

Safety Guidance for Corridor Planning Studies

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Safety Guidance for Corridor Planning Studies provides the foundation for developing the safety chapter in a corridor planning study. The development of a safety chapter assumes a general understanding of the fundamentals of how WSDOT approaches highway safety (Sustainable Highway Safety) and the direct relationship with Washington’s Strategic Highway Safety Plan (*Target Zero*). While not intended to prescribe a “cookie cutter” approach, the typical outline shown in this guide supports consistency across the agency, maximizes the potential benefit of the planning study for the program and project development process, and increases the likelihood of meeting expectations of the public, elected officials, safety stakeholders and the Department on achieving high levels of safety performance for Washington’s highways.

This Guide is organized as follows:

- Section 1: introduces the WSDOT’s approach to safety
- Section 2: discusses setting the scale and scope of the safety analysis
- Section 3: discusses the need and nature of internal consultation in the development of a safety chapter
- Section 4: describes the basic outline of a safety chapter
- Sections 5, 6 and 7: discuss the basic, intermediate and advanced level safety analysis.

1. Introduction

Providing reasonably safe highways for the traveling public is a fundamental component of WSDOT’s mission. In the early 1990s, WSDOT embarked on a deliberate and managed effort to reduce fatalities resulting from motor vehicle crashes on the state highway system. The Department has been one of the most successful in the nation in terms of reducing the frequency and severity of crashes. WSDOT success has occurred because of its willingness to be innovative and focused on reducing crashes through both reactive and proactive strategies. WSDOT has also used approaches that address both the infrastructure and human behaviors that contribute to crashes. The emphasis of safety planning is that strategies to address crashes are targeted towards the contributing factors that are associated with crash outcomes.

Figure 1 shows how fatalities have declined from 2005 on all public roads and on state highways. Integrating safety into the planning process is one of the activities necessary to sustain the reduction of fatal and serious injury crashes, ultimately reaching the goal of zero fatalities and serious injuries by 2030.

WSDOT is required under federal regulations to develop and maintain a strategic highway safety plan (*Target Zero*) for the purpose of providing safety priorities, strategies and targets. This plan is developed in partnership with the Washington Traffic Safety Commission, multiple agencies with transportation safety responsibilities and public stakeholders (including regional and metropolitan planning organizations). The *Target Zero* safety plan provides the basis for safety planning and implementation activities for WSDOT.

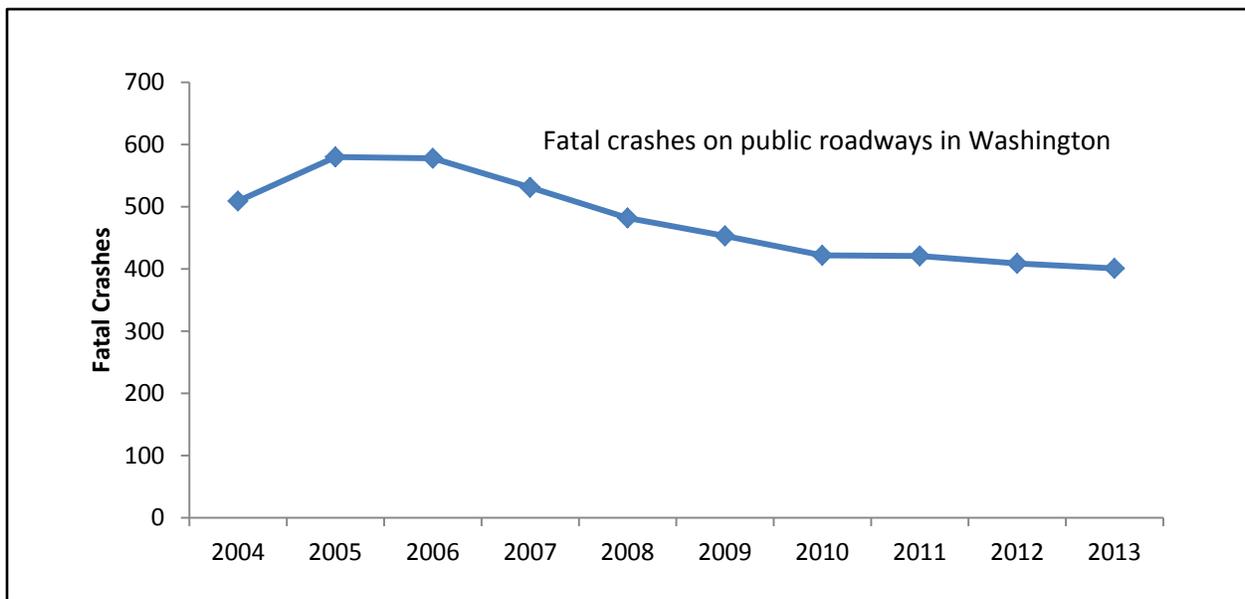


Figure 1: Fatalities on public roadways in Washington State (2004-2013)
 (Source: Fatal Accident Reporting System (FARS), WSDOT Statewide Travel and Collision Data Office)

