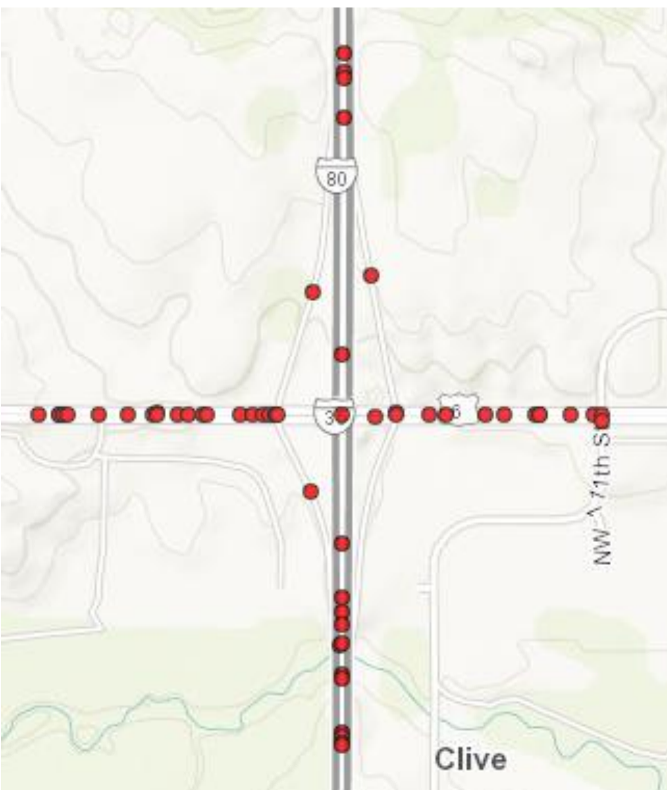



# Iowa DOT Data Driven Safety Guidance

Version 1.0
October 18, 2017

## Contents

## Tables



## Figures

*This page is intentionally left blank.*

# 1 Introduction

## 1.1 Application of this Guidance

This Data Driven Safety Guidance Document supplements the Iowa Department of Transportation (DOT) *User Guide for New or Revised Interchange Access* (Iowa DOT, 2018). It provides guidance for completing safety analyses and reporting results for Iowa DOT interchange projects. However, the steps and information in this guide can be applied to a wide range of transportation studies, including safety, feasibility, and alternative studies. Furthermore, it must be understood that safety analysis methods and tools are still improving and evolving. Therefore, the selection and application of a safety analysis method for any project or study may vary from this guidance as the practice continues to progress.

The guidance was developed to be consistent with the Federal Highway Administration's (FHWA) *Interstate System Access Informational Guide* (FHWA, 2010). The methods are based in large part on the *Highway Safety Manual* (HSM) published in 2010 and 2014 by the American Association of State Highway and Transportation Officials (AASHTO).

This document is not intended to provide a comprehensive set of evaluation procedures; instead the guidance assumes the analyst has experience with data driven safety analysis methods and will follow state and national best practices. While the guidance emphasizes predictive safety methods and the tools used to apply those methods, it also addresses other safety analysis methods. The guidance also highlights the importance of selecting the analysis methods and tools best suited to the type and scale of each project.

## 1.2 Audience for this Guidance

This guide is written for all parties involved in the change in access reporting process, including local agencies, consulting engineers, Iowa DOT staff and others participating in preparing the report and in the approval process. The steps outlined in this document can be used to assist with project scoping by breaking down different types of tasks and providing an understanding of the work. The guide also serves as a resource to use when performing the analysis, assessing existing and future safety performance, and assembling documentation. This document will help preparers of data driven safety documents understand the expectations of the process. It will also promote consistent safety analysis methods and outputs for reports. Iowa DOT and FHWA will use this guidance as a basis for reviewing submitted materials.

## 1.3 Process

The process outlined in **Figure 1-1** provides an overview of the steps for completing a data driven safety analysis for a change in access and reporting the results. These steps are further explained in the following sections.

**Figure 1-1: Process Flow Chart**

# 2 Define Area of Influence and Analysis Years

The safety area of influence and analysis years should adhere to the guidelines outlined in FHWA's *Interstate System Access Informational Guide*. They should also generally match the traffic operational analysis. However, there are safety specific considerations that could affect: the extent of the influence area; when a quantitative or qualitative evaluation is applicable; and which analysis years should be studied.

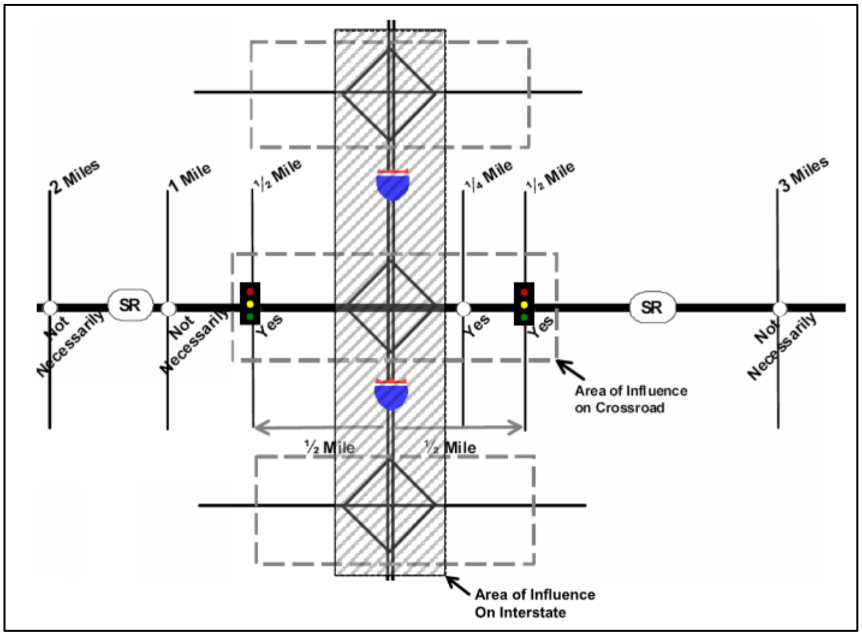
## 2.1 Area of Influence

### 2.1.1 FHWA Definition of Area of Influence

For a safety analysis it is important to define an area of influence that adequately captures the extent of the safety effects of the proposed project. According to FHWA's guidance the change in access study,

> "… should include an area of influence that addresses the safety concerns for the project and includes at least the adjacent interchanges along the Interstate including the roads in the area of influence. For most cases, this will be the same area as the operational analysis. The area of influence can and should be expanded where crash data suggests the need to do so, such as for high crash locations adjacent to the area. At a minimum, the area of influence along the crossroad should extend at least one-half mile from the ramp terminal and include the first major intersection." (FHWA, 2010) [underlining added]

**Figure 2-1: FHWA Defined Area of Influence[1]**




[1] *Source: Interstate System Access Informational Guide,* (FHWA 2010).

### 2.1.2 Iowa DOT Safety Analysis Area Guidelines

The Iowa DOT guidelines recommend considering the safety effects of the project in the following areas:

1. Areas within the Minimum Required Area of Influence[2] (see **Section 2.1.3**)
2. Areas Affected by Future Volume or Speed Changes Beyond the Minimum Required Area of Influence (see **Section 2.1.4**)

For each area, it is important to determine whether a quantitative or qualitative analysis is necessary. **Table 2-1** provides a summary on when quantitative versus qualitative safety evaluation methods are typically used.

**Table 2-1: Quantitative vs Qualitative Safety Assessment[3]**

| Region | Quantitative | Qualitative |
|---|---|---|
| **Minimum Required Area of Influence** | • Mainline, ramp, and cross-street facilities within the limits of construction of any of the alternatives under consideration<br>• Highway elements outside of the construction limits with predicted or measurable safety related changes resulting from potential physical modifications | • Crossroads<br>• Highway elements without any predicted or measurable safety related changes |
| **Areas Affected by Future Volume or Speed Changes Beyond the Minimum Required Area of Influence** | • Usually quantitative if on an interstate facility | • Non-interstate facilities (i.e., cross streets, local arterials, etc.) |

### 2.1.3 Areas within the Minimum Required Area of Influence

For each project, a determination should be made regarding which highway segments or interchanges outside of the construction limits will have their future safety performance affected by the project's proposed physical changes. Typically, these additional elements will be studied quantitatively; however, there may be situations where a qualitative assessment is appropriate.

If there is an area inside the minimum required area of influence that will not be affected:

- with regard to safety performance,
- by the physical changes,

[2] Based on limits shown in **Figure 2-1** from FHWA guidance.

[3] In unique cases, such as those discussed in **Section 3.3**, an area which would normally be evaluated quantitatively may need to be evaluated qualitatively.

