Final Report

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**EXPERT SYSTEM TO SUPPORT SITE INVESTIGATION FOR SAFETY
IMPROVEMENT**

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Final Report

Expert System to Support Site Investigation for Safety Improvement

Introduction

Specialists in transportation and other areas of engineering are trying to improve road safety. The most difficult part is determining the road features, driver behaviors, and vehicular failures that unduly increase the risk of crash. To help INDOT safety investigation teams, a previous research project developed a prototype Road Safety Investigation Tool (RSIT) for two-way stop-controlled intersections. The research summarized here has evaluated the prototype RSIT and has developed a new version RSIT2 that has incorporated the findings of the evaluation.

Findings

The evaluation of the RSIT prototype confirmed usefulness of the proposed methodology. The tool has been applied to two two-way stop-controlled intersections by a team of non-experts. The two sites have been previously investigated by experts using the standard approach. The safety investigation outcomes obtained by both the teams indicate strong similarities. The proposed RSIT method helped non-experts identify additional road hazards confirmed later by the experts' team.

RSIT has been found decreasing the required investigation team size and time as well as being useful as a training tool. RSIT presents the logical connections between driver behaviors, road elements and environment conditions.

RSIT2 is the next version of the RSIT method. The knowledge base developed for RSIT 2 includes all the major types of roads in Indiana: a) all-way stop-controlled intersection, b) road segment, c) railroad crossing, and d) signalized intersection, and e) improved two-way stop-controlled intersections. The RSIT 2 method uses the rule-based structure converted to a dynamic checklist that adjusts in real-time to the investigation progress. A friendly graphic-user interface has been developed together with a knowledge base editor to allow updating the knowledge base by the user. Finally, a novel technique of ranking safety countermeasures was developed and applied.

Implementation

The RSIT 2 is ready for implementation. The agency may easily update/modify the default knowledge base to fit its local needs. A series of workshops may be

needed to help in the implementation phase.

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16. Abstract <p>Specialists in transportation and other areas of engineering are trying to improve road safety. The most difficult part is determining the road features, driver behaviors, and vehicular failures that unduly increase the risk of crash. To help INDOT safety investigation teams, a previous research project developed a prototype Road Safety Investigation Tool (RSIT) for two-way stop-controlled intersections. The research summarized here has evaluated the prototype RSIT and has developed a new version RSIT2 that has incorporated the findings of the evaluation.</p> <p>The evaluation of the RSIT prototype confirmed usefulness of the proposed methodology. The tool has been applied to two two-way stop-controlled intersections by a team of non-experts. The two sites have been previously investigated by experts using the standard approach. The safety investigation outcomes obtained by both the teams indicate strong similarities. The proposed RSIT method helped non-experts identify additional road hazards confirmed later by the experts' team. RSIT has been found decreasing the required investigation team size and time as well as being useful as a training tool. RSIT presents the logical connections between driver behaviors, road elements and environment conditions.</p> <p>RSIT2 is the next version of the RSIT method. The knowledge base developed for RSIT 2 includes all the major types of roads in Indiana: a) all-way stop-controlled intersection, b) road segment, c) railroad crossing, and d) signalized intersection, and e) improved two-way stop-controlled intersections. The RSIT 2 method uses the rule-based structure converted to a dynamic checklist that adjusts in real-time to the investigation progress. A friendly graphic-user interface has been developed together with a knowledge base editor to allow updating the knowledge base by the user. Finally, a novel technique of ranking safety countermeasures was developed and applied.</p>			
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INDOT Research Project Implementation Plan

Date: August 12, 2009

Research Project Number: SPR-3103

Project Title: Knowledge-Based System to Support Site Investigation for Safety Improvement

Principal Investigator (PI): Andrew Tarko

Project Advisor (PA): Shuo Li Signature: _____

Principal Implementor (PIM): Mike Holowaty Signature: _____

INDOT Strategic Goal Impact Areas (select all that the implementation of this project will impact):

- ☐ Mobility ☒ Safety ☐ Economic Development ☐ Customer Service
☐ Resource Management ☐ Training

Summary of Implementation Plan: The RSIT 2 tool is ready for implementation. The graphic user-friendly interface has been updated from the prototype of RSIT. The developed knowledge base for the RSIT 2 needs to be evaluated and improved as part of implementation and regular use. The implementation effort may include a half-a-day training with participation of the PI.

Note: If more than one implementor recommended, please fill in the information on each implementor's implementation items:

Name of Implementor/User: Mike Holowaty Signature: _____

Responsible for Implementing: _____

Help or resources needed for implementation (e.g., help from PI, funding, equipment, etc.): _____

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Responsible for Implementing: _____

Help or resources needed for implementation (e.g., help from PI, funding, equipment, etc.): _____

Name of Implementor/User: _____ Signature: _____

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Help or resources needed for implementation (e.g., help from PI, funding, equipment, etc.): _____

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1 INTRODUCTION

Road safety has become a critical transportation issue around the world including the United States. Year 2005 brought the highest total number of traffic fatalities since 1990. Safety specialists are continuously striving for improvement in this area. The toughest part is determining the road features, driver behavior, and vehicular failure that unduly increase the risk of crash. Investigating roads that experience excessive number of crashes provides of an opportunity to identify specific road factors contributing to some of these crashes. Even experienced road investigators may have difficulties in connecting various pieces of information and knowledge due to the high level of uncertainty, the great complexity of safety impacts, and the gaps in what is known about driver performance during the crash. Due to the lack of standard techniques, investigative teams rely greatly on their experience and judgment. Moreover, in some cases an investigative team adheres to its past experience, routine actions, and past findings that do not necessarily reflect the causes at the currently investigated site.

Lack of adequate information, time pressure as well as lack of in-depth knowledge of the actual circumstances leading to past crashes increases the complexity of the problem. Current practice, despite the best effort of investigating teams, relies a great deal on the teams' experience and judgment, which may not be sufficient given the limited data, the complexity of roadway-driver-vehicle interactions, and the large number of possible scenarios leading to crashes. One of the tempting alternatives is to focus the investigation on roadway deficiencies that are understood to be a diversion from the current design standards. Although this may bring about sound solutions, it may also reduce the chance of discovering unusual and dangerous combinations of local conditions.

Road Safety Audit (RSA) was first time introduced in the U.S. in the early nineties. RSA was meant to address safety problems in the planning and design stages of highway project. The current RSA is implemented also to the existing road infrastructure. The Road Safety Audit may contain three steps.

- (1) Pre-investigation, where available information related to the crash history on the investigated roadway entity is collected and analyzed;
- (2) Site investigation, where the safety team investigates the road site to determine the road deficiencies; and
- (3) Post-investigation, where the safety team evaluates the findings of the site investigation and identifies a relevant set of countermeasures.