WSDOT implements Target Zero through the Sustainable Highway Safety Program. Sustainable Safety provides the policy, procedures and specific safety program categories necessary to carry out the Target Zero plan’s vision of zero fatal and serious injury crashes. Sustainable Safety is based on a principle of identifying and developing targeted solutions to targeted needs using quantitative assessment techniques. Projects developed within the Sustainable Safety philosophy use a tiered approach to alternatives assessment where short, medium and long term potential alternatives are identified within planning activities. Plans that consider budgetary and resource constraints are more likely to be implemented, reduce potential liability concerns and are better able to meet public expectations. It is important to recognize that final project selection is not identified within planning documents. Final selection occurs during scoping and programming of projects, and through agreement of the Legislature.

2. Setting the scale and scope of the analysis

2.1. Expertise and internal consultation

Highway safety is a specialist field requiring data analysis, planning, traffic operations and design professionals working together to reduce fatal and serious injury crashes. To achieve optimal results, staff working on planning studies should **conduct internal consultation with safety experts from the earliest stages of the planning effort**. This approach supports consistency with WSDOT policies and business practices, **optimizes the benefits** to investment in safety performance, and properly scales analysis efforts to reduce unnecessary expenditures. Working with experts earlier also increases the likelihood that analysis is scoped at the right level and rework is unlikely since agreements are upfront rather than later in the process.

Crash and safety performance analysis requires significant knowledge of the crash data, analytical methods and tools used at WSDOT. This knowledge is important in being able to assess, diagnose contributing factors leading to crashes and then selecting appropriate countermeasure to address these issues. The importance is outlined in the following sections of this guide.

This guide provides for different levels of analysis. These levels represent varying levels of assessment based on the complexity and need of the study. Scaling and scoping studies are an important part of providing the right level of information to support future decision making and developing solutions, programs or projects.

2.2. Establishing the Level of Analysis for the Safety Chapter of a Corridor Study

The initial level of analysis that will be performed is based on the scale and scope of the planning study, and is sufficient to assess the safety performance of the corridor or project location. Consultation with the safety expert team (identified in later sections) is used to set the appropriate level of analysis. This consultation and level of analysis determination sets clear **expectations for the staff effort needed** for the safety information being provided within the planning study. It will also guide the **development of content** and the **approach to the analysis**. These discussions occur during the **scoping of the planning study**.

For the purposes of this Guide, WSDOT identified three analysis levels consistent with WSDOT policies, procedures and actions that occur throughout planning, programming and project development.

- **Basic Analysis Level**—A basic analysis level safety section assesses and reports on the basic safety performance of the corridor using the last five calendar years (e.g., 2010 through 2014) . This level provides general descriptive information regarding current crash performance on the corridor. The findings of the assessment serve as input to the scoping and project development process. This type of safety analysis only presents factual conclusions about current conditions.
- **Intermediate Analysis Level**—An intermediate analysis includes the basic analysis level content and adds potential engineering countermeasures identification and evaluation. This analysis supports the development of conclusions and recommendations, and how to address the potential contributing factors using selected countermeasures. In addition, the potential benefits of using the selected countermeasures are included in the discussion.
- **Advanced Analysis Level**—An advanced analysis level includes the content of the basic analysis level, and adds a safety performance predictive analysis. Forecasted assessments are used to test different corridor development scenarios. These alternative development scenarios include countermeasures and potential alternatives based on other needs (e.g., environmental, mobility, modes, etc.) of the corridor.

2.3. 23 USC 409

To reduce potential liability and risks, WSDOT adds a disclaimer to safety related documents. In accordance with federal law, safety related reports, surveys, schedules, lists, or data under the provisions outlined in 23 USC 409 protects safety related documents from being subject to discovery or admitted into evidence in federal or state court proceedings or for any action for damages arising at a crash location.

The federal code is shown below:

23 U.S. Code § 409 – Discovery and admission as evidence of certain reports and surveys

Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 148 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceedings or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

Add the following disclaimer to all safety related data, reports, surveys, schedules, lists, and communication used in the planning effort. This includes sections, chapters, documents or reports.

