Crash Data Analysis Guidelines

2025 September

Preface

The following guidelines are intended for Louisiana Department of Transportation and Development (DOTD) employees, consultants, metropolitan planning organizations (MPO), and local municipalities (cities and parishes) conducting safety studies. This document is not intended to establish standards or requirements, but to serve as a guide in providing the best uniform results. For additional guidance on conducting a safety analysis please consult the latest AASHTO Highway Safety Manual.

These guidelines are available at: <http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Multimodal/Highway_Safety/Pages/Highway_Safety_Analysis_Toolbox.aspx>. The DOTD Highway Safety Section maintains and updates guidelines as needed. Contact the DOTD Highway Safety Section at <DOTDHighwaySafety@la.gov> if you need more information.

Introduction

The purpose of this document is to describe the guidelines for conducting a crash data analysis. The guidelines are intended to aid transportation professionals in the assessment of road safety performance for projects on all public roads regardless of ownership.

Understanding road safety performance is critical to developing effective projects that provide safety, mobility, and quality in maintaining, rehabilitating, and rebuilding our public roads. One of the key components of understanding road safety performance is identifying potential pre-existing safety concerns and potential implications of construction approaches.

Select Crash Data Elements

Crash data comprises the same set of crash data elements collected from the Louisiana Uniform Motor Vehicle Crash Report and assigned to specific types of roadway facilities. These elements include, but are not limited to, Intersection (demarked as True or False), Highway Classification (including Rural vs. Urban distinction), and Intersection ID (uniquely named or Null). The correct differentiation of these roadway data elements ensures the appropriate crash data analysis classification.

Existing Crash Data Analysis Classification

An analyst should know that the road system is divided into parts: segments, intersections, and interchanges – collectively known as “facilities”. Crash data analyses differ considerably depending upon how data is classified, which is by the dominant structural function of the road system. For the purposes of this document, classification

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categories include segment crash data analysis and intersection crash data analysis. Interchange crash data analysis is not yet available and therefore, segment and intersection analyses should be used as appropriate.

While these divisions may overlap geographically, they are more clearly defined operationally, but still can be tricky to parse. Intersection crashes are those that could not have occurred if the intersection was not there. An example would be a vehicle running a red-indication and crashing perpendicularly with another vehicle that proceeded after getting a green-indication. Segment crashes are those not at an intersection or ambivalent to its existence. An example would be a driver drifts off the road after a 12-hour shift and strikes the traffic-signal pole. Interchange crashes are a group of ramp-segments in a relatively small geographic area.

Segment Crash Data Analysis

To analyze existing crash data specific to a road segment, it is imperative that road segment crash data be clearly separate from other data sets, specifically intersection data. Otherwise, crash data analysis results and conclusions will not be highly valid or reliable. To analyze road segment crash data, include crashes where Intersection is False. For segment data, the Intersection Identification is irrelevant.

Intersection Crash Data Analysis

Crash counts for intersection safety analysis changes depending on the Rural/Urban classification of the intersection. Rural intersections include crashes with the same intersection ID and where the intersection crash flag is marked 'TRUE' by the investigating officer. Urban intersections include all crashes with the same intersection ID regardless of the value of the intersection crash flag.

Since there is a difference in how the data element "Intersection" is used by Law-Enforcement Officers (LEO) and DOTD, it is recommended to use a point (latitude and longitude coordinates) and radius to search for crashes that have geographically occurred at an intersection.

Crash Analysis Preparation

Before crash data analysis can begin, an analyst must be familiar with the location under consideration, as well as how DOTD delineates the location. This is applicable to road owners and is not a task typically performed by consultants who are usually given predetermined project limits.

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Location Appraisal

High-quality location appraisal will lead to sound analysis. While this mostly applies to segments, this is applicable to intersections, too. To complete a location appraisal, the analyst should gather the necessary components and evaluate the potential for adjoining road inclusion. This includes location attributes (route and mile-point, control-section and log-mile, or latitude and longitude for intersections), highway classification, annual average daily traffic (AADT), crash data, and a map of the location.