- by volume changes,
- by speed changes,
- or by any other HSM methodology input variables

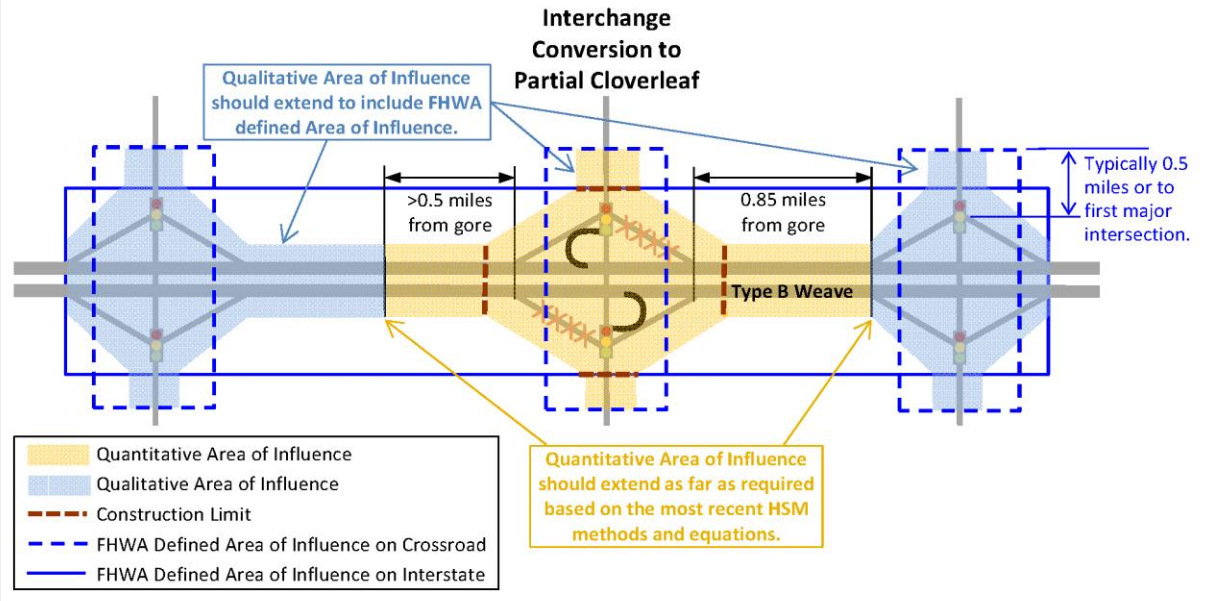
… then that area should be addressed qualitatively with a brief explanation provided as to why it was not studied quantitatively.

In accordance with the FHWA guidance, if the crash data or field observations show a need to expand the quantitative safety analysis area (on either the interstate or cross-street) then it should be extended. In general, the quantitative safety analysis should not extend beyond the limits of where there are quantifiable safety impacts due to the proposed project alternatives either on the mainline or cross-street, except where there are traffic flow or speed changes as discussed in **Section 2.1.4**.

**Example 2-1: Interchange Conversion to Partial Cloverleaf**

The example illustrated in **Figure 2-2** assumes that a diamond interchange is converted to a partial cloverleaf and that constructing the project results in no changes to freeway volumes or mainline speeds. In this example, the quantitative area of influence would include the construction limits. It would also extend along the freeway in either direction to capture the safety effects of moving the ramp gore points; HSM methods should be consulted to determine the extent of potential impact. The freeway segment to the west was analyzed quantitatively for a distance of 0.5 miles from the most westerly gore point of the alternatives being studied. The freeway segment to the east was studied as it is a Type B weave of 0.85 miles or less in length in the no-build condition.

**Figure 2-2: Area of Influence for Interchange Modifications (No Volume or Speed Changes)**



### 2.1.4 Areas Affected by Future Volume or Speed Changes Beyond the Minimum Required Area of Influence

For projects that will affect traffic volume patterns and therefore crash exposure, the project team will need to assess whether regions beyond the minimum required area of influence will need to be evaluated. To capture all safety impacts, the analysis needs to extend to a match point where both the physical infrastructure and volume patterns are the same in the future design year for the Build and No-Build scenarios. However, this is often unnecessary for effective safety decision making.

In cases where the volume patterns between analysis scenarios are expected to be sufficiently different, the differences should be documented. This would include an assessment of shifts between interchanges, but also a consideration of how traffic accesses the interchanges. This information should be available from the change in access traffic forecasting and operational analysis. **Example 2-2** provides an example safety analysis area breakdown for a conversion from an overpass to a full interchange. Similar decisions should be made when mainline, Collector-Distributor (CD) road, or ramp speeds are expected to change since the safety performance of downstream ramps and CD roads can be affected by the upstream entry speeds.

## 2.2 Analysis Years

### 2.2.1 Observed Crash Data Analysis Years

For the quantitative area of influence, the FHWA guidance states safety analysis should examine at least three years of historical/observed crash data. However, the Iowa DOT recommends the analysis use the most recent five years of available crash data. In rural areas with a low number of crashes, up to ten years of data could be used. In either case, if changes that could affect safety were made during that time, then the analysis period should be modified to use only the years since the changes were made, but based on a minimum of three years as recommended by FHWA.

**Obtain Crash Records:** See Section 4 for more information on how to obtain crash records from Iowa DOT's Office of Traffic and Safety

### 2.2.2 Predictive Safety Analysis Years

The future no-build and build quantitative safety analyses should assess the proposed design year safety conditions. The design year is typically 20 years after opening day for the proposed project.

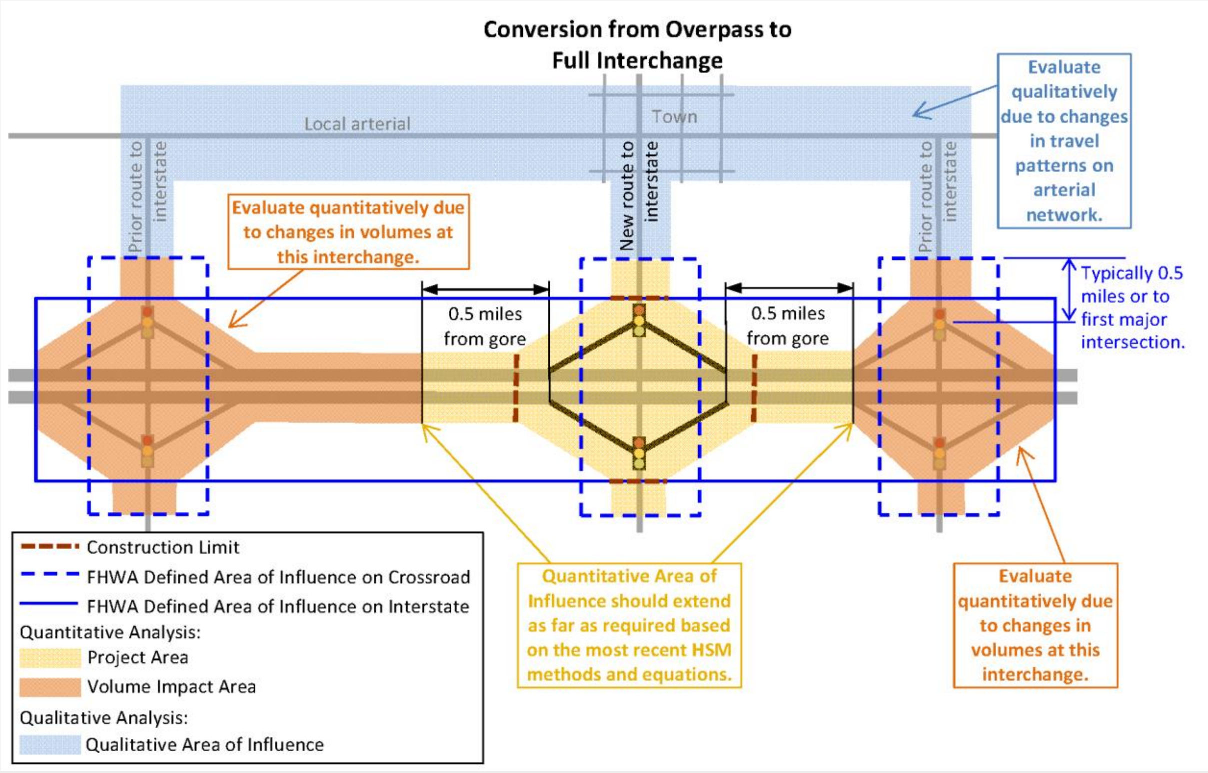
In accordance with FHWA guidance, an opening year and/or one or more phases may also be necessary if there is "phased construction, changes in land use, or other projects within the area of influence." For an Iowa DOT change in access study, if the project phasing is definitive and includes more than three years between phases, then the final build condition and all phases of three years or more in length should be assessed (using the final year of each phase as the analysis year). If the full-build phase is uncertain and/or unfunded; then the team may decide to assess the last definitive and funded phase as the final build condition. An opening year safety analysis may also be provided, if the project team determines that it is useful for informing project decision making. In general, the analysis years should be consistent with the traffic operations analysis.

**Example 2-2: Conversion from Overpass to Full Interchange**
The example illustrated in **Figure 2-3** assumes that a new interchange would draw traffic from other nearby interchanges. In this example, the quantitative are of influence would include the construction limits and extend 0.5 miles each way to capture the safety effects of gore location. Safety changes due to this shift are to be assessed as well; this could take the form of:

- A qualitative assessment which highlights expected safety benefits and drawbacks due to changes in exposure on different types of facilities.
- A system level comparison of vehicle miles traveled on different functional classification roadways.
- Quantitative HSM elements, such as crash predictions, for the interstate cross-street terminals (if that level of analysis is determined to be necessary to adequately assess the safety benefits and impacts).

In general, the quantitative analysis focuses on the interstate facilities and cross streets where changes are planned, while off-system benefits and impacts are assessed qualitatively.

**Figure 2-3: Area of Influence for New Interchange with Volume Pattern Changes**



Instead of analyzing study years as separate models, one variation that can be applied for the future predictive safety analysis is to use the built-in functionality of the HSM freeway tools (discussed later in this document) to predict crashes over the entire analysis time frame. This approach can provide a more complete picture of the predicted freeway related safety outcomes of the different alternatives. To develop a crash prediction for entire analysis time frame, freeway volumes can be entered into the Interactive Highway Safety Design Model (IHSDM) for each individual year. However, IHSDM can also interpolate volumes between a starting and ending year in order to estimate the crash prediction for the entire analysis time frame. For each change in access the analyst must determine if the crash prediction can be select year or needs to include every year in the analysis time. Where the crash prediction is every year, the analyst also must decide between developing yearly volumes and allowing IHSDM to linearly interpolate.