Under 23 U.S. Code § 409, safety data, reports, surveys, schedules, lists compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential crash sites, hazardous roadway conditions, or railway-highway crossings are not subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

3. Internal consultation

Once a basic safety performance summary for the corridor is completed and a draft purpose for the chapter is prepared, a joint internal consultation meeting occurs. Internal consultation is required for any level of analysis. This internal meeting serves multiple purposes:

- Drawing upon the corridor vision, context and purpose, the internal consultation serves as a discussion forum to identify how this information is to be communicated and presented to the intended audience within the safety chapter of the corridor planning study and with the community;
- The internal consultation allows for WSDOT safety experts in multiple offices to identify particular items that require further analysis, the scope for such analysis, and likely resources necessary to successfully complete the chapter. The use of basic safety performance summaries and assistance from WSDOT safety experts supports efficient

use of staff time, maintains consistency in analysis, and limits the impact on the safety chapter development time.

The desired outcomes of the initial internal meeting are:

- Reach agreement on the purpose, vision and scope of the safety chapter.
- Reach agreement on the findings of the basic corridor safety performance summary analysis.
- Identify any additional crash analysis to be performed and identify the safety experts who will assist in formulating targeted analysis.
- Identify and document any short, medium and long-term developments that may impact the function of the corridor-especially if there is a likelihood of impact to safety performance.
- Reach agreement and document a common approach to communicating the basic safety performance of the corridor with the public and other agencies.
- Update draft documents as necessary from input and direction of the meeting.
- Any additional effort should be consistent in terminology, data definitions and analysis for WSDOT and Target Zero; and involve safety experts in the department.
- All assumptions should be documented and findings from additional analysis should be reviewed with participants from the internal meeting.

This meeting should include (at a minimum) representation from the following WSDOT HQ Offices/Divisions:

- Systems Analysis & Planning
- Capital Program Development & Management
- HQ Traffic Operations
- Region Traffic
- Project Development
- Local Programs (for local agency considerations)
- Depending on the nature of the corridor, include any other offices as they relate to corridor safety performance.

Provide the following reference materials at this initial meeting:

- Corridor Vision (overall vision as established earlier in the planning study as well as a highlight of any specific references to safety performance)
- Corridor Context (as established earlier in the planning study as well as contextual elements directly related to safety performance)
- Draft Purpose Statement for the Safety Chapter
- Draft Summary of Corridor Safety Performance

The discussion in the meeting is based on the above mentioned materials. During the meeting, gather input from the participants about the findings of the draft summary of corridor safety performance and the summary of findings from the analysis. Fact-based input at this meeting

discussion should be used to update the draft summary of corridor safety performance of the corridor.

At this meeting, the WSDOT safety experts should identify the need for any additional analysis necessary to describe the basic safety performance of the corridor. For example, in some cases, the basic summary may point to particular characteristics in crashes that were not previously covered. Agreement should be reached on the level of effort needed to complete any additional crash analysis.

Identify and document any short, medium or long-term developments that are not widely known across WSDOT that would impact review of the corridor. For example, are there elements that would constrain our ability to achieve the corridor vision and goals or that would change how the corridor operates?

In addition, discuss and reach agreement on a common approach to communicating the basic safety performance of the corridor with the public and other agencies. This may include particular items to emphasize and approaches to addressing existing community concerns about safety performance.

Internal and external consultation occurs throughout the analysis process.

4. Basic Outline of the Safety Chapter

The typical safety chapter in a corridor planning study typically has seven subsections:

1. Purpose
2. Introduction
3. Corridor Context and Users
4. Summary of Corridor Crash History
5. Considerations for Future Changes to the Corridor
6. Corridor Crash Analysis
7. Conclusions of the Safety Chapter.

Each of these subsections provide the framework for a safety section that meets the needs of the community, reports on safety-related efforts in the corridor planning study, and adds value to scoping, the project development process, construction and future operation of the corridor.

The tone of the safety chapter is factual and objective, not opinionated. Content of the safety chapter focusses on relevant findings and graphs support key messages of the chapter. Subjective discussions that contain opinions of the authors should be avoided since these statements are subject to misinterpretation, generate unnecessary disagreement, or be inconsistent with stakeholder and public input. All of which lead to unnecessary risk and liabilities for the Department.

4.1. Purpose

The statement of purpose discusses what is driving the need for the study. The studies are typically driven by statewide identified priorities. Community concerns or perceptions may drive the analysis and should be stated as such. The purpose statement is factual and objective. An example for a basic safety chapter might be: *“The purpose of the safety chapter is to present and summarize the historic safety performance of intersections along the corridor”* versus *“The purpose of the safety chapter is to assess the unsafe intersections along the corridor.”*

Regardless of the depth of the safety chapter, the statement of purpose should be clearly stated and provide a framework to set expectations for its role in the corridor planning study. Addressing safety performance issues may not be the primary focus for all studies and a full chapter may not be needed.

