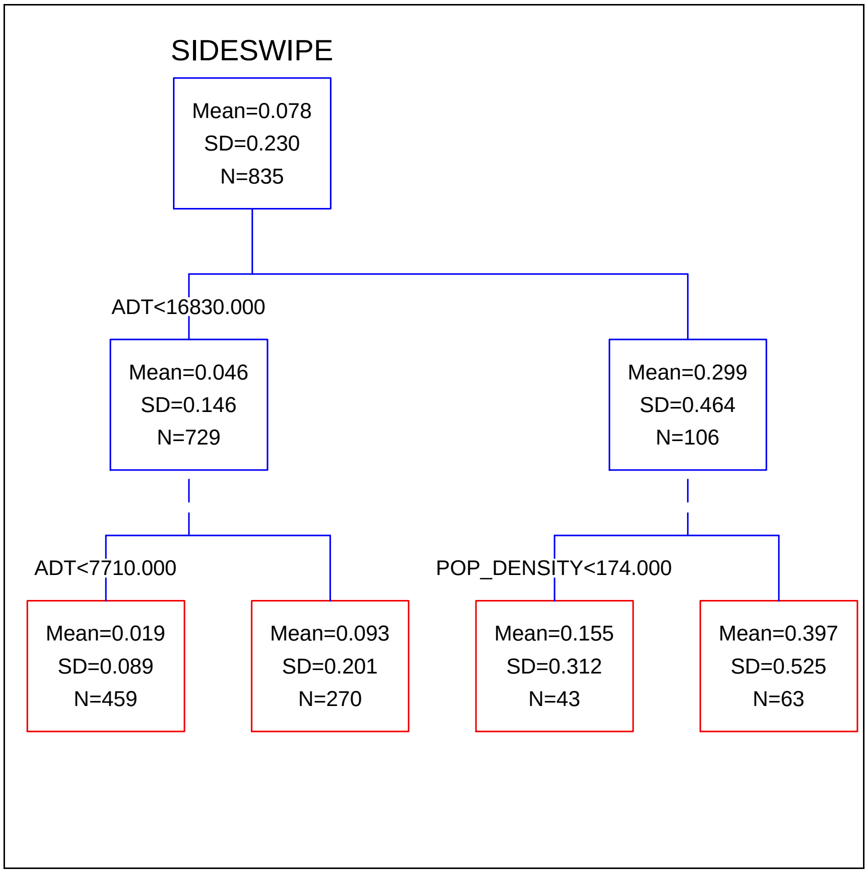


Figure A2.59. AID Tree For Signalized Intersection Legs - Left Turn Crashes

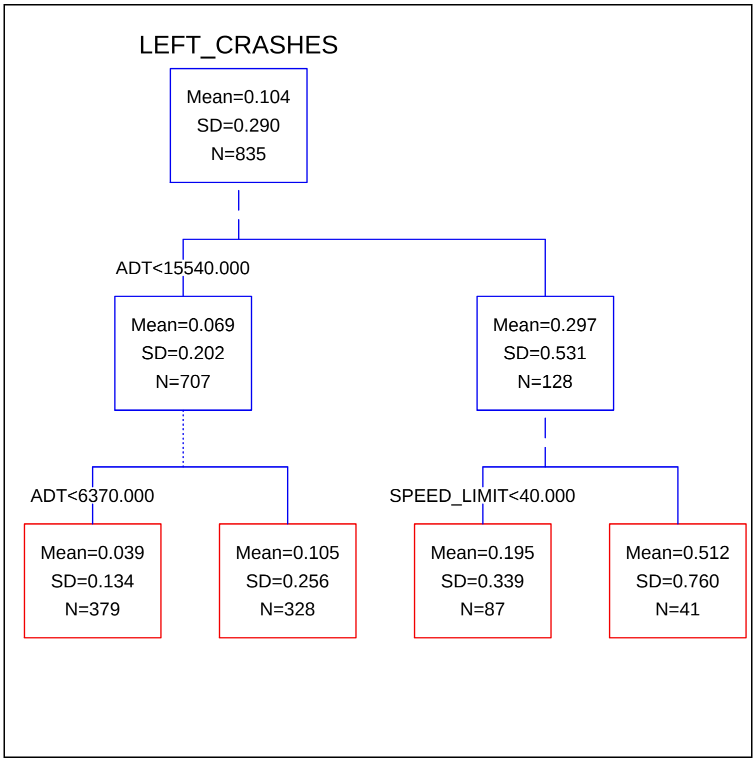


Figure A2.60. AID Tree For Signalized T Intersection Legs- Injury Crashes

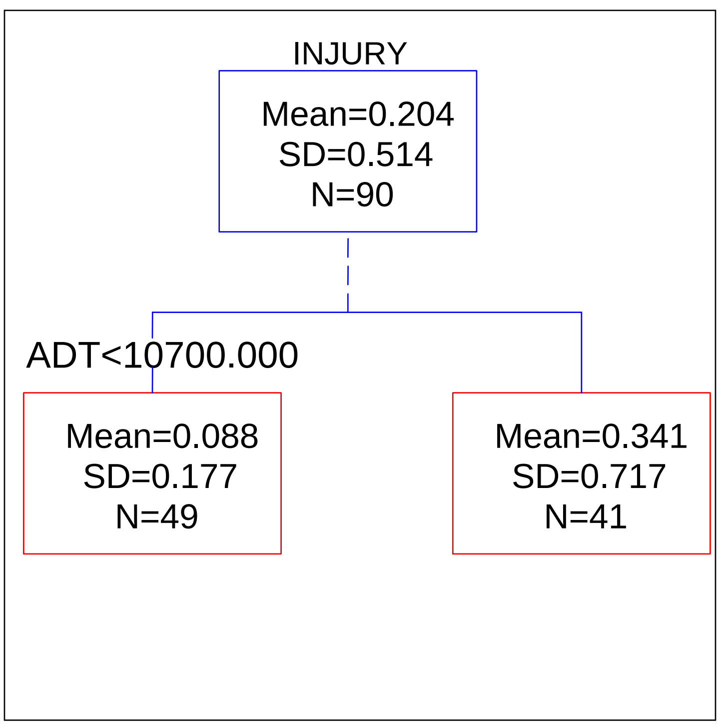


Figure A2.61. AID Tree For Signalized T Intersection Legs - PDO Crashes