# 3 Methods for Evaluating Safety Performance

The purpose of this section is to outline the methods available for evaluating highway safety performance for a change in access and to provide direction on how to select and document the most efficient and effective methods and tools for each project.

There are two primary categories of safety analysis methods: 1) Observed Crash Data Analysis and Field Review; and 2) Predictive Safety Analysis. These two approaches provide distinct quantitative measures and address different needs in the change in access process. **For Iowa DOT change in access projects, it will be necessary to use both methods to assess current highway safety performance and to predict future highway safety performance for a range of scenarios.** The specific methods and the extent of the analysis will depend on the type and magnitude of the proposed project.

There are several resources available to help select the appropriate methods and level of analysis for each project. Typical observed and predictive analysis applications for various safety assessment methods are summarized in *Scale and Scope of Safety Assessment Methods in the Project Development Process* (FHWA, 2016).

## 3.1 Observed Crash Data Analysis and Field Review

For a typical change in access it is important to evaluate the existing safety performance of the safety analysis area highways through studying historical/observed crash data. It is also important to conduct a field review to identify potential safety issues. These analyses are useful for supporting the purpose and need for the project and for setting project goals. They may also be useful for supporting the future predictive analysis.

### 3.1.1 Basic vs. Advanced Observed Crash Data Analysis

For each change in access the analyst must determine the level of detail that is needed. For a minor modification or a new interchange in an area without any known safety issues, a basic crash analysis may be sufficient. However, for a project with known safety concerns (e.g. a short weaving section) an advanced crash analysis may be necessary.

#### Basic Observed Crash Data Analysis

The basic observed crash data analysis could consist of:

- A summary review of historical/observed crash data, including GIS maps using different symbols or colors to display crash severity and manner of crash/collision impact by location to identify trends.
- Tables or graphs for severity, manner of crash/collision impact, major cause, and contributing circumstances.
- Calculating crash rates for the freeway mainline and intersections and comparing them to statewide averages.

- A field review to document observable safety issues. Information that may be documented includes geometric characteristics; traffic control devices; traffic volumes including interactions with pedestrians, bicyclists, and heavy vehicles; unique or unexpected site conditions; land use; and any elements that may suggest a safety concern (e.g. skid marks, scrapes on guardrail or trees).

See **Section 5.2** for more details on basic observed crash data analysis.

### Advanced Observed Crash Data Analysis

An advanced observed crash data analysis is necessary when safety is part of the project need or when safety concerns have been identified. This analysis would include the basic observed crash data analysis as well as additional crash data items, such as:

- Maps and graphs to help identify trends and issues
- Collision diagrams
- Highway condition diagrams (e.g., from a simple field sketch to a log of roadway characteristics by location)

See **Section 5.3** for more details on advanced observed crash data analysis.

Areas of influence that are being addressed qualitatively for safety do not require the creation of maps, graphs, and tables for the documentation; however, the analyst should review crash mapping for the area to determine if there are any safety concerns that relate to the project. Field observations should also be conducted for that portion of the safety analysis area.

## 3.2 Predictive Safety Methodologies

Most Iowa DOT change in access projects will require some level of quantitative predictive safety analysis. Some projects may require a basic analysis which clearly demonstrates a project's safety benefits, while other projects may require a more advanced analysis that takes into account many different facility types and input variables. Regardless of the level of detail, the analysis will be data driven and will rely on the HSM methods.

The 2014 Supplement to the HSM documents predictive methods for freeways, ramps, CD roads, and ramp terminals. Chapter 18 provides, "a structured methodology to estimate the expected average crash frequency (in total, by crash type, or by crash severity) for a freeway with known characteristics." (AASHTO, 2014) Chapter 19 provides the same "structured methodology" for ramps. The earlier 2010 HSM volumes address rural two-lane roads, rural multilane highways, and urban and suburban arterials.

### 3.2.1 Basic vs. Advanced Predictive Safety Analysis

For Iowa DOT change in access studies, two types of quantitative analyses are recommended. The team should select the appropriate analysis level at the start of the project. FHWA's *Scale and Scope of Safety Assessment Methods in the Project Development Process* (FHWA, 2016) contains more detailed information to help determine the appropriate level of predictive safety analysis.

#### Basic Predictive Safety Analysis

For a simple modification to an interchange, it may be possible to provide a basic predictive safety analysis for the area of influence that provides sufficient information to support good project decision making. This approach would not implement all of the steps in the HSM predictive method, but would consider the observed crash data analysis and then examine crash modification factors (CMFs) that demonstrate the future benefits of the project (see **Section 3.2.3** for a discussion of CMFs). For example, this approach might apply to an isolated loop ramp project that improves the ramp geometry (e.g. longer taper and increased radius) and the ramp terminal intersection (e.g. added turn lanes and upgraded traffic signal).

In a situation where a number of potential alternatives are being evaluated, the basic approach may be used to screen the alternatives before completing a more advanced analysis.

#### Advanced Predictive Safety Analysis

For more complex projects, the full HSM predictive methods should be applied to calculate the predicted average crash frequency for the no-build and build conditions. This includes using safety performance functions (SPFs) and CMFs to calculate the safety performance of the proposed condition. SPFs are discussed in **Section 3.2.2** and CMFs are discussed in **Section 3.2.3**. If calibration factors are available they should be used (see **Section 3.2.4**). The use of Empirical Bayes (EB) adjustments should follow the guidelines in the HSM (see **Section 3.2.5**).

A review of the existing highways and potential improvements should be conducted during the methodology selection phase of the project to identify unusual or atypical conditions that will require special treatment. For freeways, this could include a preliminary segmentation of the freeway facilities. One benefit of a preliminary segmentation process is that it can help the analyst clearly identify elements that do not conform to the current HSM imitations and therefore need special attention during the methodology development. For example, a diverging diamond interchange or an arterial weave section in a cloverleaf interchange are not directly addressed by the current published HSM methods and would require unique prediction methods based on research.

### 3.2.2 Safety Performance Functions (SPFs)

Most Iowa DOT change in access predictive safety analyses should be based on the published HSM SPFs. These SPFs address the majority of freeway and cross-street facilities that will be studied. Refer to **Section 3.3** for unique situations not currently covered by the HSM equations.

### 3.2.3 Crash Modification Factors (CMFs)

CMFs are multiplicative factors that indicate the change in the number or type of crashes that would be expected due to the presence of a specific treatment or design feature. CMFs below 1.0 indicate an expected decrease in crashes and CMFs above 1.0 indicate an expected increase in crashes due to the treatment or feature. There are two primary applications for CMFs:

- First, CMFs can be used to estimate the effects of changes in conditions on observed crash frequency, independent from predictive models. This use applies to the **basic predictive safety analysis**.
- Second, for the HSM predictive method, CMFs are used to adjust the base condition predictions from SPFs to account for additional characteristics of the highway facility. This use applies to the **advanced predictive safety analysis**. Note that the CMFs provided in the Part C sections of the HSM and calibrated with specific SPFs should only be used with those SPFs. However, additional CMFs can be applied to SPF predictions to account for additional features, within the limitations outlined in the HSM and the CMF Clearinghouse. In general, additional CMFs should be limited to no more than three, clearly independent, CMFs. Often, a lack of independence will limit the analyst to fewer than three additional CMFs.

While Part D of the HSM provides many CMFs, it does not cover all situations. However, CMFs are continually being researched and published in the CMF Clearinghouse. Not all of the CMFs published in the Clearinghouse are appropriate for use. For Iowa DOT change in access studies, only Clearinghouse CMFs with a star rating of 3 or more should be used. In addition, the analyst should review the underlying research to confirm that the CMF is applicable to the situation. All CMFs should be clearly applied, documented, and referenced in the methodology documentation. Refer to HSM, Volume 1, Section 3.5.3 for more details on applying CMFs.

Published and unpublished CMFs can also be useful for unique situations which are not captured by existing SPFs. For more discussion on unique situations, please see **Section 3.3**.

**CMF Clearinghouse:** http://www.cmfclearinghouse.org/

### 3.2.4 Calibration Factors

Iowa DOT's Office of Traffic and Safety is working to develop calibration factors to adjust the HSM SPFs to Iowa conditions. The calibration factors will adjust the HSM prediction equations that were developed using data from other states to better match local conditions, taking into account differences in climate, driver behavior, animal populations, crash reporting thresholds, and enforcement. Calibration factors have been developed for freeways and two-lane rural roads as shown in **Table 3-1** and **Table 3-2**. The calibration factors should be used in all predictive safety analysis work. Where no calibration factor is available, the analysis should clearly state that the results are not calibrated and that the results are comparative only.

Analysts can check with the Iowa DOT Office of Traffic and Safety to determine if additional calibration factors are available and for assistance in obtaining an IHSDM configuration file with the calibration factors pre-loaded.