4.2. Introduction

The introductory paragraph of the safety chapter in a corridor study report provides a roadmap for the reader for each of the subsections along with their purpose.

4.3. Corridor context and users

Describing the **context** and **users** of the corridor allows for specific design and operational approaches to be more fully incorporated into future decision making. For instance, the **function** and **role** of the corridor are key considerations in the geometrics, roadside and traffic control and operations that are appropriate for the corridor. A plan that recognizes **these characteristics** along with crash **contributing factors** increases the likelihood of reducing crashes within the corridor because countermeasures are selected based on the specific issues within the corridor versus a more general approach of broadly applied general design criteria.

Knowing the **context** of the corridor allows targeted countermeasures specific to the context to be considered. For instance, a major modal change from single vehicles to transit may change considerations of pedestrian needs because of increased pedestrian volumes along the corridor or specific crossing locations.

Corridor vision

The vision for the corridor is established and documented early in the planning process through collaborative review with stakeholders and users of the corridor. The intent of the vision is to provide a common understanding for the intended audience and for potential design considerations. For instance, if the vision of the corridor is to provide a multi-modally integrated corridor, this would lead to different considerations than a freight-oriented corridor. While the overall vision for the corridor may have been previously established and documented for the planning study, it is helpful to highlight the specific vision of the safety performance.

Safety performance in a corridor is affected by a number of factors. Because of this, it is important to identify and describe how the corridor currently functions and how it is expected to function within the planning horizon established for the study. A discussion of the future design context, operations changes and modal needs are included. It is important to recognize

that the vision sets the direction for the corridor and this ultimately impacts how safety performance is treated in terms of design, modal opportunities and operation expectations. In this sense, countermeasure selection considers compatibility with the overall corridor vision from the short, medium and long term perspectives. For instance, a solution that reduce vehicle crashes but increase vehicle speeds in a pedestrian oriented corridor may not appropriate.

Corridor context

The context of the corridor describes the physical environment, operational conditions, and typical users of the corridor, segment(s) or intersection(s) being studied. Although the general context of the corridor has been described and documented at the beginning of the study, the corridor specific contextual elements and their influence on modal safety performance should be described in this section.

Questions that can help emphasize key characteristics to frame corridor context and users specifically as it relates to safety performance can include (but is not limited to):

- a) What is the vision for the corridor?
- b) What is the current context of the corridor? This includes, but is not limited to:
 - Basic geometric characteristics (number of lanes, presence of auxiliary lanes, typical cross sections, etc.
 - Operating speed,
 - Roadside features,
 - Adjacent land use (specific consideration for major traffic generators),
 - Presence of transit, pedestrian and/or bicyclist facilities, and associated use or demand,
 - Operational characteristics of segments and intersections along the corridor,
 - Nature of conflicts between different users of the corridor.
- c) How does the current corridor differ from the vision for the corridor? How does the future context differ from the current context of the corridor?
- d) Are there specific considerations (e.g., modal issues, contributing factors common to crashes reported on the corridor) for the safety performance of the corridor based on a) the current context, b) the future context, and c) anticipated interim phases of changes in context?
- e) Who are the current users of the corridor? (Include multiple modes in the assessment), what are future considerations for these users given potential changes?
 - Specifically consider pedestrians and/or bicyclists if adjacent land use includes pedestrian generators; or if adjacent land use creates pedestrian desire lines (preferred walking paths across the corridor).

Corridor users

The following considerations can be helpful in assessing the users of a corridor and conflicts between users:

- a) Review pedestrian desire lines (the path pedestrians choose to take) using existing land use adjacent to the corridor and referencing pedestrian trails or informal pedestrian

routes currently in use by the community. Identify locations where pedestrian desire lines cross vehicular traffic (including regular vehicle traffic, large trucks, transit, bicyclist and other corridor-specific users). Assess the operating speed of vehicular traffic at crossing points. For locations where operating speeds are in excess of 40 MPH, assessment of mitigation measures to reduce operating speeds may be beneficial to the safety performance of the corridor. This occurs with assistance of traffic operations and design experts. Repeat this exercise for bicyclists where applicable.

- b) Identify points of conflict between vehicular traffic; large trucks, transit, and bicyclists along the corridor (include through-traffic and local traffic in the assessment). Assess the anticipated operating speeds of vehicles at these potential points of conflict. For instance, would the design changes have an influence on increasing or decreasing speed, and would that speed change increase or decrease the potential for and severity of crashes. Consideration and mitigation of these conflict points may be beneficial to the safety performance of the corridor.