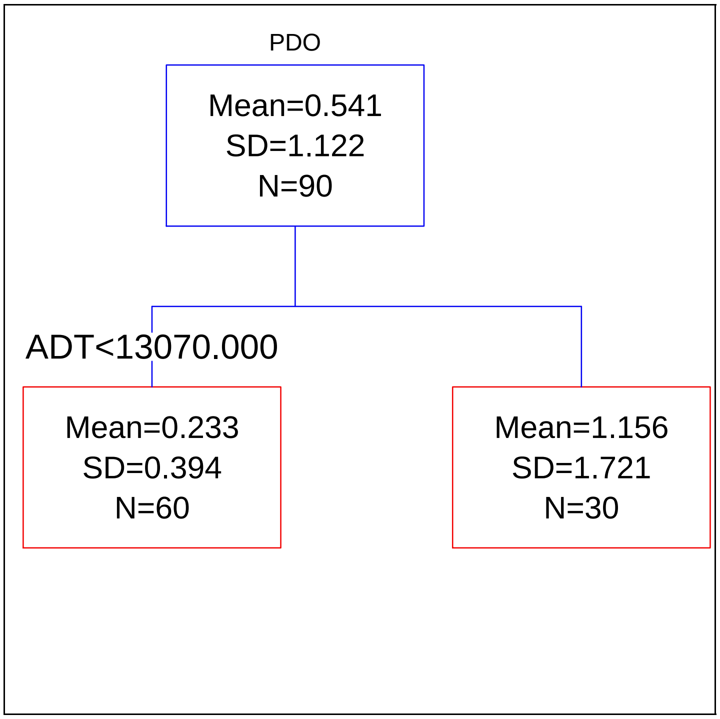


Figure A2.62. AID Tree For Signalized T Intersection Legs - Total Crashes

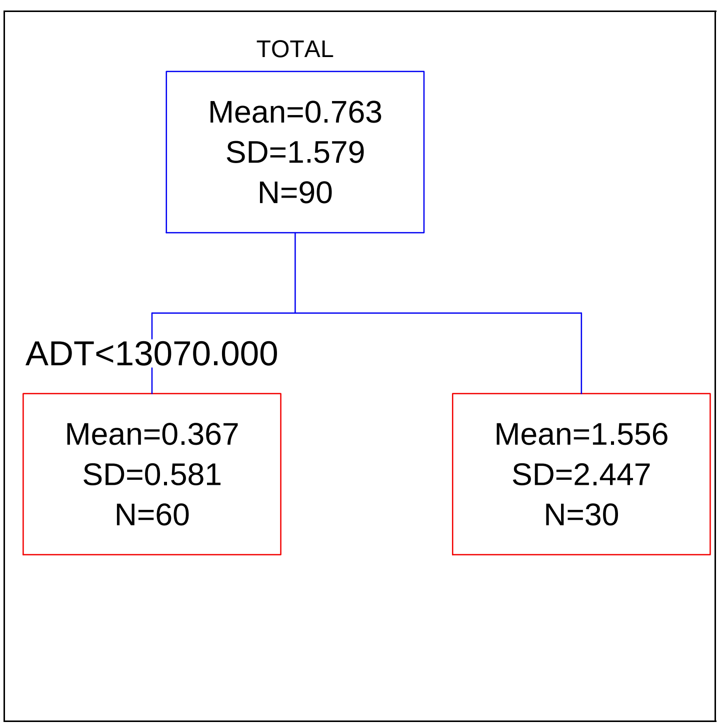


Figure A2.63. AID Tree For Signalized T Intersection Legs - Wet Pavement Crashes

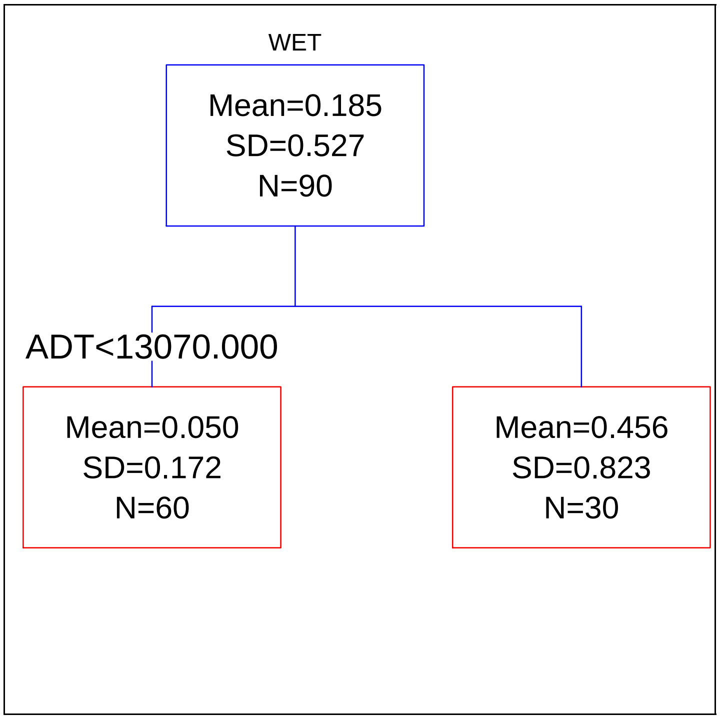


Figure A2.64. AID Tree For Signalized T Intersection Legs - Night Crashes

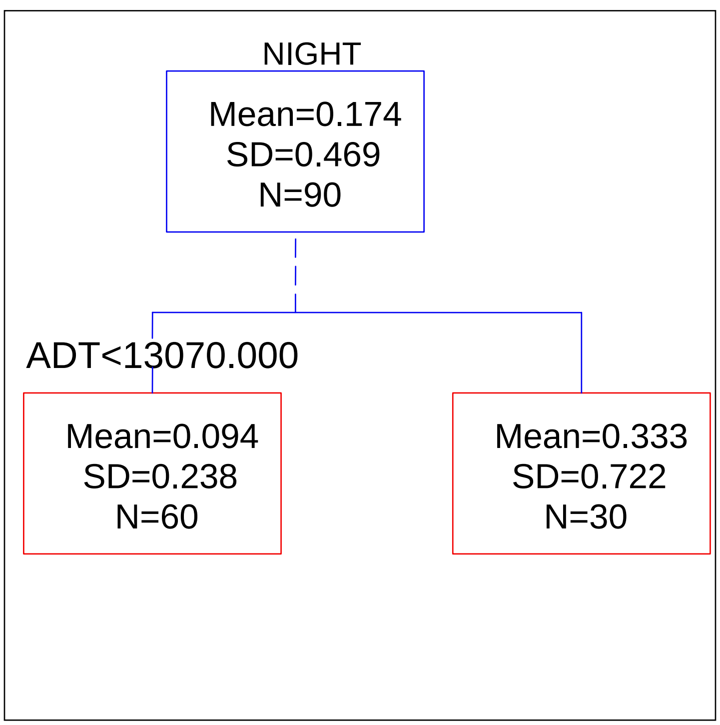