**Table 3-1: Iowa Urban and Rural Freeway Segment Calibration Factors**

| Crash Type | Calibration Factor |
|---|---|
| **Urban Freeway** | |
| Multiple-Vehicle Fatal and Injury | 1.26 |
| Multiple-Vehicle Property Damage Only | 1.79 |
| Single-Vehicle Fatal and Injury | 0.85 |
| Single-Vehicle Property Damage Only | 1.17 |
| **Rural Freeway** | |
| Multiple-Vehicle Fatal and Injury | 1.08 |
| Multiple-Vehicle Property Damage Only | 1.67 |
| Single-Vehicle Fatal and Injury | 0.64 |
| Single-Vehicle Property Damage Only | 1.16 |

**Table 3-2: Iowa Rural, Primary, Two-Lane Road Segment Calibration Factors**

| Crash Type | Calibration Factor |
|---|---|
| All Crashes | 0.837 |

### 3.2.5 Application of Empirical Bayes (EB) Method

The Empirical Bayes (EB) method uses historical/observed crash data to adjust the SPF's predicted crashes into an expected number of crashes. This method weights observed frequencies and predicted crash frequencies to provide an expected[4] crash frequency representative of both historical trends and the prediction models. This method addresses the issue of regression to the mean; however, it is only applicable if only minor geometric changes are proposed. The EB method is not applicable if the number of through lanes changes, if traffic control changes, or if there are major alignment changes. Therefore, for many change in access analyses, the EB method will not be applicable due to either the extent of the proposed changes. If multiple alternatives are

[4] *The HSM makes a distinction between Predicted Crashes and Expected Crashes. Predicted Crash Frequency is based on the geometric design, traffic control and traffic volumes of the local conditions. The Expected Crash Frequency is the combination of the predicted crash frequency weighted with the historical crash frequency (using the Empirical-Bayes methods).* (ODOT, 2017)

analyzed, the EB method should be used in all or none of the predictions so that comparisons are based on the same analytical techniques. The HSM guidance on the applicability of the EB method should be consulted before it is proposed for use. If it is used it should be documented clearly.

**EB Method Resources:** Refer to HSM, Volume 1, Section 3.5.5, the Part C Appendix, and the 2014 Supplement Appendix to determine if the EB method is applicable.

### 3.2.6 HSM Application Tools

For Iowa DOT change in access studies, the analyst can select the most appropriate implementation tool for each project. The publically available tools include:

- Interactive Highway Safety Design Model (IHSDM) – All HSM methods
- Enhanced Interchange Safety Analysis Tool (ISATe) – Freeways and Ramps
- NCHRP 17-38 HSM Spreadsheets – Non-Freeway Facilities

Other tools may also be considered, but they should be approved as part of the Methods and Assumptions document (see **Section 3.4**).

IHSDM (freeway and non-freeway elements): IHSDM is a software suite which implements the HSM predictive methods for both freeways and non-freeways. Benefits include:

- analyzing multiple facility types in one model,
- directly importing project alignment data,
- automatic corridor segmentation,
- presence of a highway graphical viewer, and
- calibration utility to help implement HSM calibration procedures.

IHSDM resources include tutorials, a help menu, and a help line with free technical support.

**IHSDM Download:** The current release may be downloaded free here: http://www.ihsdm.org

**IHSDM Support:** Phone: (202) 493–3407; Email: IHSDM.Support@dot.gov

ISATe (freeway elements only): ISATe is a macro-enabled Excel workbook for analyzing freeway segments, ramps, and ramp terminals. As an Excel based analysis tool, it is fairly easy to use; however, segmentation must be done manually and the number of analysis elements per workbook is limited. If non-freeway elements need to be modeled, then the NCHRP 17-38 HSM Spreadsheets would also need to be used.

| |
|---|
| **ISATe Spreadsheets Download:** Information for downloading ISATe and the user manual can be found at: http://www.highwaysafetymanual.org/Pages/tools_sub.aspx |

NCHRP 17-38 HSM Spreadsheets (non-freeway elements only): Similar to ISATe, the NCHRP 17-38 HSM spreadsheets are macro-enabled Excel workbooks and are fairly intuitive to use. These spreadsheets implement HSM methods for: rural two-lane, two-way roads; rural multilane highways; and urban/suburban arterials.

| |
|---|
| **NCHRP 17-38 Spreadsheets Download:** Information for downloading the spreadsheet tools can be found at http://www.highwaysafetymanual.org/Pages/tools_sub.aspx |

### 3.2.7 HSM Model Considerations

Segmentation

Depending on the project, it may be beneficial to compare the crash results of different alternatives by section of the facility. If so, the roadway section start and end points would need to be consistent across alternatives. If this approach is used, then it should be documented and approved in the Methods and Assumptions document (see **Section 3.4**). Segmentation for the purposes of modeling facilities is discussed in the HSM, Chapter 18. It should be noted that in the IHSDM tool a project corridor is automatically segmented, while ISATe requires manual segmentation, making it possible to control how segmentation is done.

Quality Control

In conformance with best practice, all data entry into software and spreadsheets should include a detail check and a quality control review. In order to minimize redundant mistakes, it may be beneficial to perform a review on the base model before copying it and modifying it to develop models for other alternatives.

## 3.3 Facilities Not Covered by the Predictive Safety Methods

If a facility cannot be modeled using the documented HSM predictive safety methods, then the following approach should be followed (This process is outlined in **Figure 3-1**):

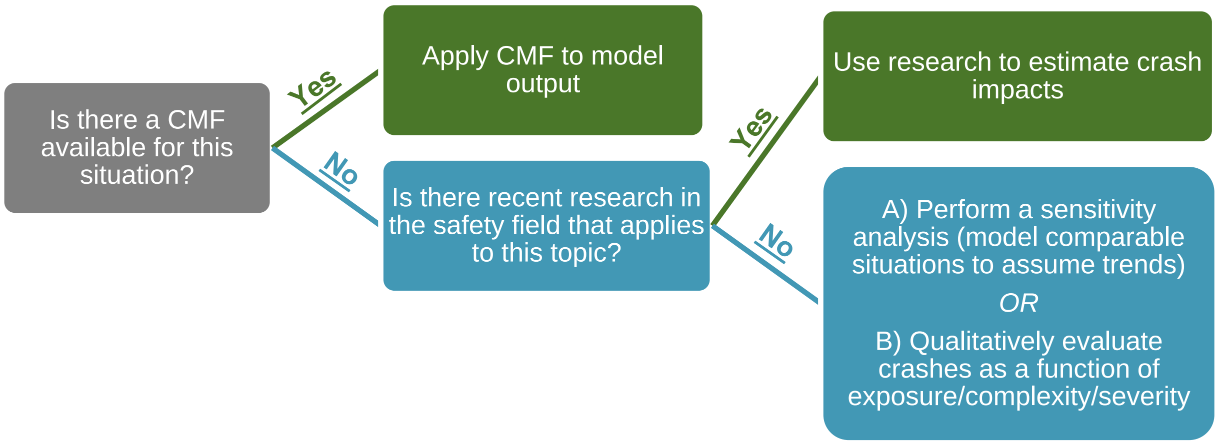
**Step 1:** Investigate whether there is a CMF available for this situation in the CMF Clearinghouse (see discussion in **Section 3.2.3**) or any other reliable sources. If yes, model the scenario without the facility and then apply the CMF to the model output. If no, move on to Step 2.

**Step 2:** Investigate if there is recent research in the safety field that applies to this topic. If there is, then use the research to provide an indication of what the CMF may be and/or assess what the crash impacts are on a higher level. If no research is available, then move on to Step 3.

**Step 3, Option A:** Perform a sensitivity analysis by modeling comparable situations and disseminating trends through a bracketing comparison. For example, if a 3-lane collector distributor (CD) road is being assessed, one may infer that a C-D road generally has fewer crashes than an arterial and more crashes than a freeway. By modeling the road as an arterial and also as a freeway, one can infer that the results are somewhere in-between.

**Step 3, Option B:** Another alternative would be to apply a qualitative framework such as evaluating crashes as a function of exposure, complexity of situation, and potential severity of the situation. By assessing these conditions, changes in exposure, complexity, and severity can be compared to estimate the qualitative safety impacts.

**Figure 3-1: Method for Addressing Facilities Not Covered by the Predictive Safety Methods**




**Example 3-1: Alternative Interchange Configuration (DDI)**

Existing SPFs in the HSM do not account for alternative interchange configurations such as a Diverging Diamond Interchange (DDI), which is also known as a Double Crossover Diamond (DCD) interchange. In this example, assume that a standard diamond interchange will be converted into a DDI. The first step would be to search the CMF Clearinghouse for applicable CMFs.

As of May 2017 there are three sets of CMFs for DDIs based on three different research documents. The analyst must examine the available CMFs and research documents to determine which ones are most applicable. This could mean selecting a project level CMF or a site specific CMF. The analysis should be adjusted as necessary for these two conditions. Once a CMF is selected, then it should be applied as directed in the HSM. The selected CMF should be clearly documented and referenced in the predictive safety analysis.

## 3.4 Methods and Assumptions Document

Some projects include development of a project-specific Methods and Assumptions (M&A) document that outlines forecasting and analysis methods and assumptions to be used on the project. M&A documents may be created for Interchange Justification Reports (IJRs), Interchange Operations Reports (IORs) or other large analysis studies. To the extent possible, the details of the proposed safety analysis approach should be incorporated into the overall M&A document. If a project M&A document is not developed for the project as a whole, such a document that is specific to the safety analysis effort should be considered and discussed with Iowa DOT for applicability on a project for multi-party agreement and for reference throughout the project. The following safety analysis information should be included in an M&A document:

- Area of Influence (quantitative and qualitative)
- Analysis Years
- Observed Crash Data Analysis Methods
- Predictive Safety Analysis Methods
- Special Methods Required

# 4 Request and Collect Data

## 4.1 Data to Support Observed Crash Data Analysis

There are several data items that are needed to support the basic observed crash data analysis including: field observations, geocoded crash data, daily traffic volumes, and comparison crash rate data. Additional items which would be needed for an advanced observed crash data analysis, such as geometry data, speed data, or copies of redacted crash reports, are further discussed in **Section 5.3**.