The common practice of the safety team during investigation is using of safety checklists that organize an audit and serves as the outcome documentation. The Purdue team has developed a comprehensive checklist (Tarko and Kanoida, 2004) as a part of the project on developing the Indiana guidelines for safety improvements (Appendix A). Unfortunately, the length of the checklist and its structure bring the following issues:

- (1) The length of the checklist can be as long as 40 pages.
- (2) The user has to browse through the entire checklist to find the question/checklist that he/she wants to address.
- (3) There is a lack of methodology to indicate a set of relevant countermeasures to address the identified road deficiencies.
- (4) The checklist neglects uncertainty of the results.

Despite its deficiencies, a checklist is a frequently used tool as a practical aid in high-crash site investigation. The objective of this research is to develop a computer-based tool to support a high-crash site investigation that provides both a better tool than a conventional checklist. The developed tool should be practical and applicable to the majority of roads in Indiana. It should include a knowledge base applicable to two-way stop-controlled intersections, all-way stop-controlled intersections, road segments, signalized intersections, and railroad crossings.

The presented report is a continuation of previous JTRP research on a prototype Road Site Investigation Tool (RSIT) limited to two-way stop-controlled intersections. In the presented current research, the developed prototype RIST is to be evaluated and improved based on the evaluation outcome. Another important objective is to expand the knowledge base to incorporate other types of roads present in Indiana.

The first chapter provides an overview of the motivation, scope, and objective of the research. In the second chapter the state-of-the-art and practice, and an overview of actual and propose safety investigation tools are provided. Chapter 3 focuses on the prototype of RSIT while Chapter 4 provides its evaluation. Chapter 5 presents the RSIT 2 concept while Chapter 6 describes the development of the new knowledge base for RSIT 2. An important study of the existing crash reduction factor providing a complete set of the values for the knowledge base is also presented. Chapter 7 provides a description of the RSIT 2 user graphical interface. Conclusions are provided in Chapter 8.

2 SAFETY INVESTIGATION TOOLS AND METHODS

2.1 Road Safety Investigation Process and Its Issues

The Road Safety Investigation process is a safety examination of selected roadway entities by teams which should include specialists in highway safety engineering (NCHRP 336, 2004). To improve the investigative process, the safety team should incorporate additional experts outside highway engineering (i.e., human factors experts).

The safety investigation process can be divided into three major stages. The first stage is called preliminary analysis and it helps in the planning of site investigation. During this stage, the safety team collects information about the investigated roadway entity, type of roadway entity, the exact location of the entity, environmental conditions (i.e., school, shopping center, etc.), and any additional data. Probably the most important element in the preliminary stage is the crash data analysis. The crash data are used to determine the predominant crash pattern, weather condition, time of accident, crash severity, and place of crash, as well as information about the primary contributing circumstances and other useful information.

One of the required steps during the preliminary analysis is to prepare a collision diagram (Figure 2-1). This helps find the predominant crash pattern. The time of the accident (for example, night time) is important for site investigation planning. A well-planned site investigation should take place during the identified periods with frequent crashes. During the preliminary analysis, after all the available data have been prepared, the investigative team can identify possible crash scenarios that may provide guidance during the site investigation by focusing the investigative team on certain periods, weather conditions, traffic movements, driver behaviors, etc.

Figure 2-1 Collision Diagram (LTAP Hazard Elimination Study)

The next stage is the site investigation. The investigation team goes to the specific location and determines the existing local conditions. The purpose of this stage is to collect actual information about road conditions, geometry, traffic conditions, and traffic characteristics. In the case of a speed study, the investigator can determine if speed violations are frequent. Collection of the data often requires photographing or videotaping the site. The team may also briefly discuss funding and decide to collect additional data or prepare additional site investigation studies. One of the common practices by the investigation team during this stage of analysis is to follow the checklist (Tarko et al. 2004). An example of the checklist is available in Appendix A. This checklist is an extensive collection of possible roadway deficiencies structured in such a way that helps customize it to the type of roadway location studied. A sample checklist prepared during site investigation is shown in Figure 2-2.

Safety Review Check List

Roadway Segment

Facility Type: _____

Page: 1 of 3

Location: Smith Road / Rogers Road

Date: Jan 18, 2006 ~~5 Jan 06~~ Time: 1:30 pm Weather: Sunny

Moving Lanes

Lane widths are inadequate for vehicle classes common to location 20'
Number of lanes are inadequate for traffic
Lanes abruptly end

Exists Problem N/A

✓		✓
		✓
		✓

Auxiliary / Turning Lanes

Inadequate advance warning of lane drop
Auxiliary lane lengths are inadequate
Taper lanes and not properly marked or inadequate length

		✓
		✓
		✓

Driveways and Parking

Driveways too closely spaced
Inadequate visibility of driveways
Parked cars limit visibility

✓	✓	
		✓

Figure 2-2 Example of the Checklist (Hazard Elimination Study for Smith and Rogers Road, Indiana, 2006)

The last stage of the safety investigation process is a post-analysis study. The safety team, upon completion of the site investigation, discusses all the findings and determines the safety deficiencies. A common issue faced in the post-analysis study is frequent identification of multiple road deficiencies and corresponding safety countermeasures. The investigative team must decide which of these countermeasures should be recommended.

Use of checklists is a common practice in a Road Safety Audit (RSA). Although the checklist helps in organizing an investigation process and provides an overview of all possible roadway deficiencies, there are also weaknesses in the checklist concept. A safety checklist is customized to a specific site beforehand based on a general knowledge of the site and the pattern of crashes at this site. The checks and their order are not modified at the site during an investigation as the knowledge of the site grows. The most relevant and promising checks may remain further down the list and by the time the investigation reaches them, the investigators may be “worn down” by the job and time pressure. These conditions can negatively affect the efficiency and effectiveness of a site

investigation. As a result, in some observed RSA investigations, the team put the checklist aside and tried to suggest potential safety candidates for improvement based on their own experience, knowledge, and judgment. In such a case, it is easy to overlook important safety deficiencies and provide inadequate safety improvements.

2.2 Frequency and Severity Rating Method

To help investigators classify the road deficiencies, a frequency and severity rating can be used (practiced by the Illinois Department of Transportation (IDOT) in the developing and existing condition). By using a frequency rating, the total number of crashes that occur on specific intersections or road segments is classified as shown in Figure 2-3.

ESTIMATED		EXPECTED CRASH FREQUENCY (per audit item)	FREQUENCY RATING
EXPOSURE	PROBABILITY		
high	High	10 or more crashes per year	<i>Frequent</i>
medium	High		
high	Medium	1 to 9 crashes per year	<i>Occasional</i>
medium	Medium		
low	High		
high	Low	less than 1 crash per year, but more than 1 crash every 10 years	<i>Infrequent</i>
low	Medium		
medium	Low	less than 1 crash every 10 years	<i>Rare</i>
low	Low		

Figure 2-3 Crash Frequency (IDOT, 2006)

The severity rating is obtained by combining the typical crashes expected with the expected crash severity; for example, a crash that involves high speed and a heavy vehicle can have an expected crash severity of probable fatality or incapacitating injury (Figure 2-4).