4.4. Summary of Corridor Crash History

The Summary of Corridor Crash Performance presents the main findings of the basic level crash analysis. The findings are presented objectively and describe the characteristics of the current and historic corridor safety performance; identifies the major contributing factors to crashes; and specific populations and user groups that are involved in these crashes.

The following elements should be analyzed and included in the summary:

- The contributing factors to fatal and serious injury crashes reported for the last five full calendar years. Contributing factors fall into 4 general categories: human factors, behavioral factors (impaired driving, driving without restraints), vehicle factors, and road environment-related factors (adverse weather; lighting conditions; intersection and related crashes; crashes on horizontal curves; crashes involving the roadside).
- Particular user groups involved in the reported crashes including, but not limited to young drivers, older drivers, bicyclists, motorcyclists, older pedestrians, large trucks, etc. Consider user groups in terms of the multimodal use of the corridor.
- Are there any particular crash types that are more common than others?
- Are there any particular times of day of a typical weekday or a typical weekend where these crashes are more prevalent?

The Summary of Corridor Safety Performance section typically consists of the following:

- a) Introductory paragraph – Provide an introductory statement for the analysis and how the crash analysis relates to WSDOT Sustainable Highway Safety and Washington’s Strategic Highway Safety Plan-Target Zero. Typical items to include:
 - i. Focus on fatal and serious injury crashes as the primary safety performance measure for the corridor.
 - ii. Review of contributing factors consistent with Target Zero priorities.
- b) Summary of findings of the analysis – Present major findings from the basic summary review and supplement the text with graphs where appropriate. Typical items include

(only highlight what most fatal and serious injury crashes have in common for the corridor):

- i. Typical crash characteristics, for example:
 - Number of vehicles involved: multiple vehicle, single vehicle crashes
 - Manner of collision: run-off-the-road, rear-end, opposite direction crashes, etc.
 - Most harmful event: fixed object crashes
 - Where: intersection and intersection-related crashes, driveway and driveway-related crashes, road segment crashes (crashes that are not intersection or intersection-related)
 - When: time of day, weekday vs. weekend, daytime vs. nighttime
- ii. Typical contributing factors – specifically note:
 - Risky behavior reported at the time of the crash, for example:
 - Alcohol and/or drug impaired driving
 - Speeding
 - Restraint and helmet use (report helmet use if any motorcyclists were involved)
 - Weather or road environment-related information, for example, snow or icy conditions; wet pavement conditions, etc. Where almost all crashes occurred during dry pavement conditions, such a statement can be valuable as well.
- iii. User types involved in reported crashes:
 - Vulnerable users: pedestrians, bicyclists (for these users, all crash injury severities may be considered), motorcyclists, young drivers, older drivers
 - Passenger vehicles, large trucks, buses, commercial vehicles, vehicles transporting hazardous materials, trains
- iv. Other typical crash characteristics reported, this may include any fatal and serious injury crashes that occurred in work zones, or are the result of vehicle-related failure (losing a wheel, tire blowout, etc.)

4.5. Considerations for Future Changes to the Corridor

The subsection *Considerations for Future Changes to the Corridor* describe items relevant to the anticipated future changes to the corridor that are most likely to impact current corridor safety performance. This subsection informs the scoping and design process, highlighting key considerations for future safety performance. The steps to develop content for this subsection are as follows:

- Step 1. Review the projects scheduled for construction and the vision for the corridor.
- Step 2. Identify particular corridor characteristics that will change as a result of a) scheduled projects, and b) achieving the vision for the corridor.
- Step 3. Summarize items that represent a change in the corridor context and that are likely to impact current corridor safety performance.
- Step 4. Report the anticipated changes in an objective manner, highlighting changes in context for consideration during scoping and design.

4.6. Corridor Crash Analysis

The corridor crash analysis section is completed for cases where an intermediate or advanced level analysis is performed as part of the study. Given the level of effort of such an analysis, it is only to be completed if required or agreed upon as part of internal consultation.

4.7. Conclusions of the Safety Chapter

The conclusions for the safety section summarizes key characteristics of the corridor context, and the fatal and serious injury collision history (include findings from incident management reports where applicable).

5. Basic Level Crash Analysis

This section summarizes the basic crash analysis required to quantify safety performance as part of a planning study. Refer to the following sections for additional effort required in the intermediate and advanced analysis levels. Note that basic analysis is prerequisite in completing the intermediate and advanced level analysis.