Road segments should be sufficiently long – at minimum 0.4 miles for urban areas and 0.6 miles for rural areas. Segments that are too short may not produce valid and reliable crash data analysis. Segments that are too long will trend towards average and thus not produce meaningful results either. Urban segments should not be longer than 2 miles, while rural segments may be up to 8 miles.

Evaluation of Potential for Adjoining Road Inclusion

The adjoining road's potential for inclusion is a stand-alone, informal evaluation that will require engineering judgment. This evaluation involves considering the location attributes, highway classification, and the AADT, to determine which adjoining roads, if any, should be included in the crash data analysis.

When evaluating the potential for including adjoining intersections, the intersection's turn-lanes should automatically be included in the crash data analysis. Since not all intersections have turn-lanes and the intersection's functional area varies with traffic, determining the extents of an intersection may involve some engineering judgmentand may consider factors such as queue length, speed, and adjacent land use..

When evaluating the potential for including adjoining segments into your segment analysis, judgement should be exercised. If the segment's Highway Classification differs at all from the adjoining segment's Highway Classification, or if the segment's AADT differs greatly from the adjoining segment's AADT, then do not include that adjoining segment.

For a Traffic Management Plan (TMP), the adjoining segment where construction signs are placed should be included in the analysis. If lane closures are anticipated on the segment, then the 95th percentile queue on the adjoining segment should be included in the crash data analysis.

Safety Performance Methodology

Road safety performance methodology comprises three components. First is crash history, followed by safety evaluation, and completed with pattern recognition analysis. For TMP only, there is a fourth component – Cumulative Crashes by Time of Day. DOTD

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Highway Safety Section has some tools available to expedite calculations and provide consistency.

Crash History

A site's crash history will provide a glimpse into the road's existing safety characteristics, but only so much information can be gleaned. The crash history presents statistics to show the percentage of Collision Manner types, Crash Type options, Severity types, etc. The crash history is limited as it is does not compare the statistics to similar facilities, nor does it delve deeply into the data. Without having a valid and reliable comparison, it cannot be determined if there is actually a safety concern based on safety performance, hence its limitations.

Safety Comparison

In safety comparison, analysts compare their facility's crash rate to a statistical model for that facility type to determine safety performance. For most facilities, DOTD has a nonlinear statistical model, Safety Performance Function (SPF), which can be used as the comparison statistical model. DOTD has developed many SPFs for segment highway classifications and intersection classifications based on crash data and traffic exposure. For the remaining facilities: interchanges, ramps, and one-way roads, DOTD has yet to develop a SPF. In these instances, where DOTD agrees that no SPF could be used, then the number-rate (discussed later) should be used as the comparison model or an SPF of a facility most similar.

The "All Severity" SPF is the model derived from using all crashes for a given highway classification, while the "Injury Severity" SPF is the model using crashes where Severity is not "O" (Property Damage Only). The equations for each SPF with their respective coefficients and over-dispersion parameters are readily available in Appendix-A.

Safety Service Level

This is a categorical classification used to help understand the relative safety performance. The Safety Service Level is described in terms of LOSS (Level of Service of Safety). The degree of deviation from the respective SPF will place the segment or intersection into one of four LOSS classifications:

- LOSS 1: Negligible Potential for Safety Improvement
- LOSS 2: Low Potential for Safety Improvement
- LOSS 3: Moderate Potential for Safety Improvement
- LOSS 4: High Potential for Safety Improvement