TYPICAL CRASHES EXPECTED (per audit item)	EXPECTED CRASH SEVERITY	SEVERITY RATING
crashes involving high speeds or heavy vehicles, pedestrians, or bicycles	probable fatality or incapacitating injury	<i>High</i>
crashes involving medium to high speed; head-on, crossing, or off-road crashes	moderate to severe injury	<i>High Moderate</i>
crashes involving medium to low speeds; left-turn and right-turn crashes	minor to moderate injury	<i>Low Moderate</i>
crashes involving low to medium speeds; rear-end or sideswipe crashes	property damage only or minor injury	<i>Low</i>

Figure 2-4 Severity Rating (IDOT, 2006)

By combining the severity rating and the frequency rating, the crash risk assessment is obtained. Levels D, E, and F represent the highest crash risk, where safety implementation is needed as shown in Figure 2-5.

FREQUENCY RATING	SEVERITY RATING			
	<i>Low</i>	<i>Low Moderate</i>	<i>High Moderate</i>	<i>High</i>
<i>Frequent</i>	C	D	E	F
<i>Occasional</i>	B	C	D	E
<i>Infrequent</i>	A	B	C	D
<i>Rare</i>	A	A	B	C

Crash Risk Ratings:

A: lowest risk level

D: moderate-high risk level

B: low risk level

E: high risk level

C: moderate-low risk level

F: highest risk level

Figure 2-5 Crash Risk Assessment (IDOT, 2006)

During site investigation and post-analysis, the safety team develops a list of all possible safety issues. This list is evaluated according to the expected safety risk of associated crashes. Risk is defined by the degree of frequency and the severity of the expected crashes for each safety issue and is given an overall rating level as represented in Table 2-1.

Following is an example of using the crash risk assessment technique. The observations were made by the IDOT safety team during road safety audits in Williamson County, Illinois (Illinois, 2006). One of the observations during the site investigation was insufficient sight distance triangles (Figure 2-6). The expected frequency and severity were classified as occasional, severe; (Table 2-1) what constitutes a high crash rating and level E.

Table 2-1 Example of the Rash Risk Assessment (IDOT, Williamson County RSA)

<i>Expected Frequency</i>	<i>Expected Severity</i>	<i>Risk Rating</i>	E
Occasional	Severe	High

Figure 2-6 Insufficient Sight Distances (Williamson County RSA, Illinois 2006)

Because the insufficient sight distances represent level E, this observation had to be considered. Therefore, the following suggestion was proposed: “Clear vegetation, including strategic tree removal, relocate signs, and regrade slopes or reduce crests to establish sight distance.

2.3 Interactive Highway Safety Design Model

The IHSDM (Interactive Highway Safety Design Model) is an advanced public domain decision support system developed to evaluate the safety and operational effects of geometry design on rural two-lane roads (Kindler et al. 2006). The IHSDM released in

2003 is the cumulative work of researchers and developers over a number of years (Krammes et al. 2003). The current available version of this software provides six modules:

- (1) Crash Prediction. The crash prediction module predicts the expected frequency of crashes based on geometry design and traffic characteristics. The base statistical model used to predict crash frequency is derived from negative binomial regression analysis. Moreover, the Accident Modification Factors (AMF) was used to adjust the base model for individual roadway characteristics. The Empirical Bayesian (EB) technique was used to adjust the model to location-specific data.
- (2) Design Consistency. This module was developed to evaluate safety on horizontal curves. In addition, for evaluation purposes the speed-profile was used. The output of this module provides information that helps diagnose safety issues on roadway entities and checks for alignment design.
- (3) Driver/Vehicle. This model will be added to the future version of IHSDM to evaluate driver performance on the road and its interaction with the vehicle.
- (4) Intersection Review. This module was developed to evaluate intersection safety based on verification in current geometry design. This module focuses on intersection configuration and horizontal/vertical alignment. Because this model is closely related to improving safety on roadway entities (intersection – similar to RSIT), it will be discussed in more detail below.
- (5) Policy Review. This module reviews and checks four categories: cross section, horizontal alignment vertical alignment, and sight distance with design standards specified by AASHTO.
- (6) Traffic Analysis. This module “uses the TWOPAS traffic simulation module to estimate traffic quality of service measures for an existing or proposed design under current or projected future traffic flows.” (FHWA/IDOT, 2005)

The Intersection Diagnostic Review Model (IDRN) described in p. 4 is discussed below in more detail. The IDRM is designated to be used after other modules (crash prediction, policy review, and design consistency) are performed. The output from the previous modules is used as an input into IDRM. The IDRM provides a

comprehensive review of the intersection design. The knowledge base for at-grade intersections on two-lane highways was developed. The knowledge base is organized into a set of engineering models that are selected based on geometry and safety concerns at the intersections. As a result, 111 potential design problems were identified and 21 models were developed for the IDRM knowledge base. These models include: intersection sight distance (ISD) – based models, stopping sight distance (SSD) –based models, decision sight distance (DSD) based models, clearance time models, turn-lane models, and miscellaneous models. As a result, the IHSDM (IDRM) contains a sufficient knowledge base to check the geometry design for each approach as well as for all intersections. The knowledge base is supported in the engineering models that consist of the most importance factors, which have to be checked for geometry design standards. Information about the actual obstruction of the intersection sight distance is derived by the user. This approach creates a more effective tool and gives more adequate findings

The example below presents the model for intersection sight distance on the left turn minor road. This model defines intersection sight distance by Equation 2.1

$$ISD = 0.276Vt$$

Equation 2.1

where:

ISD – intersection sight distance (m),

V – initial speed (km/h),

t – time gap (s).

The initial speed is set up to the actual 85th percentile speed of traffic on the selected major road. To evaluate ISD on the specific intersection, the following procedure applies:

- (1) Select a pair of major – and – minor road approaches.
- (2) Determine the actual 85th percentile speed on the elected major road approach.
- (3) Select an appropriate time gap.
- (4) Address the sight triangle issue. In the case of sight obstruction such as: vegetation, man-made obstacles, etc. ask the user if region X is clear of roadside sight obstruction.

After all the information is provided, the ISD is compared with the calculated threshold and is adequate if a needed advisory message is displayed.

In Figure 2-7, the example of the IHSDM IDRM is presented including: a configuration of the intersection, potential safety concern and design improvements.

Figure 2-7 IDRM Example

The IHSDM was developed for use in engineering studies, functional/conceptual design, preliminary design, and detailed design stages.

2.4 Road Safety Audit Software

The Federal Highway Administration (FHWA) in cooperation with software development and transportation companies developed a prototype of RSA Software (RSAS). Currently, the evaluation version of this software (Beta Version 1.00.0002, January 2006) is available.