### 4.1.1 Field Observations

Field observations should be made during peak periods of a typical day and may be done through observing video data or through physical observation. If traffic volumes are being collected as part of the change in access study or if field observations are being made for traffic operations, it is preferable to perform field observations on the same day(s). Key observations should be documented, such as: high-risk vehicle maneuvers, vehicle-pedestrian conflicts, less than desirable roadway factors[5], and other potential contributing factors. Field observations can supplement traditional crash records. Observations may either help explain why crashes occurred or reveal issues that have not resulted in a crash.

### 4.1.2 Geocoded Crash Data

The geocoded crash data allows for the creation of key maps and tables as well as the computation of crash rate calculations. For a change in access study the most recent three to five years of crash data should be collected for the quantitative safety analysis area. In rural situations, where the crash frequency is low, 10 years of data could be collected instead. **When using a longer timeframe, it is important to check for changes that could affect the analysis (e.g. geometry, barrier, or traffic control changes).**

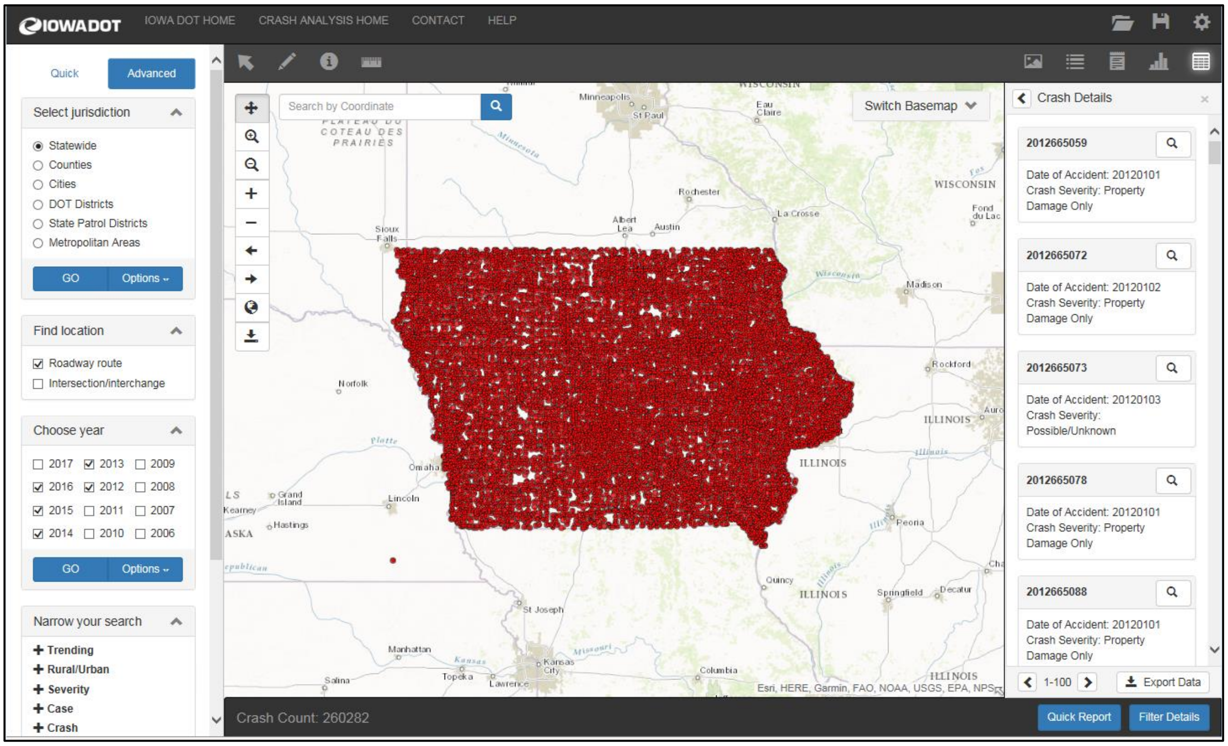
> **Obtain Crash Records:** See Section 2.2.1 for more information on how to select the analysis time frame.

Iowa DOT's Office of Traffic and Safety Crash Analysis Resources webpage provides several resources for obtaining crash analysis data. Iowa DOT's Geographic Information System-based Safety Analysis, Visualization, and Exploration Resource (GIS-SAVER) crash software program has recently been publically released as an online tool called web-SAVER (see **Figure 4-1**). Through the web-SAVER interface, one can select project boundaries and then export crash data to the following formats: xlsx (Microsoft Excel), csv (Comma-Separated Values), txt (Text File), shapefile (used for GIS software), or

[5] Examples of roadway factors include: inadequate sightlines/sight distance, lack of shoulders, horizontal or vertical curves with small radii, inadequate advanced warning systems, poor road surface conditions, etc.

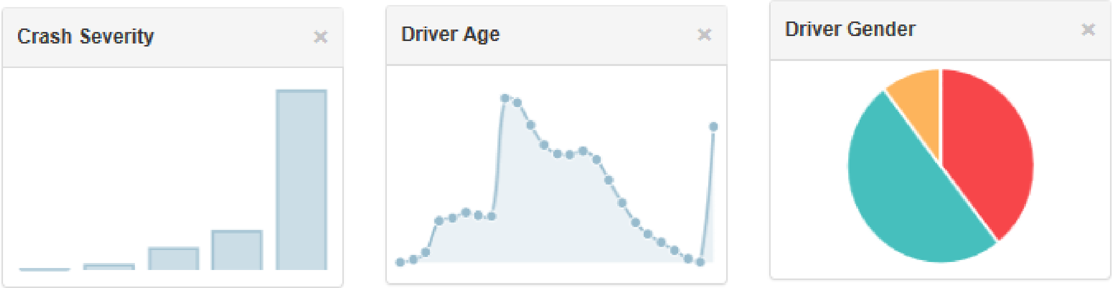
kmz/kml (Keyhole Markup Language, often used for importing into Google Earth). Additionally, the program can output either Quick Reports or Abbreviated Reports, which summarize detailed information on all crash data points selected by the user.

### Figure 4-1: Iowa DOT's web-SAVER Program[6]




The web-SAVER software is also capable of producing summary charts which could be utilized in documentation. **Figure 4-2** provides examples of summary chart types available through the program.

### Figure 4-2: Example Charts from Iowa DOT's web-SAVER Program[7]




---

[6] *Screenshot of program main page, March, 2017.*

[7] *Screenshot of program main page, March, 2017.*

web-SAVER will continually be upgraded by Iowa DOT. With each new release, functionality will be expanded. As a result, some information may not yet be available through the program such as vehicle characteristics or driver characteristics. The following process should be followed to obtain this additional information:

1. Obtain all available information from web-SAVER within the project boundaries.
2. Export crash record data to a Microsoft Excel workbook and create a list of crash case numbers. Be sure to remove all duplicates in excel (this can be done by selecting the range of cells and clicking "Remove Duplicates" on the data tab in the data tools group).
3. Email Iowa DOT Office of Traffic and Safety the consolidated list and be sure to indicate which data fields are needed (crash record, vehicle record, and people/driver record). Also, it is advised that data requests be submitted as early as possible to allow for time needed to process and respond to requests.

**Iowa DOT Office of Traffic and Safety, Crash Analysis Web Page:**
http://www.iowadot.gov/crashanalysis/index.htm
**web-SAVER*:** https://saver.iowadot.gov/
**Note: For more information on web-SAVER features, access the program Help Documentation, which can be found by clicking "Help" in the program.*

### 4.1.3 Daily Traffic Volume Data

Daily traffic volume data (e.g., annual average daily traffic) is needed for computing crash rates and for understanding the character of the freeway segment and surrounding cross streets. When computing crash rates, daily volumes should be representative of the historical/observed crash data analysis study period.

There are various sources for obtaining daily traffic volumes, including collecting traffic counts as part of the project, and also obtaining traffic count book data from the Iowa DOT Office of Systems Planning, found through the link shown below. If only hourly volumes are available, then K factors (the proportion of daily traffic occurring in an hour) can be used to approximate daily volumes. K factors should be developed in coordination with Iowa DOT Office of Systems Planning. **Traffic data requests from Iowa DOT for the safety analysis should be coordinated with the traffic operations analysis data requests to obtain consistent data and prevent duplicate requests.**

**Links to Iowa Traffic Reports:** https://iowadot.gov/maps/data/volume-of-traffic-on-the-primary-road-system

### 4.1.4 Comparison Crash Rate Data

After computing crash rates, they should be compared to statewide crash rate averages to establish a baseline. A comparison to statewide averages does not indicate if the area is performing as well as it could or if there is a pattern in the crashes that could be corrected. Statewide crash rate averages are provided on Iowa DOT's Office of Traffic and Safety webpage at the link shown below.

> **Iowa DOT Statewide Crash Averages:**
> http://www.iowadot.gov/crashanalysis/comparablesprofilesmain.htm

## 4.2 Data to Support Predictive Safety Analysis

### 4.2.1 Geometric Data

Most safety models require that geometric data be entered into the analysis. This includes the variables listed in **Table 4-1**. Further information, including geometric data needs for cross road facilities can be found in the HSM.