Figure A2.65. AID Tree For Signalized T Intersection Legs - Rear end Crashes

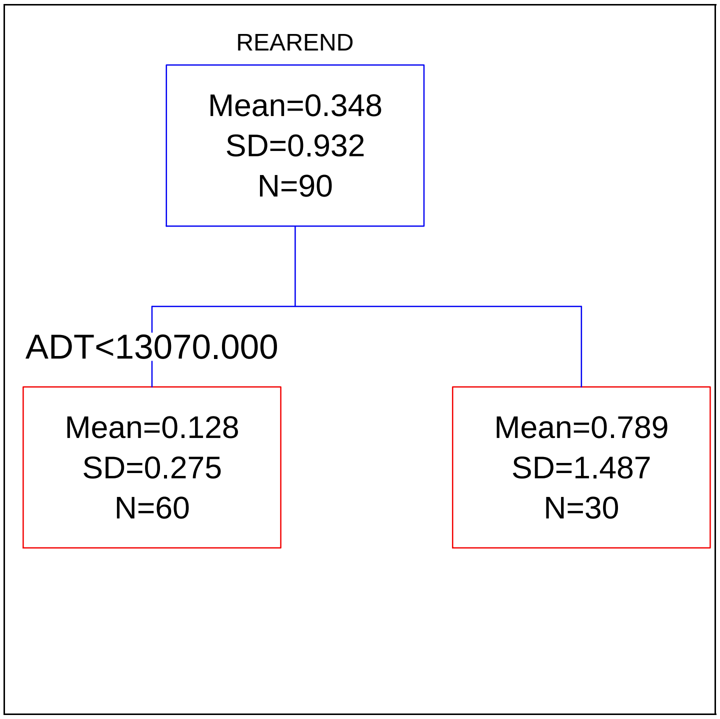


Figure A2.66. AID Tree For Signalized T Intersection Legs - Sideswipe Crashes

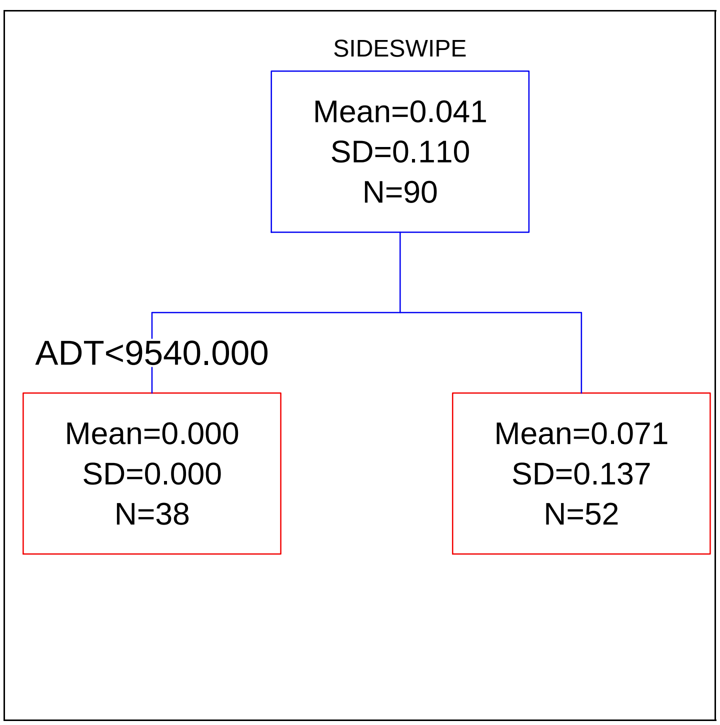


Figure A2.67. AID Tree For Signalized T Intersection Legs - Fixed Object Crashes

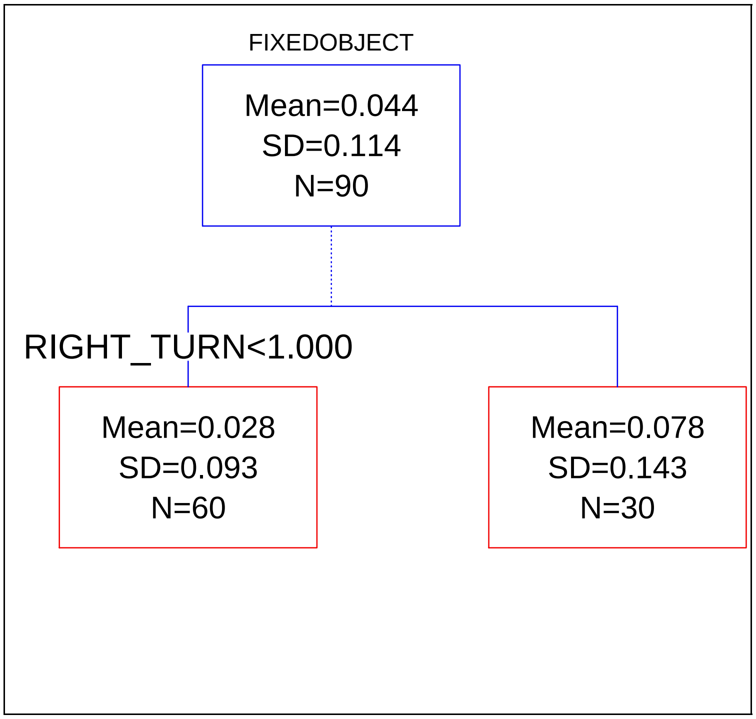