5.1. Obtaining crash data for analysis

Obtaining crash data for analysis used in the safety chapter of a corridor study typically occurs using the AASHTOWare Safety Analyst (Safety Analyst). Safety Analyst is updated annually. Safety Analyst generates summaries and charts that are useful in determining the contributing factors to crashes. Additional information may be necessary to determine contributing factors and this may require the use of cross tabulated data. These data summaries are produced using WSDOT's data warehouse (<http://datamining>). Visit the internal WSDOT Sustainable Highway Safety website for other tools that can be helpful in the review of crash data.

5.2. Introduction to quantifying safety performance (levels of analysis)

Quantification of safety at WSDOT is primarily related to understanding fatal and injury crash potential at a site, corridor or network given the characteristics that exist at a given location. WSDOT uses Safety Analyst to perform a network level screening of the system to identify segments and intersections on the system for further review by the regions, using methods described in Part B of the AASHTO Highway Safety Manual. Identifying locations in this manner provides an improved process to using rates or just the total number of fatal and serious injury crashes reported on the system.

In addition, Safety Analyst provides an efficient and effective review of summaries of reported historic (observed) fatal and serious injury crashes for a given corridor, segment or intersection because of its ability to quickly produce tables and graphs.

It is important to note that because of common misunderstandings related to the use of crash rates and their implications on safety performance WSDOT avoids the use of crash rates in safety documents and efforts to quantify safety performance.

When elements, such as the impacts of traffic, geometrics or future changes in the facility need to be evaluated, it is necessary to use additional tools for the analysis activities. The predictive methods chapters use Safety Performance Functions and Crash Modification Factors, SPFs and CMFs respectively to incorporate site characteristics. These methods are detailed and require expertise in their use and interpretation. The level of expertise necessary should be considered as part of the expert team's responsibility.

5.3. Steps in the basic crash analysis

A basic level analysis consists of four steps with the expert team. First, a review of the existing safety performance is carried out. Second, the corridor characteristics are reviewed alongside the safety performance review findings. Third, the findings from the reviews are summarized. This summary is then used in an internal consultation process with the WSDOT planning study stakeholders. The outcome of the reviews and the internal consultation is then summarized and documented.

The focus of a basic level of analysis is to provide the historic safety performance of a corridor: it reports on the major contributing factors to the fatal and serious injury crashes; and specific populations/ user groups that are involved in crashes on the corridor. Safety Analyst reports may be supplemented by ICAT, CAT, IHSDM, ISATe and Excess Crashes Statistical Tool as necessary to provide additional information not provided by Safety Analyst.

5.4. Review existing corridor safety performance

The purpose of **reviewing the existing corridor safety performance** is to identify contributing factors to fatal and serious injury crashes, and to summarize these findings.

The following questions can be helpful in identifying key information about safety performance:

- a) What are the contributing factors to fatal and serious injury crashes reported for the last five years (full calendar years)?
- b) What are the reported behavioral contributing factors to the crashes? For example: impaired driving, driving without restraints.
- c) Are there any common road environment characteristics for the reported crashes? For example: adverse weather, nighttime conditions, intersection and related crashes, crashes on horizontal curves, crashes involving the roadside.
- d) Are there particular user groups that are involved in the reported crashes? For example: younger drivers, older drivers, motorcyclists, older pedestrians, large trucks. Consider these user groups in terms of the multimodal role of the corridor (in the present and anticipated in the future).
- e) Are there any particular crash types that are more common?
- f) Are there any particular times of day of a typical weekday or a typical weekend where these crashes are more prevalent?

In the **corridor review** the existing corridor safety performance is considered alongside the corridor vision, context, and **other characteristics deemed relevant to safety performance**. Example questions may include, but are not limited to:

- Speed is a fundamental aspect of design and operation of a facility. Consult with the Region Traffic Office when reviewing speed related elements. Identify the target speed. Review the typical speeds associated with the current cross-section and roadway specific characteristics. This does not refer to actual operating speeds but to the concept of self-explaining roadways (e.g., roadways that provide road users information on how best to use the roadway).
- How does the target speed of the corridor correspond to actual operating speeds on the corridor?
- Are there transit or school bus stops located along the corridor? If yes, where are the pedestrians coming from and how do they get to/from these stops?
- In reviewing adjacent land use: how compatible are target speeds and the actual operating speeds from a multi-modal perspective?
- Are there any common pedestrian desire lines crossing the corridor? Are these pedestrian desire lines conflicting with passenger vehicles, heavy vehicles, bicyclists, vehicular traffic? How are these conflicts being addressed?