FHWA RSAS allows the development of a customized list of checks (prompt or detailed) provided by the auditor information. The welcome windows presented in Figure 2-8 Road Safety Audits Software (RSAS) allows the provision of basic background

information related to the investigated entity i.e. project number, project description, start/end date, etc.

The screenshot shows the 'Road Safety Audit - Admin (RSA) - [Classification (New Project)]' window. It features a menu bar with 'Project', 'Manage', 'Report', 'Data', 'Archiving', 'Window', and 'Help'. The main interface is divided into three primary sections. The 'Project Details' section contains input fields for 'Project No.', 'Project Name', 'Client', 'Project Description', and 'Project Comment'. It also includes 'Created By' (set to 'admin'), 'Start Date' (Sunday, October 14, 2007), and 'End Date' (Sunday, October 14, 2007). The 'Project Characteristics' section has dropdown menus for 'Audit Type' and 'What type of project is this?'. The 'Project Auditors' section includes a large empty list box, a 'Select Auditor(s) ...' button, and a 'View Audit ...' button. On the right side, there are 'Save', 'Upload File(s) ...', and 'Close' buttons.

Figure 2-8 Road Safety Audits Software (RSAS)

In addition, the presented software allows a user to choose between different audit types: planning stage, preliminary stage, final decision stage, work zone traffic scheme, pre-opening stage, existing roads, and land use development proposals. In the next step, based on the project characteristics provided such as: service function, climatic conditions, design speed, adjacent land use, etc. (Figure 2-9), the software generates the checklist (prompt or detailed) as well as a summary list. An example of a detailed generated checklist is presented in Figure 2-10.

Moreover, the RSAS allows multiple users accessibility and administration functions. The final report as well as the current stage can be saved and opened later for further investigation.

The RSAS is currently in the development process; therefore, the beta version will be improved in the near future and additional functionality will be added.

Project Characteristics

Audit Type: Existing Roads

Which Units of Measure will be used for this project?: US

What is the Adjacent Land Use?: Urban

What is the Design Speed?: 35 mph

Is the roadway divided or undivided?: Undivided

What is the Service Function?: Arterial

Please characterize the surrounding terrain.: Rolling

What are the climatic conditions with respect to temperature?: Mild Winter (no freezing, icing)

What are the climatic conditions with respect to snow?: Snow in Winter

Which of the following best describes the roadway scheme?: Road section including interchange(s) and non-signalized at-grade ir

What type of project is this?: Construction of completely new alignment (undeveloped comidor)

Figure 2-9 RSAS Project Characteristics

Road Safety Audit

10/14/2007

Checklist: (Detailed)

ROAD FUNCTION, CLASSIFICATION, ENVIRONMENT	Yes / No	Comment
General road function, classification, environment		
Is the road function and classification the same as it was when the road was designed and constructed?		
Is the road environment the same as it was when the road was designed and constructed (no new developments, no new pedestrian/bicyclists activities, special events, scenic vistas etc)		
ROAD ALIGNMENT AND CROSS SECTION		
Visibility, sight distance		
Is sight distance adequate for the speed of traffic using the route?		
Is adequate sight distance provided for intersections and crossings? (e.g., pedestrian, bicyclist, cattle, rail crossings)		
Is adequate sight distance provided at all private driveways and property entrances?		
Design speed		

Figure 2-10 RSAS Checklist Example

2.5 Summary

This chapter presented an overview of road safety investigation methods and tools. Available tools dedicated to road safety investigation were discussed. The review of available tools and methods pointed out lack of an adequate approach that can be efficiently during road safety investigation. The lack of in-depth knowledge of the actual circumstances leading to past crashes increases the complexity of the problem. Current practice, despite the best effort of investigating teams, relies a great deal on the teams' experience and judgment, which may not be sufficient given the limited data, the complexity of roadway-driver-vehicle interactions, and the large number of possible scenarios leading to crashes.

A computer-based method is needed to organize an efficient site investigation as well as to utilize all available pieces of information. This tool should be user-friendly and allows for flexibility to update or change the implemented knowledge by a user to customize it to the user needs.

3 Prototype RSIT

A prototype of the Road Safety Investigation Tool (RSIT) was developed at Purdue University (Tarko et al. 2006). This prototype is applicable to two-way stop-controlled (TWSC) intersections. The RSIT proposed a new method that utilizes a tree-like knowledge base of the safety countermeasures and their connection with the roadway conditions and crash patterns. The implemented knowledge takes the form of an “intelligent” checklist that leads the investigator through relevant questions in an interactive process. The sequence of affirmative responses forms the set of conditions that point out the corresponding countermeasure.

The development of the prototype of RSIT was accomplished in three phases:

- (1) Knowledge acquisition,
- (2) Knowledge representation, and
- (3) Knowledge implementation.

In the first phase, available sources of information about safety and countermeasures at two-way stop-controlled intersections were identified. In the second phase, the relevant knowledge was extracted and combined in a tree-like knowledge base. In the last phase, a graphic user interface was developed to facilitate forward chaining applied to determine suitable safety countermeasures during site investigation.

The acquisition process of the developed knowledge includes information found in the following sources: text on human factors (Senders et al. 1991; Wiener et al. 1984; and others), publication on safety facts (Traffic Safety Facts), guidance and manuals for Road Safety Investigation, final reports (LTAP reports; Treat et al. 1979), observation safety specialist at work, and other relevant sources. The protocol analysis technique was used to identify relevant facts and logical relationships in the available information. By using the protocol generation technique and particularly interviewing safety experts and observing their work during two road safety audits by INDOT, IDOT, and TDOT teams, additional rules and facts were obtained. The applied protocol generation technique allowed reorganizing, updating, and improving the finding obtained in the protocol analysis phase. Direct observations of the safety team at work in the field in particular turned out to be an important part of the knowledge base development. The developed knowledge based is limited to two-way stop-controlled intersection.

In the knowledge representation part, the hierarchical generation technique was used to develop the final structure of the acquired knowledge. This structure is a decision tree with the forward chaining technique for solution seeking. Because this tool was developed to help investigators determine potential roadway deficiencies during a site investigation, it must mimic the most effective decision-making process during a site investigation. This process can be summarized from the top to the bottom and it includes a sequence of multiple-choice questions. The starting point is to specify all applicable crash patterns. Therefore, the top level of the knowledge is represented by five choices:

- (1) Crash types (six types),
- (2) Time of collision,
- (3) Weather conditions,
- (4) Pedestrians/bicycle collisions, and
- (5) Intersection conspicuity.

This representation was established for the limited (two-way stop-controlled intersection) knowledge base.

The most significant different between the prototype of RSIT and other available methods discussed in the previous chapter is the logical connection among the three stages of driver information processing with driver errors and crash occurrence that RSIT proposed. Such connections are presented in Figure 3-1.