**Table 4-1: Geometric Data Needs for Freeway Facilities**

| Freeways | Ramps | Ramp Terminals/Intersections |
|---|---|---|
| • Number of Lanes<br>• Length of Segment<br>• Horizontal Curve Data<br>• Lane, Shoulder, and Median Width<br>• Rumble Strip Length<br>• Length and Offset of Barrier<br>• Presence of Type B Weaving<br>• Distance to Nearest Ramps<br>• Clear Zone Width | • Number of Lanes<br>• Length of Segment<br>• Horizontal Curve Data<br>• Lane and Shoulder Width (Paved)<br>• Length and Offset of Barrier<br>• Presence of Weaving (C-D Road Only)<br>• Type of Traffic Control at Crossroad Terminal | • Terminal Configuration<br>• Traffic Control Type<br>• Presence of Public Street at Terminal<br>• Exit Ramp Skew Angle<br>• Distance to Nearest Ramp/Public Street<br>• Crossroad Median Width<br>• Number of Lanes on Crossroad and Ramp<br>• Right Turn Channelization<br>• Presence of Left- and Right-Turn Bays<br>• Width of Left-Turn Bays<br>• Number of Driveways and Public Streets Near Terminal (within 250ft) |

In order to compare scenarios, it is important that geometric data be available for existing conditions as well as proposed conditions. The analysis will be more accurate if the geometric information is detailed.

#### Existing Conditions

There are several methods that can be used for obtaining the existing conditions geometry data. If a survey is available for the project area, that can be used. High quality aerial photography is another method. Current as-built highway plans and/or field measurements can also be used.

The Roadway Access Management System (RAMS) is an Iowa DOT database used to store roadway data. Most relevant to safety analysis are the traffic and roadway geometrics maintained in the database for all Iowa public roads. RAMS data can be extracted to input in IHSDM; however, the RAMS location information is in milepoint and needs to be converted to stations for IHSDM.

#### Proposed Conditions

Concept sketches or design plans should be obtained to enter the proposed geometries into the safety models. If using IHSDM, then it is possible to directly import alignment data from LandXML format into IHSDM. Note that it is possible to create LandXML files from alignment files, such as InRoads. For the spreadsheet models it is necessary to hand enter data, but once entered the data can be copied from one segment or file to another (using certain Excel techniques). Coordinate with geometric designers to determine the geometric inputs.

### 4.2.2 Traffic Volumes

Most safety models require the use of daily (24-hour) counts. When available and applicable, data should be obtained for multiple years to correlate with the entire study period. Since traffic analysis also typically requires volume data, coordinate with traffic modelers when requesting data from Iowa DOT to apply consistent data and prevent duplicate requests.

Future traffic volumes should also be developed in coordination with Iowa DOT Office of Systems Planning and should be coordinated with those performing the traffic operations analysis.

**Iowa DOT Office of Systems Planning Web Page:**
http://www.iowadot.gov/systems_planning/index.htm

# 5 Complete Existing Safety Performance

As outlined in Section 3.1, there are two general levels for evaluating the existing safety performance. The basic observed crash data analysis applies to change in access for projects that include only minor modifications or an area without any known safety issues. Advanced observed crash data analysis (which builds on the basic analysis) is to be used for all other change in access studies. Before performing an evaluation, however, Iowa's safety improvement candidate list should be consulted (see Section 5.1).

## 5.1 Safety Improvement Candidate List

Iowa DOT's Office of Traffic and Safety periodically updates a list of the Safety Improvement Candidate Locations (SICL) in Iowa and this list is available online. This list should be reviewed to determine if any sites in the safety analysis area are identified as a SICL. The webpage provides links to information prepared for each site to aid in the analysis of candidate sites.

If any intersection in the safety analysis area is listed as a SICL, the location should be closely observed during field reviews. Furthermore, preparing a collision diagram for the intersection may help identify existing crash patterns that can be addressed with project improvements. Finally, if a SICL is a key intersection in the safety analysis area, this indicates that advanced safety analysis methods should be used instead of the basic safety analysis methods.

**Iowa DOT Safety Improvement Candidate Locations:**
https://www.iowadot.gov/crashanalysis/top200.aspx

## 5.2 Basic Observed Crash Data Analysis

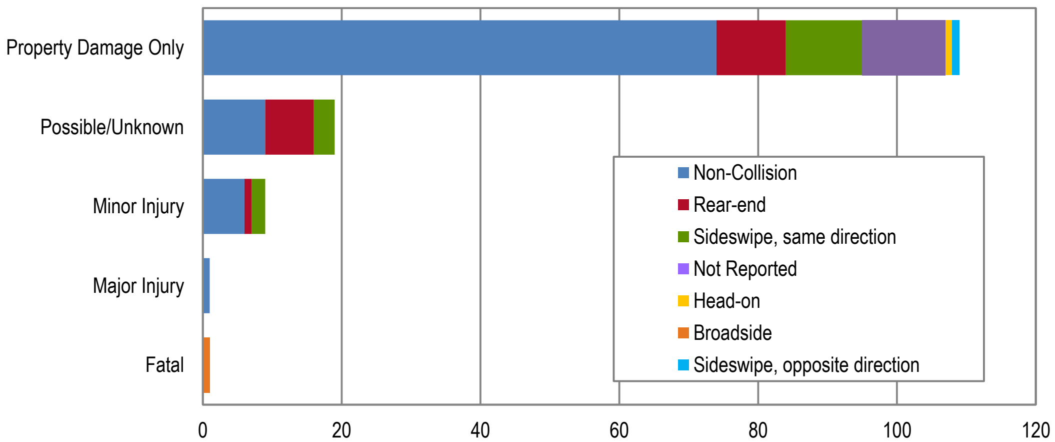
The basic observed crash data analysis should provide a crash data review for the quantitative area of influence. A quick summary of the general fields includes:

- **Crash Identifiers** (date, day of week, time of day)
- **Crash Type / Manner of Collision** (rear end, sideswipe, head-on, single vehicle, etc.)
- **Crash Severity** (fatal, serious injury, minor injury, possible injury, property damage only)
- **Location and Sequence of Events** (direction of travel, location, most harmful event)
- **Contributing Circumstances** (road condition, lighting, weather, impairment of drivers, etc.)

Web-SAVER software can be used to help prepare the review. Graphs and maps should be used to make crash patterns more apparent. Often graphs and maps help reveal patterns that are not as clear using only tables.

The basic analysis should include GIS maps showing at least crash severity and manner of collision. Graphs and tables should be prepared to address location, severity, manner of collision, major cause, and contributing circumstances. These should be designed to help identify any crash trends. **Figure 5-1** shows an example graph, highlighting crash severity by crash type. **Table 5-1** and **Table 5-2** provide examples of manner of crash and major cause of crash summaries. Additional crash data fields should be addressed as determined to be needed to screen for safety issues in the quantitative area of influence.

### Figure 5-1: Example Graphical Summary




The most recent Iowa crash report form and code sheets can be found at the link shown below. These sheets provide the detailed data fields that can be examined. The analyst should examine all of the data fields to determine which ones are most useful for evaluating the safety performance of the quantitative area of influence for each specific project.

**Crash Report Form and Code Sheets:**
http://www.iowadot.gov/mvd/driverslicense/accidents.htm

The analyst should also use Web-SAVER software to review the qualitative area of influence. No maps, graphs, or tables need to be created for inclusion in the documentation unless the review reveals issues that relate to the change in access.

### Table 5-1: Example Manner of Crash Summary (Segments)[8]

| Manner of Crash | Number of Crashes |
|---|---|
| Rear-end | 259 |
| Sideswipe - same direction | 229 |
| Broadside | 1 |
| Angle - oncoming left turn | 1 |
| Head-on | 1 |
| Not reported | 26 |
| Non-collision | 424 |
| Unknown | 6 |
| **Total Crashes** | **947** |

*Source: HDR, based on 2009 – 2013 crash data provided by the Iowa DOT Office of Traffic and Safety, January 2015.*

### Table 5-2: Example Major Cause of Crash Summary (Segments)[9]

| Cause of Crash | Number of Crashes |
|---|---|
| Animal | 41 |
| Operating vehicle in an erratic/reckless/careless/negligent/ aggressive manner | 26 |
| Lost control | 46 |
| Made improper turn | 1 |
| Driving too fast for conditions | 230 |
| Followed too close | 94 |
| Swerving/evasive action | 204 |
| Ran off road - left | 66 |
| Ran off road - right | 63 |
| Crossed centerline | 21 |
| Exceeded authorized speed | 8 |
| FTYROW: From yield sign | 2 |
| FTYROW: Other (explain in narrative) | 63 |
| Equipment failure | 3 |
| Inattentive/distracted by: Use of phone or other device | 1 |
| Other (explain in narrative): Other improper action | 28 |
| Other (explain in narrative): No improper action | 13 |
| Unknown | 22 |
| Other (explain in narrative): Vision obstructed | 3 |
| Cargo/equipment loss or shift | 2 |
| Ran off road - straight | 4 |
| Over correcting/over steering | 4 |
| Traveling wrong way or on wrong side of road | 2 |
| **Total Crashes** | **947** |

*Source: HDR, based on 2009 – 2013 crash data provided by the Iowa DOT Office of Traffic and Safety, January 2015.*

Crash rates (total and fatal or fatal+injury) should be calculated for the freeway mainline, crossroads, and any intersections in the quantitative area of influence. These rates

[8] *Source: I-80/35/235 Northeast Mixmaster –Interchange Justification Report. Prepared by HDR Engineering, Inc. for Iowa Department of Transportation* (November 2015).

[9] *Source: I-80/35/235 Northeast Mixmaster –Interchange Justification Report. Prepared by HDR Engineering, Inc. for Iowa Department of Transportation* (November 2015).

should be compared to statewide averages (see **Section 0**). **Table 5-2** shows an example of how total crash rate data could be summarized for mainline segments.