In addition to the **safety performance review** of crash data, describe items 1) relevant to the anticipated future changes to the corridor that are most likely to impact current corridor safety performance or 2) other data or information relevant to the corridor study including, but not limited to:

- Local and/or community input
- Previous planning studies that identified and used statistical (scientific) methods to quantify safety performance – do they coincide or relate to the current safety performance?
- Current or future programmed projects within the corridor that may impact the corridor study recommendations, especially if the project is a potential solution to current safety performance needs.
- Particular corridor characteristics that will change as a result of scheduled projects, and achieving the vision for the corridor.
- Summarize the items that represent a change in the corridor context and that are likely to impact the current corridor safety performance.

6. Intermediate Level Crash Analysis

The Intermediate Crash Analysis level is used when countermeasure recommendations are required as part of the corridor study.

6.1. Elements of intermediate level crash analysis

In the intermediate level crash analysis, a basic level analysis is first performed and then countermeasures are identified and evaluated using methods consistent with WSDOT policies and processes. This ensures that recommendations for countermeasures in a corridor study are based on the priority array criteria used for other safety investments in WSDOT, and thus improve the likelihood of implementation.

The focus of countermeasure selection in the intermediate crash analysis is to identify those measures that would be most likely to reduce fatal and serious injury given contributing factors or crash types occurring on the corridor. The process for identifying and evaluating countermeasures should be consistent with the requirements for the WSDOT Crash Analysis Report Template.

In the intermediate level crash analysis the assumptions, approach and findings of the evaluation of countermeasures are documented. Note that countermeasures are identified based on the findings from the basic level crash analysis. These findings may indicate additional expertise is needed to assist in countermeasure assessment. For instance, if the preponderance of crashes is alcohol or drug related a discussion with Washington Traffic Safety Commission or Washington State Patrol about potential countermeasures (e.g., enforcement) that would likely bring about behavioral change is appropriate.

Referencing contributing factors in other discipline areas (e.g., human factors, behavioral, enforcement, etc.) that may offer potential for improvement, without specific recommendations as to how the countermeasures are implemented is appropriate. When another agency makes a recommendation, it can be included in the study but would need to be specifically identified as such. This reflects the mutual respect between agencies for their respective areas of expertise; their operational responsibilities and scope; and focusses WSDOT efforts on engineering, but allows for a greater understanding of behavioral concerns. Engineering countermeasures are targeted. Evaluate lower cost solutions with a higher rate of return over the short term first, then medium and higher cost solutions next. Least cost solutions are preferred and this ordering will assist in comparative analysis and decision making. The measures should target fatal and serious injury crashes of particular types and the selection should be based on acceptable WSDOT practice and Crash Modification Factors policies.

It is not the purpose of the planning study to select the preferred countermeasure, but to identify potential countermeasures that would have a high probability for crash reduction benefits. Advice on countermeasures is provided by WSDOT's internal consultation and external experts with knowledge of engineering, enforcement and educational countermeasures.

6.2. Identification of engineering countermeasures

Use the findings from the basic crash analysis to identify the target crash types for the corridor. Target crash types for the corridor are crashes that share characteristics and are common to the corridor. A corridor may have several target crash types and these types may not be mutually exclusive. Target crash types can be quite specific (single vehicle run off the road crashes at nighttime and on curves) or general (multiple vehicle crashes at intersections). Target crashes reflect common contributing factors, context (land use, users, speed), and site conditions (operational conditions).

Use the target crash types to identify potential countermeasures to reduce the fatal and serious injury crashes in one or more of the target crash types identified. Working with the internal

safety expert group is critical to identifying appropriate countermeasures. This group draws upon their background; current science of safety; and WSDOT's experience with countermeasures. This approach allows for identification of engineering countermeasures most likely to be cost-effective and appropriate for implementation on the corridor as well as internal support for recommended countermeasures.

Engineering countermeasures focus on the most common fatal and serious injury crashes, or target crashes on the corridor. In identifying countermeasures, it is helpful to consider:

- a) The current, intermediate and ultimate corridor context and corridor vision related to safety performance.
- b) The target crash characteristics when focusing on fatal and serious injury crashes, and crashes involving pedestrians and bicyclists.
- c) The potential impact of the countermeasure as it relates to the ability of law enforcement to adequately perform enforcement activities within the corridor; the ability of emergency response personnel to deal with incidents in a timely manner; the ability to change road user behavior.
- d) Existing engineering warrants or requirements, for example, where countermeasures include changes in traffic control, analysis and WSDOT procedures should be followed to verify that the change is consistent with WSDOT policy, meets the required warrants and that the proposed control change is compatible with the corridor context.
- e) Selection and application of potential countermeasures may not be straightforward. Consult with Region and HQ experts.