In the three stages of driver information processing, the starting point is reception of a stimulus. In Figure 3-1a, this stimulus is generated by the presence of a STOP sign. If the STOP sign is missing, then a driver unfamiliar with the intersection will not consider stopping. Even if the STOP sign is not missing, it is not guaranteed that the driver will stop because the STOP sign, although existing, may not be visible (Figure 3-1b). A driver will probably fail to perceive the need for stopping if the STOP sign is not visible (Figure 3-1c). Adequate safety countermeasures to improve visibility are needed. If the STOP sign is visible, then the driver will probably recognize the sign and will consider stopping (Figure 3-1d).

At this point, adequate safety improvements depend on the actual roadway conditions (Figure 3-1e). The knowledge tree presented in Figure 3-1 has been built around the sequence of driving sub-tasks aimed to avoid collision (perception, cognition, action) and performed repeatedly in two stages of approaching an intersection (pre-approach and approach).

The established knowledge base for the prototype of the RSIT tool was facilitated to be used during field investigation by developing the Graphic User Interface (GUI).

The GUI is a flexible tool for browsing the knowledge base and preparing the final report where the proposed safety countermeasures are described, including complete conditions that imply the proposed improvements and user comments. The GUI of the proposed prototype of the RSIT is presented in Figure 3-2.

The welcome window of the prototype of RSIT is presented in Figure 3-2 (A). The user is allowed to start new investigation by pre-loading developed knowledge base or edit existing knowledge base. The editing is implemented and is allowed by commercial free available software (HDS). The next step of RSA is to determine the type of accidents that

need to be investigated (Figure 3-2 (B)). The structure of the investigation process, based on proposed prototype of RSIT is presented in Figure 3-2 (C)). The user by answering questions defines deficiencies to finally have a chance to point out adequate countermeasures and provided if necessary own comments. In the last step the report is automatically generated (Figure 3-2 (D)). For more information related to the presented prototype of RSIT (including user manual) the user is referred to Tarko et al. (2006).

The last step of developing the prototype of RSIT was evaluation. The evaluation part is described in details in the next chapter.

Figure 3-1 Knowledge Base for Right-Angle Collision (using HDS tool)

A

B

C

D

Figure 3-2 The RSIT - Prototype

4 RSIT EVALUATION

The developed prototype was evaluated in two ways: (1) In the field by user of the tool applied to two intersections, and (2) Through a software presentation and following up discussion of experts (members of the Study Advisory Committee for the project). The evaluation part was applied to the prototype with the knowledge base developed for two-way stop-controlled intersections.

In the first evaluation phase, inexperienced site investigators used the RSIT and worked independently from each other and obtained similar solutions. Their solutions agree well with the solutions found by the team of site investigation experts who used traditional checklists. Surprisingly, some of the inexperienced investigators pointed out relevant improvements that were overlooked by the experts. On average, the time needed for a RSIT-supported site investigation was shorter than for the checklist-supported investigation. In the second phase, the feedback from the Study advisory Committee members involved in this research has helped identify additional needs for the tool improvements and led to a new version of RSIT – RSIT2.

The original prototype of RSIT was evaluated to verify its usefulness. The evaluation compared findings obtained at the same locations with two methods:

- 1) The standard method of formal road safety investigations conducted by an experienced team, and
- 2) The proposed prototype of RSIT method applied to safety investigations conducted by several groups of “non-experts” (transportation professionals who do not participate in high-crash site investigations)

Two two-way stop-controlled intersections were included in the evaluation:

Stadium Avenue and Grant Street, West Lafayette, Tippecanoe County, Indiana

Sixth Street and Salem Street, Lafayette, Tippecanoe County, Indiana

On June 28, 2006, a road safety review was conducted at the two intersections. The follow-up The follow-up evaluation session was held on August 22, 2006. The roadway and weather conditions weather conditions on that day were similar to the conditions at the time when the formal investigations took place. Seventeen participants included county engineers, city engineers, and

engineers, and transportation planning specialists. The participants were divided into six teams of teams of two or three persons and then introduced to Tablets PC and to the RSIT method. Before the investigation was conducted the general description of the intersections, the statistics and statistics and details of crashes including collisions diagrams were presented. To assure independences of the results the participants were requested not to communicate with other teams. Members of the same team were encouraged to work together. After the introductory introductory part, the investigation of the two sites was conducted in two phases. In the first phase, first phase, three teams were assigned to the Stadium Avenue and Grant Street intersection and intersection and three teams to the Sixth Street and Salem Street intersection. In the second phase, second phase, the teams switched the intersections. This procedure has yielded investigation results investigation results for each of the two sites from six evaluation teams. The results are presented in presented in **Table 4-1** and **Table 4-2**.

Table 4-2

To interpret the results let us focus on one isolated example. During Road Safety Investigation on the intersection: Stadium Avenue and Grand Street, West Lafayette, Tippecanoe County, Indiana experts team found the following safety issue: “Inadequate intersection warning.” The proposed countermeasures include: “Install intersection warning signs (Adding a yellow flasher to the warning sign, street name).” Non-Expert teams that investigated the same location found the same safety issue and proposed the following countermeasure: “Install warning signs in advance of intersections (5 teams).” This countermeasure was proposed by five teams out of six. In some cases i.e. Truck movement non-experts did not identify this specific problem as a safety concern compare with expert. The reason for that was non truck movement present during investigation done by non-experts.

4.1 Deficiencies-based Evaluation

The evaluated method of proposed prototype of RSIT generates two types of outcomes: roadway deficiencies and safety countermeasures. Out of these two outcomes, the road deficiencies are much more difficult to identify. There are countless ways the site geometry, traffic control, drivers, and combination of the three can contribute to a high

risk of crashes at investigated sites. On the other hand, the safety countermeasures are relatively easy to point out once the roadway deficiencies are known.