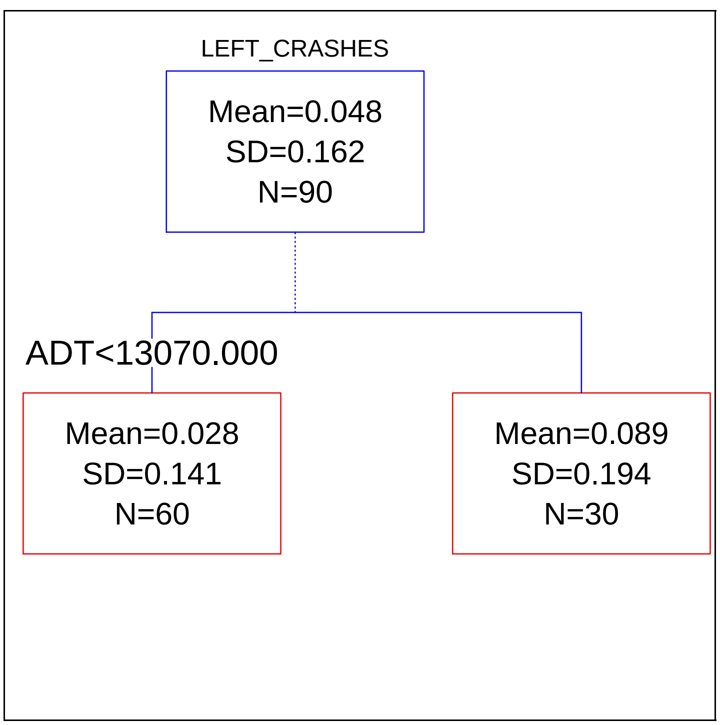


Figure A2.68. AID Tree For Signalized T Intersection Legs - Left Turn Crashes



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APPENDIX III Recommended Regression Models

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The key to read the crash models is:

X_1 = Number of Left turn lanes
X_2 = Number of Left/Through lanes
X_3 = Number of Through lanes
X_4 = Number of Right/Through lanes
X_5 = Number of Right turn lanes
X_6 = Number of Right/Left turn lanes
X_7 = Number of Right/Through/Left turn lanes
X_8 = Population Density (in hundred persons per area of 1 mile radius)
X_9 = Speed posted (in units of 10 mph)
X_{10} = ADT (in units of 1000 veh per day)