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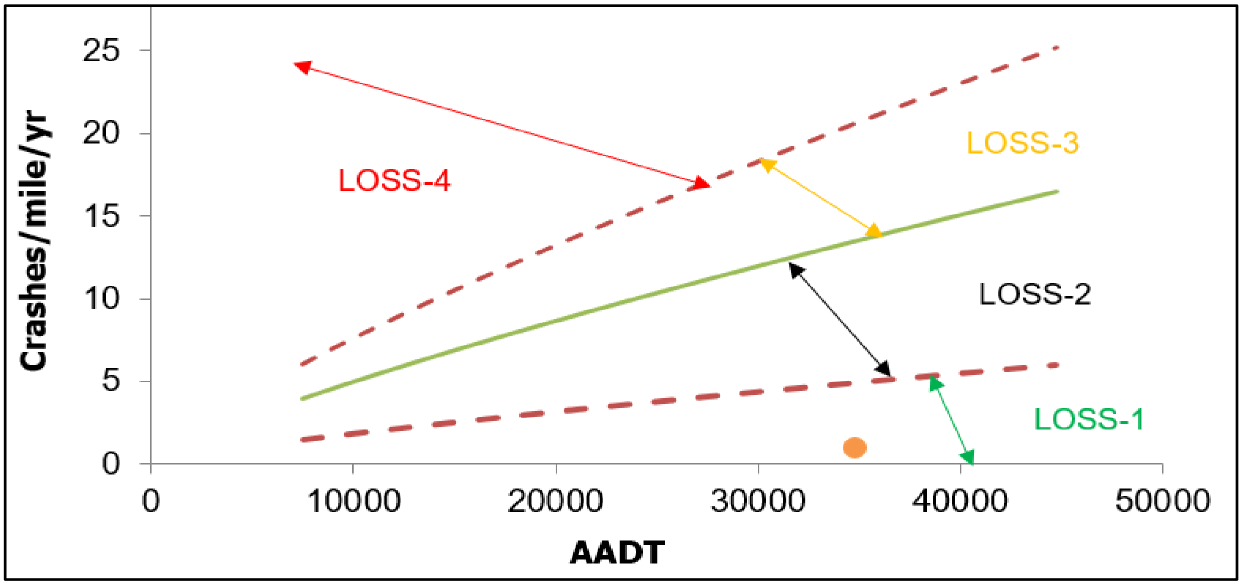

Figure-1 Urban 5-lane SPF - Injury Crashes

Figure-1 presents an example of an urban five-lane roadway segment comparison. The orange dot shows where the segment falls compared to the relevant SPF (green line). The boundaries dividing LOSS-1 from LOSS-2, and LOSS-3 from LOSS-4 are determined by percentiles (in this case 20% and 80%) of the Gamma distribution for all crashes within the same highway classification. As it is shown, the segment falls below the 20the percentile line, which means the segment is LOSS-1.

Although the Safety Service Level provides a comparison of current performance to the statistical model, it does not provide any information related to the nature of the potential safety concern itself. If a potential safety concern is present, the Safety Service Level will describe only its magnitude in the form of safety performance. The nature of the problem is determined by pattern recognition.

DOTD Network Screening Lists

This is a process where all of the facilities are evaluated for safety performance in a wholesale manner. While this does produce results for the entire state, this uses algorithmically constructed segmentation and the same size intersections – neither ideal. Network screening is performed annually by DOTD for segments and intersections in accordance with the AASHTO Highway Safety Manual (HSM) recommendations to inform the Highway Safety Improvement Program. Each segment or intersection is screened using it's site-specific SPF with the available AADT. DOTD publishes an annual High Potential for Safety Improvement (HPSI) List as a result of this process for planners, engineers, and program managers to easily identify high priority locations for safety improvment. Upon request from DOTD Safety Section or Project Manager, this information can be probided on a project-specific basis to provide insight into the

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existing safety performance. However, any public release or public sharing of the network screening list must be done so with explicit, written permission from DOTD's Highway Safety Section. When a location has been identified as a HPSI location, it is an indication that the safety may be a purpose and need of the project and additional analysis may be required to confirm issues and devise a site specific mitigation plan.

Number-Rate

For some facilities where a SPF has not yet been developed and DOTD's Highway Safety's Administrator agrees than no SPF could be used, then the number-rate could be used instead. The method is slightly different for segments than for intersections. It is preferable to use whole years of data.

For roadway segments use the following formula:

$$R_s = (C \times 10^6) / (L \times AADT \times D)$$

Where: R_s = segment crash rate

C = crash count (crashes)

D = analysis days (days)

L = segment length (miles)

AADT = annual average daily traffic (vehicles/day)

For intersections use the following formula:

$$R_i = (C \times 10^6) / (EV \times D)$$

Where: R_i = intersection crash rate

C = crash count (crashes)

D = analysis days (days)

EV (Entering Vehicles) = average vehicles entering intersection each day from all approaches (vehicles/day)

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Pattern Recognition Analysis

Pattern Recognition Analysis (PRA) compares the site's category percentages to its comparison group's average. These categories are Collison Manner, Crash Type, Lighting, Surface Condition, Location Type, etc. For intersections the site is compared once, while for segments the sliding window technique is used.