Table 4-1 Prototype evaluation: Identified site deficiencies and proposed safety countermeasures at Stadium Avenue and Grand Street, West Lafayette, Tippecanoe County, Indiana

Formal Road Safety Audit	Prototype of Proposed Method (RSIT)
Inadequate intersection visibility <ul style="list-style-type: none"> Trim trees and shrubs Relocate stop bars closer to the intersection. 	Inadequate intersection visibility <ul style="list-style-type: none"> Remove the object obstructing the sight triangle / Trim vegetation (5 teams)¹ Relocate stop bars closer to the intersection (3 teams)
Inadequate intersection warning <ul style="list-style-type: none"> Install intersection warning signs (Adding a yellow flasher to the warning sign, street name) 	Inadequate intersection warning <ul style="list-style-type: none"> Install warning signs in advance of intersections (5 teams)
Pedestrians collision <ul style="list-style-type: none"> Install handicap ramps Mark crosswalks 	Pedestrians collision <ul style="list-style-type: none"> Improve signage and/or marking of the crosswalk (4 teams) Install lighting (3 teams)
Speed limit violation <ul style="list-style-type: none"> Increase speed enforcement. Add changeable message signs to the speed limit sign that indicates drivers speed. 	Speed limit violation <ul style="list-style-type: none"> Provide targeted speed enforcement (4 teams) Provide traffic calming on intersection approaches through a combination of geometric and traffic control devices (3 teams)
Possible inadequate winter pavement condition <ul style="list-style-type: none"> Include the intersections as “first response” areas for winter highway maintenance. 	Possible inadequate winter pavement condition <ul style="list-style-type: none"> Improve winter maintenance preparedness (shorter response time) (3 teams) Use salt to prevent snow or ice from forming or from sticking to the road surface (3 teams)
Parking enforcement <ul style="list-style-type: none"> Extend the no parking zones. Post and enforce the no parking area as a “tow away” zone 	Not identified
Not identified	Bike collision <ul style="list-style-type: none"> Install lighting (2 teams) Widen the outside through lanes or add bike lanes. Replace poorly designed drain grates with bicycle-safe types (2 teams)
Not identified	Nighttime collision <ul style="list-style-type: none"> Install lighting (4 teams) Improve channelization/delineation (1 team)

Table 4-2 Prototype evaluation: Identified site deficiencies and proposed safety countermeasures at 6th Street and Salem Street, Lafayette, Tippecanoe County, Indiana

Formal Road Safety Audit	Prototype of Proposed Method (RSIT)
Inadequate intersection sight triangle <ul style="list-style-type: none"> Relocate stop bars. Check turning radii 	Inadequate intersection sight triangle <ul style="list-style-type: none"> Relocate stop bar (3 teams)¹ Install corner mirrors (2 teams) Install traffic signals (1 team) Remove the object obstructing the sight of the stop sign (3 teams) Double Post Stop Signs (2 teams)
Excessive speed <ul style="list-style-type: none"> Perform a speed study on Salem Street, add changeable speed message signs indicating driver speed 	Excessive speed <ul style="list-style-type: none"> Provide targeted speed enforcement (5 teams) Post dynamic message sign to display the speed of approaching vehicles (2 teams) Conduct speed Study (2 teams) Provide traffic calming on intersection approaches through a combination of geometric and traffic control devices (3 teams)
Inadequate pavement marking/ signing <ul style="list-style-type: none"> Provide pavement marking (guidance for drivers, arrows) 	Inadequate pavement marking/ signing <ul style="list-style-type: none"> Provide adequate lanes signing or marking (5 teams) Improve pavement marking (arrows on pavement) (4 teams) Provide adequate turning markers or pavement markings (4 teams) Install left /right turn bays if turning volume is considerable (2 teams)
Inadequate warning of the intersection <ul style="list-style-type: none"> Add intersection warning signs (added street name) 	Inadequate warning of the intersection <ul style="list-style-type: none"> Install warning signs in advance of intersections (5 teams) Install larger regulatory and warning signs (2 teams)
Parking zone <ul style="list-style-type: none"> Relocate double yellow lane line to the east to accommodate left turning vehicles. Eliminate parking 	Parking zone <ul style="list-style-type: none"> Eliminate parking (2 teams)
Inadequate location of the stop sign <ul style="list-style-type: none"> Remove a portion of sidewalk in front of the tavern in order to place the stop sign 	Inadequate location of the stop sign <ul style="list-style-type: none"> Double Post Stop Signs (2 teams)

Formal Road Safety Audit	Prototype of Proposed Method (RSIT)
closer to the intersection	
Inadequate space for left turn vehicles <ul style="list-style-type: none"> Reconstruct the radius at the southwest corner to provide adequate area for left turns 	Not identified
Truck movement <ul style="list-style-type: none"> Pass an ordinance and post “No thru trucks” 	Not identified
Not identified	Nighttime collision <ul style="list-style-type: none"> Improve street lights (4 teams). Remove distracting commercial (2 teams) lights. Upgrade signing (3 teams)
Not identified	Pedestrians block left turn <ul style="list-style-type: none"> Increase the crosswalk setback (3 teams)
Not identified	Adverse-weather collisions <ul style="list-style-type: none"> Install static or variable message signs displaying weather information (2 teams) Use sand to increase pavement friction. Use salt to prevent snow or ice from forming or from sticking to the road surface. Groove pavement surface (2 teams)

The difference in complexity between the two identification tasks is reflected in the knowledge base. The branches of the knowledge tree represent alternative local conditions and the site investigator spends most of the time to identify these conditions. Once the set of local conditions are known, a short list of relevant countermeasures is proposed by the tool. In some cases, the same safety countermeasures apply to different roadway conditions. It is obvious, that the proposed method should be evaluated by checking the identified roadway deficiencies rather than checking the identified safety countermeasures.

The evaluation criteria of the method included consistency and validity of the identified roadway deficiencies and efficiency of the method. The consistency was determined by comparing the results obtained by the non-experts while the validity was checked by comparing the non-experts results with the results obtained in formal safety

audits. The method efficiency was measured with the time needed to complete a site investigation.

Consistency of the results is the first indication that the method may be valid. Obvious contradictions among results obtained by different investigative teams indicate that some of the solutions produced with the method must be invalid (there cannot be several contradicting answers to the same question). Different but not obviously contradicting results indicate that the method produces incomplete solutions (different teams arrive at different parts of the same solution). Consistency of the investigation results was measured with the similarity of site deficiencies identified by the three evaluation teams and is presented in Table 4-3.

The number of deficiencies identified by any of the non-expert team out of many possible is limited (7 at the first intersection and 9 at the second one). All of the identified deficiencies were pointed out by at least two teams. Only four out of 16 were pointed out by two teams while nine were identified by four or five teams. Although the consistency could be better, the one reached at the two studied intersections was satisfactory given the lack of experience of the investigative teams. Some team members using the Tablet PC for the first time reported difficulties. No obvious contradictions were found in the results obtained by the six teams at the two investigated sites.

Validity of the results is more difficult to evaluate than consistency because the correct solutions (ground truth) are not known. The method available and used by us was comparing the results obtained by experts with the results obtained by non-experts. The notion was that the expert results are of better quality than the ones obtained by inexperienced investigators. The following discussion is based on the results shown in Table 4-3. For the first intersection, the experts pointed out six deficiencies, when non-experts indicated five of them. Missing the parking issue by the non-experts might be caused by different parking situation during their site visit compared to the conditions during the format safety audit (daytime conditions, weather, and geometry conditions were identical or similar). Furthermore, 70% of the non-experts teams pointed out the same findings as the experts (in average four out of six teams).