Table 19. Recommended Crash Models for Signalized 4-way Intersection Legs

Signalized legs	
Crash Type	Recommended Models
Night crashes	Condition 1 $Y = -0.003 + 0.205*X_2 + 0.229*X_3 - 0.303*X_5 + 0.012*X_{10}$
	Condition 2 $Y = 0.158 - 0.292*X_1 + 0.215*X_3 + 0.295*X_4$
	Condition 3 $Y = 0.447$
	Condition 4 $Y = 0.906$
Fixed Object crashes	No data
Injury crashes	Condition 1 $Y = 0.009 + 0.170*X_2 - 0.090*X_5 + 0.010*X_{10}$
	Condition 2 $Y = -0.158 + 0.333*X_1 + 0.358*X_2$
	Condition 3 $Y = 0.200 + 0.413*X_3$
	Condition 4 $Y = 0.527$
	Condition 5 $Y = 0.583$
	Condition 6 $Y = 0.609 + 0.046*X_8$
Left turn crashes	Condition 1 $Y = -0.028 + 0.016*X_9$
	Condition 2 $Y = 0.008 - 0.067*X_1 + 0.048*X_4 + 0.023*X_9$
	Condition 3 $Y = -0.361 + 0.167*X_9$
	Condition 4 $Y = 0.512$
PDO crashes	Condition 1 $Y = -0.476 - 0.146*X_1 + 0.120 X_9 + 0.076X_{10}$
	Condition 2 $Y = -0.906 + 0.936*X_1 + 1.680*X_2 + 0.588*X_3 + 0.442*X_4 + 1.852*X_7$
	Condition 3 $Y = 1.664$
	Condition 4 $Y = -2.458 + 0.179*X_{10}$
Rear end crashes	Condition 1 $Y = -0.334 - 0.123*X_1 + 0.067*X_9 + 0.052*X_{10}$
	Condition 2 $Y = 0.022 + 0.408*X_2 + 0.272*X_3 + 0.312*X_4 + 0.459*X_7$
	Condition 3 $Y = 0.421 + 0.053*X_8$
	Condition 4 $Y = 0.421 + 0.053*X_8$

	Condition 5	$Y = -2.836+0.157*X_{10}$
Sideswipe crashes	Condition 1	$Y = -0.006-0.023*X_1+0.007*X_{10}$
	Condition 2	$Y = -0.174+0.156*X_1+0.297*X_2+0.072*X_3+0.083*X_4+0.233*X_7$
	Condition 3	$Y = -0.181+0.077*X_3+0.006*X_{10}$
	Condition 4	$Y = 0.397$
Total crashes	Condition 1	$Y = -0.748-0.211*X_2+0.199*X_9+0.103*X_{10}$
	Condition 2	$Y = -0.862+0.905*X_1+1.650*X_2+0.741*X_3$ $0.604*X_4+2.258*X_7$
	Condition 3	$Y = 2.321$
	Condition 4	$Y = 3.650$
Wet crashes	Condition 1	$Y = -0.126+0.033*X_9+0.017*X_{10}$
	Condition 2	$Y = 0.019+0.060*X_9$
	Condition 3	$Y = 0.550$
	Condition 4	$Y = -2.157+0.099*X_{10}$

Table 20. Recommended Crash Models for Signalized T- Intersection Legs

Signalized T-intersection legs	
Crash Type	Recommended Models
Night crashes	Condition 1 $Y = -0.077+0.041*X_3+0.020*X_9$
	Condition 2 $Y = 0.333$
Fixed Object crashes	Condition 1 $Y = 0.028$
	Condition 2 $Y = 0.017+0.101*X_3$
Injury crashes	Condition 1 $Y = -0.216+0.079*X_3+0.027*X_9+0.019*X_{10}$
	Condition 2 $Y = 0.341$
Left turn crashes	Condition 1 $Y = -0.008+0.074*X_3$
	Condition 2 $Y = 0.069+0.598*X_6$
PDO crashes	Condition 1 $Y = 0.233$
	Condition 2 $Y = 1.156$
Rear end crashes	Condition 1 $Y = 0.038+0.080*X_3$
	Condition 2 $Y = 0.789$
Sideswipe crashes	*No equation*
	Condition 2 $Y = 0.071$
Total crashes	Condition 1 $Y = -0.192+0.335*X_1+0.049*X_{10}$
	Condition 2 $Y = 1.556$
Wet crashes	Condition 1 $Y = 0.050$
	Condition 2 $Y = 0.456$

Table 21. Recommended Crash Models for Two Way Stop Control Intersections - (No Control) Legs