Issues may arise if unsophisticated PRA are used. Direct comparisons between statistics fail to inform users as to whether the differences are significant. Segments pose additional challenges over intersections. Longer segments lend themselves to categorize closer to the average percentages, potentially missing over-representations within the segment. Therefore, analysts should be careful to ensure that segments are not too long. See "Location Appraisal" for guidelines on length of segments to analyze.

Bernoulli Trials

Bernoulli Trials are used to determine significance. A Bernoulli trial (or binomial trial) is a random experiment with exactly two possible outcomes: "success" or "failure", in which the probability of success is the same every time the experiment is conducted. Assuming that crashes can be analyzed as independent Bernoulli trials, consider the following example:

The crash history of a 1-mile long segment shows that there were 20 total crashes; including 4 rear-end crashes (20% of total crashes). If the statewide average for rear-end crashes is 19%, for example, a direct comparison would indicate that there is over-representation. However, considering that each crash can be viewed as a Bernoulli Trial with 19% probability of being a rear-end crash, the probability of having 4 rear-end crashes out of 20 total crashes can be calculated using the Cumulative Binomial Distribution function within Excel as shown in Figure-2.

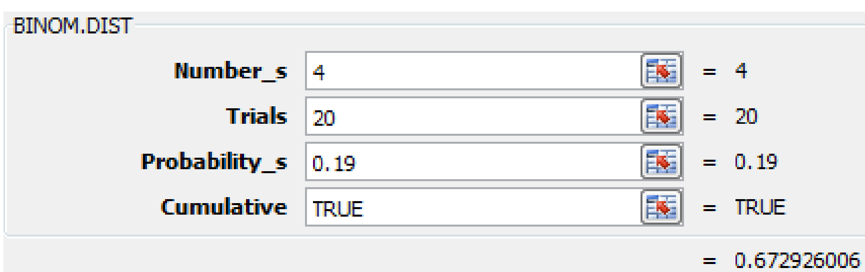

Figure-2 Excel Function - Binomial Distribution

As it is shown, the probability for this event to actually occur is only 67% which may be considered low. DOTD Highway Safety Section recommends using probabilities over 90% to be significant.

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Hidden Over-Representation

To find hidden over-representation within a segment, the segment is divided into pieces. Assuming that the crashes are located properly, consider the following example:

A roadway improvement project involves a 5-mile long segment. Figure-3 illustrates the crash history within the project limits divided into 1-mile buckets. When analyzing the segment as a whole (5 miles), 30% of the crashes (15 out of 50) are roadway departures. If the statewide average for a roadway under this classification is 32%, for example, we would conclude that there is no over-representation. However, by considering “mile 3” only, roadway departures would represent 70% of the crashes (7 out of 10), which would trigger over-representation. Therefore, a significant yet correctible problem is revealed, which is otherwise not detected when the segment is analyzed as a whole.

	mile 1	mile 2	mile 3	mile 4	mile 5
Rwy Departures =	2	2	7	3	1
Other =	8	8	3	7	9
Total =	10	10	10	10	10

Rwy Departures =	15
Other =	35
Total =	50

Figure-3 Crash Data Diagram Segmented by 1-mi Sections

Sliding Window

The Sliding Window technique is better at finding hidden over-representation. This process determines a scanning window’s (scanning interval) length and its δ (scanning increment). Figure-4 illustrates the process.