**Table 5-3: Example Crash Rate Summary (Segments)[10]**

| Location [1] | Length (miles) | ADT [2] | Number of Crashes | Crashes/ 100 MVM [3] | Statewide Crashes/ 100 MVM [4] |
|---|---|---|---|---|---|
| **Eastbound I-80** | | | | | |
| M1 | 0.25 | 43,205 | 43 | **218.14** | 100 |
| M2 | 0.38 | 37,681 | 14 | 53.57 | 100 |
| M3 | 0.42 | 39,635 | 17 | 55.96 | 100 |
| M4 | 0.58 | 41,651 | 46 | **104.34** | 100 |
| M5 | 0.24 | 36,453 | 29 | **181.63** | 100 |
| M6 | 0.35 | 30,753 | 34 | **173.09** | 100 |
| M7 | 2.26 | 37,128 | 173 | **112.97** | 100 |
| **Westbound I-80** | | | | | |
| M8 | 1.89 | 38,527 | 119 | 89.55 | 100 |
| M9 | 0.31 | 33,134 | 36 | **192.05** | 100 |
| M10 | 0.41 | 29,317 | 28 | **127.64** | 100 |
| M11 | 0.64 | 42,428 | 74 | **149.33** | 100 |
| M12 | 0.36 | 39,342 | 4 | 15.48 | 100 |
| M13 | 0.40 | 42,641 | 16 | 51.40 | 100 |
| M14 | 0.21 | 46,046 | 36 | **204.00** | 100 |
| **Northbound I-235/35** | | | | | |
| M15 | 0.94 | 30,882 | 31 | 58.51 | 100 |
| M16 | 0.78 | 19,648 | 32 | **114.41** | 100 |
| M17 | 1.14 | 37,309 | 67 | 86.32 | 100 |
| **Southbound I-35/235** | | | | | |
| M18 | 1.13 | 37,915 | 54 | 69.06 | 100 |
| M19 | 0.77 | 18,236 | 32 | **124.87** | 100 |
| M20 | 1.06 | 32,110 | 62 | 99.81 | 100 |

*Source: HDR, based on 2009 – 2013 crash data provided by the Iowa DOT Office of Traffic and Safety, January 2015.*
[1] *Locations of Mainline Segments shown graphically in **Figure 2.1-4**.*
[2] *Year 2012 Annual Daily Traffic, Iowa DOT Office of Systems Planning, December 2014.*
[3] *MVM – Million Vehicle Miles. Highlighted cells indicate calculated crash rate exceeding the statewide average.*
[4] *Iowa DOT Office of Traffic and Safety, May 13, 2015, Crash Rates and Crash Densities in Iowa by Road System 2005 – 2014 (6-year Average: 2009 – 2014), Municipal Interstate. The 6-year Average was used in the absence of the 5-year Average of 2009 – 2013.*

A field review (see **Section 4.1.1**) should be conducted to document observable safety issues. Any potential safety issues identified should be documented. For any issues identified, the crash data should be checked to confirm that there is not a substantive safety concern related to that issue.

[10] *Source: I-80/35/235 Northeast Mixmaster –Interchange Justification Report. Prepared by HDR Engineering, Inc. for Iowa Department of Transportation* (November 2015).

## 5.3 Advanced Observed Crash Data Analysis

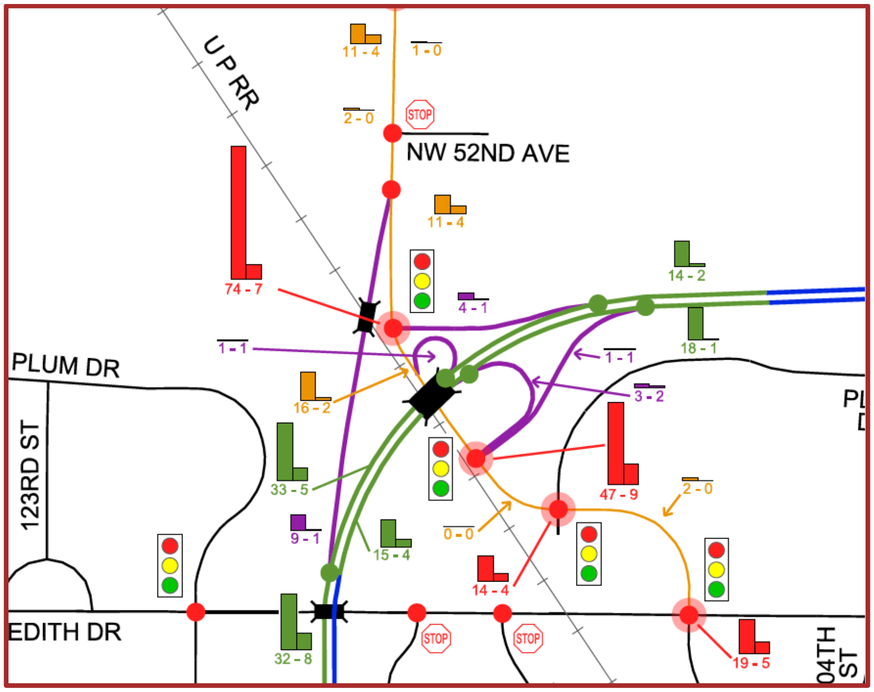
The advanced observed crash data analysis should include all of the elements discussed for the basic analysis; however, it would be expanded to cover the full range of crash data fields. Thus it would include topics such as: time of day, vehicle type, roadway characteristics, etc. Again, a series of graphs and tables should be produced to document trends.

Additional maps may also be needed to more fully identify trends and issues. An advanced analysis could also include the following if determined to be necessary:

- **Collision diagrams** (provides a visual identification of crash concentration, especially severe or specific crash types)
- **Highway condition diagrams**
- **Crash frequency/rate/density maps**

**Figure 5-2** is an example crash frequency map from the Interstate 35/Interstate 80 and Iowa Highway 141 Interchange IJR. In this example, two bars are shown for each location. The left bar is the total number of crashes while the right bar is the number of injury crashes. Each location is colored to help the reader quickly identify if the location is classified as an intersection, an arterial road, a ramp, a merge/diverge or a freeway mainline.

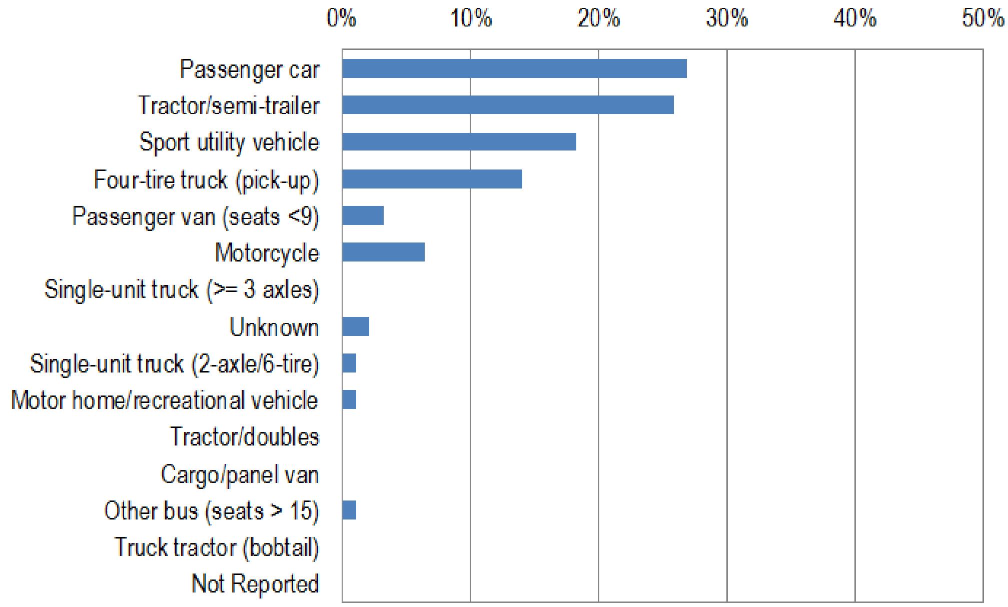
**Figure 5-2: Example Crash Frequency Map**[11]




11 *Source: Interstate 35/Interstate 80 and Iowa Highway 141 Interchange–NW 100th Street Interchange–Interchange Justification Report. Prepared by HR Green, Inc. for Iowa Department of Transportation (June 2015).*

**Figure 5-3** shows a summary of the vehicles involved in crashes on a section of Rural I-80 in Iowa as part of an advanced baseline analysis.

**Figure 5-3: Example Vehicle Type Distribution**[12]




**Resources for Summarizing Crashes by Location:**

- HSM, Section 5.2.2
- FHWA Resource: https://safety.fhwa.dot.gov/local_rural/training/fhwasa14072/sec6.cfm
- Iowa Crash Report Form and Code Sheets (see link in **Section 5.2**)
- Highway Safety Investigation Manual for the Oregon DOT: http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/docs/pdf/odot_safety_investigation_manual_final.pdf
- Traffic Engineering Manual for Minnesota DOT: http://www.dot.state.mn.us/trafficeng/publ/tem/2015/chapter11.pdf

For this more in depth analysis, the field observations should be more comprehensive, documenting potential safety issues such as: small curve radii, steep vertical grades, or sight distance issues. The physical features should be correlated with the crash maps and tables. By examining the crash data in detail, the analyst can identify key issues and define safety related project goals and needs.