6.3. Evaluation of impacts on law enforcement

Review the anticipated impact of each alternative scenario on law enforcement for any adverse impacts on the ability of law enforcement to perform enforcement along the corridor. This review may include considerations for adjustments to the proposed scenario(s) to facilitate enforcement activities if such considerations do not increase overall anticipated implementation costs. Present findings and include potential mitigation where appropriate.

6.4. Evaluation of impacts on incident response

Review the anticipated impact of each alternative scenario on incident management and emergency medical services. If incident management reports exist for the corridor, review the incident management performance over the last three years (contact the WSDOT Program Manager for Incident Response information). Key factors to consider include, for example, the likelihood of particular types of incidents occurring along the corridor (including the time of day) and clearance times. Present findings and include potential mitigation where appropriate.

6.5. Evaluation of potential engineering countermeasures

Safety Analyst will provide a set of potential countermeasures. The WSDOT crash modification list and the FHWA Crash Modification Factors Clearinghouse can be used to identify potential countermeasures and their impacts. Further refinement of the list may be necessary because not all countermeasures will be appropriate or cost effective. The Crash Analysis Report relies upon information identified in the planning study to be appropriate for future analysis that

occurs in scoping. Therefore, this report provides a framework to further refine a potential countermeasure list when done in consultation with internal experts. It is also imperative that the WSDOT safety and priority array policies and best practices are followed since projects outside of these elements are not likely to receive funding approval. This analysis includes use of the AASHTO Highway Safety Manual (Parts C and D) (2010), predictive method and crash modification factors available from the HQ Traffic Office.

6.6. Document and present findings and recommendations

Document the assumptions, methods and steps followed in the intermediate crash analysis; summarize the findings and present the recommendations of the analysis.

7. Advanced Crash Analysis Level

In advanced level analysis, a basic crash analysis is performed and then the safety performance of alternative corridor development scenarios and proposed countermeasures evaluated. The assumptions, methods used, and findings from the analysis are documented and recommendations for specific countermeasures and mitigation are presented.

7.1. Elements of an advanced crash analysis

The advanced crash analysis consists of five elements:

- 1) Perform a basic level crash analysis and complete the internal consultation.
- 2) Perform a basic human factors review of the corridor, and identify any mitigation based on the findings of this review.
- 3) Evaluate the anticipated impact of each scenario on law enforcement, and identify any mitigation based on the findings of this review (refer to Section 5.3)
- 4) Evaluate the anticipated impact of each scenario on emergency and incident response, and identify any mitigation based on the findings of this review (refer to Section 5.4)
- 5) Perform a safety predictive analysis of each of the alternative corridor development scenarios (these scenarios include the proposed countermeasures and mitigation based on the findings from the human factors review, evaluation of potential impacts on law enforcement and incident response).

Note that the safety predictive method by itself does not allow for a review of human factors or the potential impact on law enforcement or incident management. In some cases, the HSM may not offer the ability to quantify the impact of a particular change on safety performance as the scientific knowledge may not exist yet or is not yet incorporated into the HSM predictive methodology.

An advanced crash analysis requires a thorough understanding and experience in the application of the predictive method and its limitations, application of the method in each context, and current best practices at WSDOT; human factors review; and evaluation of impacts on enforcement and incident response. This analysis will require the assistance of the safety expert team or other regionally assigned experts capable of performing this task.

7.2. Human factors review

Perform a basic human factors review of the alternative corridor development scenarios and report findings of impacts that cannot be estimated using the HSM. Use the TRB Human Factors Guideline (NCHRP 600, 2nd Edition 2012):

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600Second.pdf for the review. Present potential mitigation for findings of the review where appropriate. Note that the human factors review can be performed at the basic or intermediate level as well.

7.3. Safety predictive analysis

Quantify the anticipated safety performance of each alternative scenario (with countermeasures and mitigation), using the Highway Safety Manual (HSM) Predictive Method (Chapters 10-12, 18 and/or 19).

Keep in mind that WSDOT is also developing multiple safety performance functions (SPF) for individual highways and conditions and that these may replace the use of the HSM predictive method for those facility types. This information will be placed on the Sustainable Safety Website when available

(<http://wwwi.wsdot.wa.gov/RiskManagment/SHS/>). The predictive analysis uses the AASHTO Highway Safety Manual Predictive Method.

7.4. Document and present findings and recommendations

Document the assumptions, method and steps followed in the advanced crash analysis; summarize the findings and present the recommendations of the analysis.