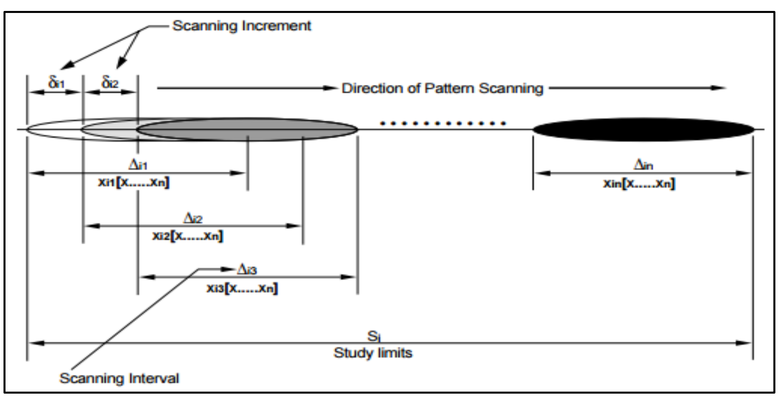

Figure-4 Sliding Window Technique

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Starting at the beginning of the segment, the first scanning window is analyzed using Bernoulli Trials to determine over-representation. Then, the scanning interval slides a distance δ (scanning increment) and the process loops until all scanning windows have been analyzed. Although this procedure could be a long and tedious process if manually calculated, DOTD offers a tool to perform the analysis quickly.

Traffic Management Plans (TMPs)

Some additional analysis may be needed to perform TMPs. To inform lane closure determination, it is helpful to know when existing crashes occur on a specific corridor. This can be accomplished by plotting crash times of day by days of the week. Since most traffic patterns are specific to weekdays or weekends, the crash data should be divided this way as well. Example graphs depicting crashes by time and day are shown in Figure-5.

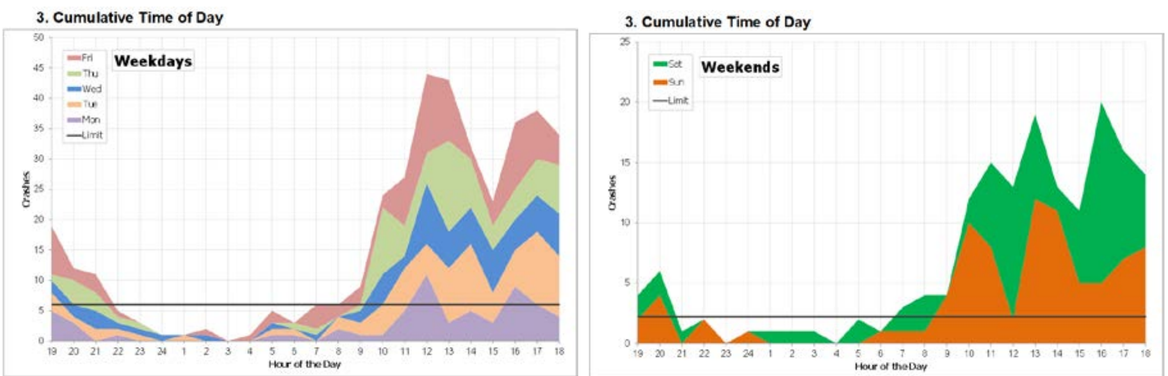

Figure-5 Cumulative Time of Day graphs

CRASH DATA QUALITY

Crash data quality assurance is the process of reviewing critical elements from select crash reports, and ensuring that the data elements are properly coded. Typically, a crash data listing will provide sufficient information to complete a preliminary project level crash data analysis. However, in some cases, it is necessary to review critical individual crash reports to gain a better understanding of the safety concerns and to correct inconsistent crash data.

There are many reasons why reviewing crash reports may improve the crash data analysis. Not all crashes that occur are reported and the crashes that are reported may have elements that are not coded correctly. The level and quality of formal and on-job training for LEOs varies throughout the state and the interpretation of the elements contained in the uniform crash report may differ across jurisdictions. Also, LEOs may not be aware all of the data elements they are capturing or how some element pairs function together. Crash data inaccuracies and incompleteness may also be due to missing information for vehicles and/or drivers, and drivers who are not truthful or not aware of the circumstances of the crash. LEOs may be tasked with

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other duties, like securing a crash scene and issuing citations, before completing the crash report.

Patterns at intersections are easily understood when there are no other access connections (driveways, median crossovers, etc.) within the intersection. Those are rarely cases, more often access connections exist within the functional area of the intersection and determining where the patterns exist requires some investigation. Quality assurance is easily performed alongside this investigation.