Table 4-3 Roadway Deficiencies Identified at the Two Investigated Sites

Stadium Ave. and Grand Street, West Lafayette, Tippecanoe County, Indiana											
	A	B	C	D	E	F	G	H			
Team 1	X	X	X	X				X			
Team 2		X	X		X		X				
Team 3	X	X		X				X			
Team 4	X			X	X						
Team 5	X	X	X				X	X			
Team 6	X	X	X	X	X			X			
Experts	X	X	X	X	X	X		<u>X</u>			
X – Identified deficiencies <u>X</u> – Deficiency added by the experts after reviewing solutions proposed by the RSIT Deficiencies: A - Inadequate intersection visibility; B - Inadequate intersection warning; C - Pedestrians collision; D - Speed limit violation; E - Possible inadequate winter pavement condition; F - Parking enforcement; G - Bike collision; H - Night time collision.											
6 th Street and Salem Street, Lafayette, Tippecanoe County, Indiana											
	A	B	C	D	E	F	G	H	I	J	K
Team 1	X	X		X	X				X		X
Team 2		X	X	X		X				X	
Team 3	X		X	X	X	X			X	X	
Team 4		X	X	X							
Team 5		X	X	X					X	X	X
Team 6	X	X	X						X		
Experts	X	X	X	X	X	X	X	X	<u>X</u>		
X – Identified deficiencies <u>X</u> – Deficiency added by the experts after reviewing solutions proposed by the RSIT Deficiencies: A - Inadequate intersection sight triangle; B - Excessive speed; C - Inadequate pavement marking/ signing; D - Inadequate warning of the intersection; E - Parking zone; F - Inadequate location of the stop sign; G - Inadequate space for left turn vehicles; H - Truck movement; I - Night time collision; J - Pedestrians block left turn; K - Adverse-weather collisions											

Additionally the non-experts (four out of six non-experts teams) using the prototype of RSIT pointed out on the both investigated intersections, nighttime collisions issue which was not considered by the experts. The experts, after reviewing the prototype

findings, updated their final report. For the second intersection, nearly four out of six non-experts teams indicate the same deficiencies as the experts. Two expert findings were not present in the non-experts results. One of them: “truck movement” could not be identified by the non-experts because neither past truck accidents nor considerable truck traffic during their visit took place. The results obtained by experts and non-experts are strikingly similar which is an important positive evaluation outcome.

The time needed for a RSIT-supported prototype site investigation was shorter than for the checklist-supported investigation. Further reduction in a RSIT-based prototype site investigating is expected after the investigative team equipped with the prototype of RSIT was two or three members while the typical safety audit involves three to four members.

The most spectacular result of the evaluation was helping inexperienced investigators properly determine safety deficiencies as well as preventing overlooking some important safety issues. Experts investigated both intersections overlooked one of the safety concerns: nighttime collisions (almost 30% related crashes). The non-experts using the prototype of RSIT indicate nighttime collisions as an important safety issue (four teams out of six).

4.2 Countermeasures-based Evaluation

The presented above evaluation results have confirmed that site deficiencies were satisfactorily identified. These positive results confirm the concept of the method and its implementation. The next step in the presented evaluation was to check the identified countermeasures. This phase is of lesser weight because any needed modifications of the countermeasures in the tool can be easily implemented and they do not affect the knowledge. Nevertheless, the consistency and validity of the safety countermeasures have been evaluated based on the results presented in Table 4-1 and Table 4-2. The results exhibit similar consistency and a sign of validity as the identified site deficiencies. Some discrepancies could also be found. An example is presented in Figure 4-1. Group 1 proposed installing a corner mirror which is not proposed by Group 4.

Figure 4-1 The prototype of RSIT - report

4.3 Summary

The proposed prototype with limited knowledge base guides an investigation team through a sequence of checks and determines the probable roadway factors contributing to crash occurrence. Even though the developed knowledge is complex, it has an easily understandable structure represented by a user-friendly interface. The knowledge structure and functionality of the GUI are easy to understand even for non-experts. The developed knowledge base provides a more detailed explanation for each individual roadway deficiency compared to the findings from the road safety report, which confirms the previous statement that even experienced investigators can overlook important factors. By using developed knowledge, the time spent on the investigation process should decrease. The implemented knowledge can decrease the size of the team, which

usually should contain specialists from the different areas of geometry, safety, and human factors. In addition, by using the knowledge base in a user-friendly graphic interface, the automatically generated final report presents in an easy and understandable way the searching process including users comments and the proposed final solutions. Furthermore, the developed knowledge base can be used as a training tool to represent the logical connection between the time of the crash, the driver, and the roadway elements that contributed to roadway safety.

Although, the developed prototype of RSIT brought significant improvement over existing method, the evaluation part emphasized the need for modifications.

- 1) The knowledge developed for two-way stop-controlled intersection need to be revised and updated based on feedback from the evaluation part.
- 2) The investigation process should relate to the road components to allow tracking which parts of the road/intersection has been investigated and to allow documenting the findings in relation to these parts. For example, some safety checks apply to an entire intersection while some other to individual intersection approaches or exits.
- 3) The current knowledge must be expanded to include all-way stop-controlled intersection, road segment, rail road crossing, and signalized intersection.
- 4) The software should allow easier editing of the existing knowledge base by releasing the user from deciding how to “trim” or “expand” the knowledge base tree.
- 5) Uncertainty of some observations and conclusions together with their importance for a safety enhancement should be incorporated into the post-investigation process to help rank the identified multiple safety countermeasures for implementation.

5 RSIT2 CONCEPT

The presented concept of RSIT2 is based on a novel idea of an optimal investigation based on an optimal checklist with its dynamic updating in the course of site investigation. This approach makes the investigation process the most effective (the least expensive). As the previous RSIT, RSIT2 uses rules as building blocks of the knowledge base. The knowledge updating can be executed by removing, adding, or modifying current rules.

First, we will introduce the concept of a rule-based checklist with estimating the investigation costs and some rule-of-thumb optimization strategies. Then, the knowledge base structure is explained, and finally, the RSIT2 software described in general terms.

5.1 Checklist Optimization Problem

Checklists are used to diagnose problems or/and to select relevant actions. In a general case, a checklist is a collection of if-then rules typically organized in two columns: the first column includes *conditions* and the second column includes relevant conclusions. Table 5-1 demonstrates this structure. Checklists are widely used because they are convenient, intuitive, and provide straightforward inventory of relevant knowledge. This inventory is easy to update by adding or removing rules.

Before we introduce an investigation cost function, let us propose a checklist structured differently than the one shown in Table 5-1. The modified checklist is easier to optimize than the conventional one.