[12] *Source: Interstate 80 Planning Study (PEL) - Automated Corridors. Prepared by HDR Engineering, Inc. for Iowa Department of Transportation (June 2017).*

# 6 Complete the Future Performance Evaluation

Implementation of the approved predictive safety methodology began during the development of the technical approach, specifically with the development of the Methods and Assumption document (see **Section 3.4**). With that starting point, the analyst should use the data described in **Section 4.2** to complete the predictive safety analysis.

## 6.1 Consider Range of Performance Measures to Understand Impacts

Through comparing estimated changes in crash frequencies, crash severities, crash costs, and crash types, safety impacts of transportation decisions can be quantified. Safety performance measures may vary depending on the purpose of the project and also based on the complexity of the analysis (basic versus advanced).

**Example 6-1: Performance Measure Based on Project Goals**

- Scenario A: If a road facility is being investigated for proposed changes to improve safety, then the cost of the reduced number of crashes could be quantified to calculate a benefit/cost ratio.
- Scenario B: If the goal of a project is to improve traffic operations on a high volume roadway but a slight increase in crashes is expected, then the controlling performance measure may be a reduction in user costs versus cost of expected/predicted increase in crash frequency.

When quantitatively or quantitatively and qualitatively comparing safety performance, it may be beneficial to consider multiple performance measures. **Example 6-2** describes a scenario where this would be necessary.

**Example 6-2: Scenario Where Multiple Performance Measures May Need to be Considered**

An overpass, such as the one shown in **Figure 2-3**, is being replaced with an interchange. This new interchange is anticipated to attract higher volumes of traffic to the freeway segment due to it being closer to a town than the surrounding interchanges.

Adding interchanges typically increases crash frequency in the project area, but there are safety performance measures that might support moving forward with the project. For example, the new interchange may attract traffic from adjacent interchanges, reducing crashes at those locations. It may also shift traffic from a lower design standard portion of the arterial network to a newly upgraded arterial connection to the interchange. The analysis could therefore consider the overall crash prediction, reporting crashes on segments, at intersections, at interchanges, and for the entire system. To normalize the results for volumes and exposure the results could also be presented as crashes per million vehicle miles traveled (MVMT) for the system. These performance measures could also consider crash prediction by severity. A new interchange may also better accommodate bicycles and pedestrians across the freeway, which could be documented as a safety performance measure (either quantitatively or qualitatively). This approach would provide a range of performance metrics for decision making.

As mentioned in **Section 2.1**, it may be important to consider benefits outside of the safety analysis area. For these outside areas, qualitative questions should be asked such as:

- Is traffic being drawn to a facility with a better safety performance?
- Is traffic being taken out of an area (e.g., downtown or retail business district) where the safety performance would differ from the improved area?
- Are reduced trip lengths reducing exposure (vehicle miles travelled)?

By understanding the changes taking place in the surrounding areas through these types of investigations, one may be able to assess at a high level that safety will either improve or remain the same.

## 6.2 Compare Alternatives

Performance measures should be summarized for each alternative in a manner which makes them easy to compare. By comparing performance measures such as construction cost, predicted crash frequency, predicted crash rates, predicted crash costs, severity, etc. among different alternatives, decisions can be made more easily in regard to which alternative is preferred. An example of comparative predicted crash frequency and crash rates is provided in **Table 6-1**. Both crash frequency and crash rate were included in the example project because the proposed improvements were projected to increase freeway volumes resulting in more freeway crashes in some segments. Including crash rate as a performance measure demonstrates how the alternatives perform when normalized by volume. Supporting this table should be a qualitative assessment of the anticipated safety benefits of shifting traffic to the freeway from the supporting arterial road network.

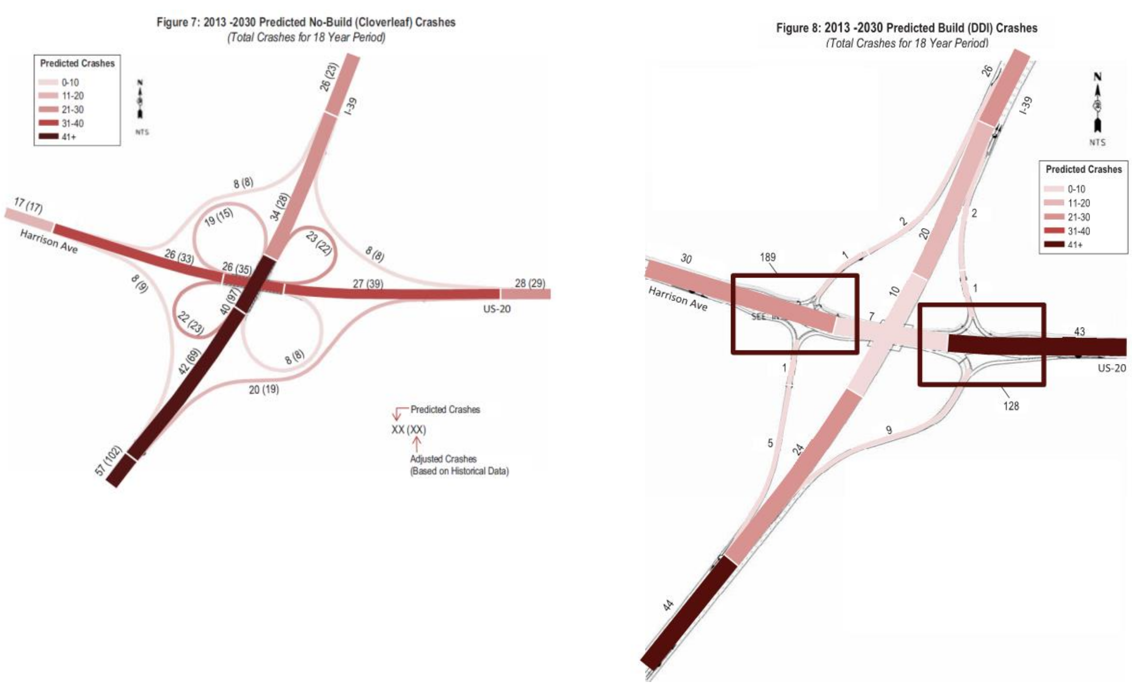
### Table 6-1: Example Predictive Crash Alternative Comparison

| Segment ID | Future Year Predicted Crashes | | | | | |
|---|---|---|---|---|---|---|
| | No Build | | Alternative 1 | | Alternative 2 | |
| | Total Crashes | Crashes/100 MVM | Total Crashes | Crashes/100 MVM | Total Crashes | Crashes/100 MVM |
| Seg 1 | 10.4 | 88 | 10.1 | 70 | 10.5 | 68 |
| Seg 2 | 9.3 | 67 | 9.2 | 53 | 9.8 | 50 |
| Seg 3 | 9.1 | 66 | 8.8 | 51 | 8.8 | 51 |
| Seg 4 | 8.5 | 70 | 11.2 | 74 | 11.2 | 74 |
| Seg 5 | 2.9 | 62 | 2.6 | 54 | 3.2 | 50 |

Green highlighted cells indicate predicted crash frequency or rate for Alternative 2 or 3 is below the predicted frequency/rate for No Build. Red highlighted cells indicate predicted crash frequency or rate for Alternative 2 or 3 is above the predicted frequency/rate for No Build.

**Figure 6-1** is an example crash prediction figure for a proposed diverging diamond interchange that was used to compare crashes with a similar no-build figure for the same interchange.

### Figure 6-1: Example Comparison of No Build and Build Crash Predictions[13]




[13] *Source: Predictive Crash Analysis; Interstate 39 at US Route 20 (Harrison Avenue); Rockford, Illinois [Technical Memorandum]. Prepared by HDR Engineering, Inc. for Illinois Department of Transportation (October 2014).*

# 7 Documentation

Data driven safety analysis is often completed as part of a change in access study; however, the analysis can be part of different type of project or standalone evaluation. Regardless of the type of project for data driven safety analysis, a standalone memorandum that summarizes the safety analysis should be developed. The memorandum should present the following:

- Safety analysis methods and assumptions
- Data and sources
- Existing conditions safety analysis results
- Predictive safety analysis results

For large projects where safety is one of many components, the safety standalone documentation should be provided in an Appendix. It is recommended that key points from the safety analysis are included within the main body of the project report.

# 8 References

The following reports and documents were consulted in the development of this guidance. Please refer to them for more information on the topics presented in this report.


- *Highway Safety Manual*, (AASHTO, 2010 and 2014) [available for purchase through the AASHTO Bookstore, https://bookstore.transportation.org/)
- *Highway Safety Manual User Guide, (TRB, 2014) http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP17-50_UserGuide.pdf*
- *Interstate System Access Informational Guide,* (FHWA, 2010) https://www.fhwa.dot.gov/design/interstate/pubs/access/access.pdf
- *Process for New or Revised Interchange Access: User Guide 2.2*, (Iowa DOT, 2013) https://www.iowadot.gov/pdf_files/IJRUserGuide.pdf
- *Scale and Scope of Safety Assessment Methods in the Project Development Process*, (FHWA, 2016) https://safety.fhwa.dot.gov/hsm/fhwasa16106/
- *Washington State Department of Transportation Design Manual*, Chapter 550 (WSDOT, 2016) http://www.wsdot.wa.gov/Publications/Manuals/M22-01.htm
- *Analysis Procedures Manual*, Chapter 4: Safety (ODOT, 2017) http://www.oregon.gov/ODOT/TD/TP/APM/APMv2_Ch4.pdf
- *Institute of Transportation Engineers (ITE) Traffic Engineering Handbook, Seventh Edition* (2016) [not available on-line]