Data Sampling Size

Data generated from a small sample can be misleading because they can be significantly influenced by small variances. It is important to exercise engineering judgment when identifying crash patterns for segments or intersections with a small sample size of crashes.

There are some ways to overcome small sample sizes. One way is by adding an additional year, beyond the usual five, up to six years, until a reasonable sample size is achieved. This can be done so long as consistent operations have occurred at the site during the duration queried. For segments there is the potential option of extending the limits.

Behavior Elements

It is noted that data elements associated with fatal motor vehicle crash reports are usually of high quality with relatively few missing values. Fatal crashes require investigation of behavioral elements, including but not limited to seatbelt use, speeding, distractions, impairments, etc. Data elements associated with non-fatal motor vehicle crash reports are usually of lesser quality and behavioral elements are occasionally omitted from the crash report.

Accessing Crash Data

Crash data is traffic incident information recorded by various police agencies and uploaded to a state database, which is maintained by Louisiana State University's Center for Analytics Research and Transportation Safety (CARTS). Contact DOTD Highway Safety Section to gain access to our current crash data system.

The crash data file for a given year is preliminary until quality reviews are conducted for the entire year and the year is officially closed by the DOTD Highway Safety Section. This typically occurs eight months after the previous year's end. This timeframe allows a few weeks for law enforcement agencies to submit any outstanding crash reports and several more weeks for map-spotting efforts to confirm location and roadway attributes, as well as select quality assurance activities for other critical data fields.

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Considering Potential Countermeasures

Countermeasures are crash mitigation strategies. There are two main groups – behavioral and infrastructure and operations. Engineering judgment should be used and all factors should be considered when selecting crash mitigation strategies. The crash data analysis may provide insight into driver behavior. Behavioral countermeasures are best explored with your Regional Safety Coalition. Contact DOTD Highway Safety Section to get in contact with your Regional Safety Coalition. The following table focuses on Infrastructure and Operational strategies. It groups the countermeasures by crash groups (Crash Types, not to be confused with the DOTD crash data element "Crash Type") and then by possible cause.

Table 1: Countermeasures Grouped by Crash Type

Crash Type	Possible Cause	Potential Countermeasure
Access-related	Left-turning vehicles	Install median
		Install/lengthen left turn lanes
	Improperly located driveway	Move driveway to side street
		Install channelizing islands to define driveway location
		Consolidate adjacent driveways
	Right-turning vehicles	Provide right turn lanes
		Increase width of driveways
		Widen through lanes
		Increase curb radii
	Large volume of through traffic	Move driveway to side street
		Construct a local service road
	Large volume of driveway traffic	Signalize driveway
		Provide accel/decel lanes
		Channelize driveway
	Restricted sight distance	Remove obstruction
	Inadequate lighting	Install lighting
Bridges	Alignment	Realign bridge/roadway
		Install advance warning signs

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		Add/Improve delineation
	Narrow roadway	Widen structure
		Add/Improve delineation
		Install signing/signals
	Visibility	Remove obstruction
		Install advance warning signs
		Add/Improve delineation
	Vertical clearance	Rebuild structure/adjust roadway grade
		Install advance warning signs
		Add/Improve delineation
		Provide height restriction/warning
	Slippery surface	Resurface deck
		Improve skid resistance
		Improve drainage
		Enhance signing
	Rough surface	Resurface deck
		Rehabilitate joints
		Regrade approaches
	Inadequate barrier system	Upgrade guardrail
		Upgrade approach rail/terminals
		Upgrade bridge - approach rail connections
		Remove hazardous curb
		Improve delineation
Intersection-related	Large volume of left/right turns (from side street)	Widen road
		Channelize intersection
		Install STOP signs
		Install signal/roundabout
		Increase curb radii