Two way stop control intersection- (no control) legs	
Crash Type	Recommended Models
Night crashes	Condition 1 $Y = 0.031+0.192*X_5$
	Condition 2 $Y = 0.115$
	Condition 3 $Y = 0.229$
	Condition 4 $Y = 0.231$
Fixed Object crashes	*No equations*
	Condition 2 $Y = 0.167*X_4$
	Condition 3 $Y = -0.198+0.180*X_2+0.084*X_4+0.173*X_7+0.008*X_{10}$
	Condition 4 $Y = -0.217+0.295*X_2+0.070*X_3+0.178*X_4+0.217*X_7$
	Condition 5 $Y = 0.088$
Injury crashes	Condition 1 $Y = 0.207$
	Condition 2 $Y = 0.216+1.182*X_1-0.634*X_3$
	Condition 3 $Y = 0.567$
Left turn crashes	Condition 1 $Y = -0.087+0.109*X_2+0.101*X_4+0.100*X_7$
	Condition 2 $Y = 0.063$
PDO crashes	Condition 1 $Y = 0.094+0.573*X_4+0.351*X_5$
	Condition 2 $Y = 0.333$
	Condition 3 $Y = -1.492+2.604*X_2+1.208*X_7+0.171*X_{10}$
Rear end crashes	Condition 1 $Y = 0.032$
	Condition 2 $Y = -0.182+0.052*X_9$
	Condition 3 $Y = -0.958+0.110*X_{10}$
Sideswipe crashes	Condition 1 $Y = 0.006$
	Condition 2 $Y = 0.444*X_2$
Total crashes	Condition 1 $Y = 0.261+1.072*X_4+0.517*X_5$
	Condition 2 $Y = 0.596$
	Condition 3 $Y = -2.215+3.328*X_2+1.838*X_7+0.286*X_{10}$
Wet crashes	Condition 1 $Y = 0.032+0.301*X_4$
	Condition 2 $Y = 0.032$
	Condition 3 $Y = 0.125$
	Condition 4 $Y = 0.194$

Table 22. Recommended Crash Models for Two Way Stop Control Intersections- Stop Controlled Legs

Two way stop control intersection - (stop control) legs	
Crash Type	Recommended Models
Night crashes	Condition 1 $Y = 0.005$
	Condition 2 $Y = 0.037$
	Condition 3 $Y = 0.101$
Fixed Object crashes	Condition 1 $Y = 0.007$
	Condition 2 $Y = 0.037$
Injury crashes	Condition 1 $Y = 0.066$
	Condition 2 $Y = 0.180$
PDO crashes	Condition 1 $Y = 0.027$
	Condition 2 $Y = 0.140$
	Condition 3 $Y = 0.310$
Rear end crashes	Condition 1 $Y = -0.008+0.035*X_5+0.008*X_{10}$
	Condition 2 $Y = 0.182$
Total crashes	Condition 1 $Y = 0.071$
	Condition 2 $Y = 0.211$
	Condition 3 $Y = 0.465$
Wet crashes	Condition 1 $Y = 0.006+0.76*x_5+0.01*X_8$
	Condition 2 $Y = 0.030$
	Condition 3 $Y = 0.046$
	Condition 4 $Y = 0.156$

Table 23. Recommended Crash Models for Flashing Beacon Controlled Intersections- No Control Legs

Flashing beacon controlled intersection- no control legs	
Crash Type	Recommended Models
Night crashes	Condition 1 $Y = 0.092$
	Condition 2 $Y = 0.257$
Fixed Object crashes	Condition 1 $Y = -0.029+0.017*X_8$
	Condition 2 $Y = 0.167*X_3$
Injury crashes	Condition 1 $Y = -0.442+0.578*X_4+0.067*X_{10}$
	Condition 2 $Y = 0.487$
	Condition 3 $Y = 0.010+0.323*X_5$
Left turn crashes	Condition 1 $Y = 0.010+0.323*X_5$
	Condition 2 $Y = -0.494+0.153*X_1+0.577*X_2+0.206*X_3+ 0.534*X_4+0.494*X_7$
PDO crashes	Condition 1 $Y = 0.362$
	Condition 2 $Y = 0.687$
Rear end crashes	Condition 1 $Y = 0.04$
	Condition 2 $Y = 0.042+0.308*X_7$
Sideswipe crashes	Condition 1 $Y = 0.007$
	Condition 2 $Y = 0.044$
Total crashes	Condition 1 $Y = 0.816$
	Condition 2 $Y = 1.286$
Wet crashes	Condition 1 $Y = 0.120$
	Condition 2 $Y = 0.236$

Table 24. Recommended Crash Models for Flashing Beacon Controlled Intersections-Stop Controlled Legs