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Restricted sight distance	Remove sight obstructions
	Provide adequate channelization
	Provide left/right turn lanes
	Install warning signs
	Install STOP signs
	Install signal/roundabout
	Install advance markings to supplement signs
	Install STOP bars
Slippery surface	Improve skid resistance
	Improve drainage
Large volume of turning vehicles	Provide left/right turn lanes
	Increase curb radii
	Install signal/roundabout
Inadequate lighting	Install lighting
Lack of adequate gaps	Install signal/roundabout
	Install STOP signs
Crossing pedestrians	Install/improve ped signing/marking
	Install signal
Large total intersection volume	Install signal
	Add traffic lane
Excessive vehicle speed on approaches	Install rumble strips in travel lane
Inadequate traffic control devices	Upgrade traffic control devices
Poor visibility of signals	Install/enhance advance warning signs
	Install overhead signals
	Install 12" LED signal lenses
	Install visors/backplates
	Relocate signals to far side of intersection

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		Remove sight obstructions
		Add illuminated/retroreflectorized signs
	Unwarranted signals	Remove signals
	Inadequate signal timing	Upgrade signal system timing/phasing
Nighttime	Poor visibility	Install/enhance advance warning signs
		Install/enhance pavement markings
		Install lighting
Overturn	Roadside features	Flatten slopes/ditches
		Relocate drainage facilities
		Extend culverts
		Provide traversable culvert end treatments
		Install/improve traffic barriers
	Inadequate shoulder	Widen shoulder
		Upgrade shoulder surface
		Remove curb/obstruction
	Pavement	Eliminate edge drop-off
		Improve
Pedestrian or Bicycle	Poor visibility	Remove sight obstructions
		Install pedestrian crossing signs and pavement markings
		Install median for refuge
		Add "WALK" phase
		Install lighting
		Install advance warning signs
		Reduce speed limit
		Install/Improve sidewalks/bicycle paths
Railroad	Restricted sight distance	Install/enhance advance warning signs
		Install/enhance pavement markings
		Remove sight obstructions

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		Provide preemption
		Install gates
		Install lighting
Rear End	Slippery pavement	Improve pavement condition
		Install high friction surface treatment
	Driver inattention	Provide advance warning signs
		Eliminate unnecessary signing
		Install transverse rumble strips
Right Angle (at Unsignalized Intersection)	Restricted sight distance	Install warning signs
		Install STOP signs
		Install yield signs
		Remove sight obstructions
		Install signal/roundabout
		Install lighting
Right Angle (at Signalized Intersection)	Poor visibility of signals	Install advance warning signs
		Install back plates
		Remove sight obstructions
		Add signal heads
		Upgrade to 12" LED heads
	Inadequate signal timing	Provide protected only left turn phase
		Adjust amber phase
		Provide all-red clearance interval
		Install detection
		Improve coordination
Run off the Road	Slippery pavement/ponded water	Improve pavement condition/skid resistance
		Improve drainage

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	Inadequate road design and/or maintenance	Improve superelevation
		Improve shoulders
		Eliminate shoulder drop-off
		Install/improve traffic barriers
		Enhance signing
		Widen lanes
		Flatten slopes/ditches
		Improve alignment/grade
		Remove/Reduce/Delineate roadside hazards
	Poor delineation	Install roadside delineators
		Install advance warning signs
		Improve/install pavement markings
	Poor visibility	Increase sign size
		Install lighting
		Evaluate sight distance
Side Swipe or Head-On	Inadequate road design and/or maintenance	Perform necessary road surface repairs
		Install median or guardrail
		Reevaluate no passing zones
		Provide roadside delineators
		Improve alignment/grade
		Widen lanes
		Provide passing lanes
		Improve shoulders
		Install rumble strips
	Excessive vehicle speed	Set speed limit based on speed study
	Inadequate pavement markings	Install/improve centerlines, lane lanes, edge lines
		Install reflectorized markers

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	Inadequate signing	Provide advance direction and warning signs
		Add illuminated street name signs
	Superfluous signing	Limit signs to meet standards
Wet Weather	Slippery pavement	Improve pavement condition
		Install high friction surface treatment
		Improve drainage
	Poor visibility	Install raised pavement markers

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Appendix-A Crash Cost

Severity	Cost
K - Fatal	$2,036,913
A - Suspected Serious	$ 582,241
B - Suspected Minor	$ 198,021
C - Possible	$ 66,461
O - Property Damage Only	$ 28,363

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