Flashing beacon controlled intersection- stop control legs	
Crash Type	Recommended Models
Night crashes	Condition 1 *No equation*
	Condition 2 Y = 0.021
	Condition 3 Y = 0.054
	Condition 4 Y = 0.194
Fixed Object crashes	Condition 1 *No equation*
	Condition 2 $Y = -0.018+0.513*X_8$
	Condition 3 Y = 0.027
Injury crashes	Condition 1 Y = 0.052
	Condition 2 Y = 0.141
PDO crashes	Condition 1 Y = 0.128
	Condition 2 Y = 0.390
	Condition 3 Y = 0.588
Rear end crashes	Condition 1 Y = 0.022
	Condition 2 Y = 0.068
	Condition 3 Y = 0.183
Sideswipe crashes	Condition 1 *No equation*
	Condition 2 $Y = 0.009+0.015*X_8$
Total crashes	Condition 1 Y = 0.186;
	Condition 2 $Y = 0.192 + 0.036*X_8$
	Condition 3 Y = 0.695
Wet crashes	Condition 1 Y = 0.029
	Condition 2 Y = 0.146

Table 25. Recommended Crash Models for One Way Stop T Intersections with One Way Stop Control - No Control Legs

T intersection with one way stop control - no control legs	
Crash Type	Recommended Models
Night crashes	Condition 1 $Y = -0.316+0.354*X_2+0.295*X_3+0.334*X_4+0.011*X_8$
	Condition 2 $Y = -0.206+0.192*X_2+0.179*X_3+0.184*X_4+0.003*X_{10}$
	Condition 3 $Y = 0.159+0.357*X_1-0.168*X_3$
Fixed Object crashes	Condition 1 $Y = 0.029$
	Condition 2 $Y = -0.029+0.006*X_{10}$
	Condition 3 $Y = 0.071*X_1$
	Condition 4 $Y = 0.102$;
Injury crashes	Condition 1 $Y = 0.031-0.667*X_1+0.635*X_3-0.667*X_5$
	Condition 2 $Y = 0.017+0.199*X_5+0.006*X_8$
	Condition 3 $Y = 0.179$
Left turn crashes	Condition 1 $Y = 0.003+0.019*X_5$
	Condition 2 $Y = 0.019$
PDO crashes	Condition 1 $Y = 0.052+0.054*X_2+0.019*X_8$
	Condition 2 $Y = -0.362+0.1*X_9$
	Condition 3 $Y = 0.293$
	Condition 4 $Y = 0.368$
Rear end crashes	Condition 1 $Y = 0.024-0.333*X_1+0.309*X_3-0.333*X_5$
	Condition 2 $Y = 0.099$
	Condition 3 $Y = -0.492+0.176*X_9$
	Condition 4 $Y = 0.267$
Sideswipe crashes	Condition 1 $Y = 0.001$
	Condition 2 *No equation*
	Condition 3 $Y = 0.005$
	Condition 4 $Y = 0.045$
Total crashes	Condition 1 $Y = 0.113+0.019*X_8$
	Condition 2 $Y = -0.126+0.49*X_{10}$
	Condition 3 $Y = 0.558-0.222*X_3$
Wet crashes	Condition 1 $Y = 0.007+0.028*X_2$
	Condition 2 $Y= -0.667+0.667*X_2+0.667*X_3+0.667*X_4$
	Condition 3 $Y = 0.133$

Table 26. Recommended Crash Models For One Way Stop T Intersections With One Way Stop Control - Stop Controlled Legs

T intersection with one way stop control - stop control legs	
Crash Type	Recommended Models
Night crashes	Condition 1 $Y = 0.014$
	Condition 2 $Y = 0.042$
	Condition 3 $Y = 0.094$;
Fixed Object crashes	Condition 1 $Y = 0.011$
	Condition 2 $Y = 0.010$
	Condition 3 $Y = 0.053$
	Condition 4 $Y = 0.089$
Injury crashes	Condition 1 $Y = 0.004$
	Condition 2 $Y = 0.075$
	Condition 3 $Y = 0.104$
Left turn crashes	Condition 1 *No equation*
	Condition 2 $Y = 0.011$
PDO crashes	Condition 1 $Y = 0.056$
	Condition 2 $Y = 0.204$
Rear end crashes	Condition 1 $Y = -0.004+0.011*X_{10}$
	Condition 2 $Y = 0.178$
Sideswipe crashes	Condition 1 $Y = 0.002$
	Condition 2 $Y = 0.022$
Total crashes	Condition 1 $Y = 0.052$
	Condition 2 $Y = 0.189$
	Condition 3 $Y = 0.312$
Wet crashes	Condition 1 $Y = 0.004$
	Condition 2 $Y = 0.028$
	Condition 3 $Y = -0.022+0.020*X_{10}$