Table 5-1 Conventional checklist

IF	THEN
$X_{1,1} \dots \text{and } X_{1,N1}$	C_1
$X_{2,1} \dots \text{and } X_{2,N2}$	C_2
.....	
$X_{M,1} \dots \text{and } X_{M,NM}$	C_M

A conventional checklist shown in Table 5-1 is equivalent to the following set of rules:

Equation 5-1

Some of the atoms $X_{i,j}$ are the same. After removing the repetitions, renumbering the atoms from $1...N$, and reordering them in some way, the following sequence is obtained: $X_{n(1)}, X_{n(2)}, \dots, X_{n(N)}$, where $X_{n(i)}$ stands for an atom originally indexed between 1 and N , and being at position i on the new checklist. These checks are performed in the order indicated by i . After the investigation is completed, the results include the checks with their logical values (true, false). These results and the set of rules (Equation 5-1) determine which conclusions C_j are true (countermeasures to be selected). The proposed checklist structure including single conditions $X_{n(1)}, X_{n(2)}, \dots, X_{n(N)}$ is currently used by road safety engineers. The essential difference is the lack of formal rules that are the starting point for forming the checklist. Consideration of these rules in connection with the checklist allow three important operations lacking in the current road safety investigation: (1) Optimization of the checks order prior the investigation, (2) Updating the checklist in the course of the investigation, (3) Derivation of the relevant countermeasures after the investigation.

Let us now propose a method of evaluating the cost of an investigation. Let $X_{n(1)}, X_{n(2)}, \dots, X_{n(N)}$ be a list of checks. If performing check $n(i)$ costs $c_{n(i)}$ and moving from check n to check m costs $c_{n,m}$, then an investigation that follows a **complete** list of checks $X_{n(1)}, X_{n(2)}, \dots, X_{n(N)}$ costs

Equation 5-2

The investigation cost in Equation 5-2 assumes that all the checks are performed. Using the rules linking checks with countermeasures allows elimination of some checks during the investigation. Let the investigation be at line i of the checklist. At this point of the investigation, a number of if-then rules are refuted because they include at least one of the false conditions among C_i conditions checked. Other rules are still active. The check C_i can be skipped if it does not support any of the remaining active rules. Let us denote the likelihood of skipping check $X_{n(i)}$ as $P_{n(i)}$. Now, the expected investigation cost is the sum of the expected cost of checks and the expected cost of transfers between checks:

Equation 5-3

In some cases, the transfer costs can be neglected and in some other cases the check costs can be neglected. Investigating a geographically large area that involves just visual inspection of spots takes a considerable time and resources to travel between the points while the cost of checks is small. This case is a traveling salesman problem and is well researched. In the case of investigating a geographically limited object such as a road intersection with variety of checks ranging from visual inspection to elaborated measurements, both the cost components are present and cannot be neglected.

There are three ways of improving a checklist and an efficiency of their use.

- 1) Checks that provide a great potential of eliminating other checks, particularly those expensive, should be placed close to the top of the list.
- 2) Some checks may be more expensive than other. These more expensive checks should appear close to the bottom of the list to give them a bigger chance to be refuted.
- 3) The pairs of checks with inexpensive transfer should be consecutive while the pairs with expensive transfer should be separated from each other.

5.2 RSIT2 Knowledge Representation

For the purpose of the Road Safety Investigation Tool 2 (RSIT2), the knowledge representation has been changed. Instead of tree-like structure (Figure 5-1) implemented as embedded folders (Figure 5-2), the new knowledge takes a form of a collection of rules. To represent the new knowledge structure based on rules, two entities composing a rule are adopted: conditions (X_i) and countermeasures (C_i). Each rule can contain only one countermeasure and one or several conditions. For the development and implementation purpose, the rule is written in such a way that the countermeasure opens the rule and is followed by conditions as shown in Figure 5-3. This modification is syntactic only and it does not change the logical meaning of the rule.

The new structure adopted for RSIT 2 has a number of significant advantages.

- a) The explicit use of rules tremendously helps the user update or modify the knowledge base by adding or removing rules that are logical and self explaining. A dedicated knowledge base editor (KB Editor) facilitates this important function.
- b) Developing new knowledge bases conducted in this research is also easier because it does not require converting the rules into a tree – a non-trivial task for complex cases. The KB Editor can be used to enter a brand new knowledge base.
- c) The rules can be easily generalized by adding variables that represent road components such as approaches, exits, etc. This modification allows developing a generic knowledge base that can be instantiated to a studied case by replacing the variables with the names of approaches, roads, exits, etc. This modification addresses the requirement that the tool better guides through the investigation by relating checks to specific road components and documents countermeasures more specifically. For example, the old condition: “Right-angle collisions”, reads in the new version as: “Right-angle collisions between #A1 and #A2 vehicles”. With additional conditions defining the two variables #A1 and #A2: “#A1 major approach”, “#A2 minor approach”.

Figure 5-1 RSIT Prototype Knowledge Structure

Figure 5-2 The Prototype of RSIT Knowledge Base

Figure 5-3 RSIT 2 Rule Syntax

- d) The checklist composed of single checks-conditions can be optimized by ordering these checks in such a way that the expected cost of the investigation is the lowest. This cost includes the cost of checks and the cost of moving from one check to the other. The beforehand checklist optimization is possible thanks to a joint consideration of the checklist and the corresponding rules. This optimization task is equivalent to optimizing a tree structure – a task that does not have to be performed by the user.
- e) The main sources of cost savings is skipping checks that do not have to be performed any longer because they do not affect the investigation results due to the outcome of the checks performed earlier. This real-time checklist updating is another unique feature of the developed method.

The two-way stop-controlled intersection knowledge base developed for the prototype of RSIT was updated. The new updated knowledge base includes over 200 rules. In addition, the knowledge bases for Road Segment, Signalized Intersection, Rail Road Crossing, and All-way Stop-Controlled intersection has been developed. They are presented in Appendix D.

Moreover, evaluation of identified countermeasures in order to help the user narrow the selection to a practical extent is introduced. The countermeasure evaluation is based on the expected safety reduction and cost level of the countermeasures.

To bring additional features including allow optimization of the checklist and ranking the identified countermeasures based on their expected safety effectiveness and cost, additional attributes checks and countermeasures are needed. Checks have associated the following attributes:

- a) Probability of passing (being true)
- b) Cost of the check
- c) Off-Site (check performed before the investigation)
- d) References (location where a file with additional explanatory material can be found)

The “Probability” attribute describes the assessed likelihood that a specific condition occurs (check passes). The “Cost” attribute tells how expensive the check is. Three cost levels 1-3 are used with level 3 being most expensive. The “Off-site” attribute

defines that a check is performed prior the site investigation. The “References” provides a link to a relevant pdf document relevant to a given check.

Table 5-2 Example checks with corresponding attributes

	Probability	Cost	Off - Site	Refere nce
Inadequate shoulders width on #R1 road	30	3	n	82302
Inadequate signing for multi-lane approach	20	2	n	N
Too short acceleration lane for vehicles merging into #E1 exit	15	2	n	N
Inadequate visibility of pedestrians	15	2	n	N
Inadequate sight distance toward vehicles approaching intersection on #A1 approach	40	2	n	422a
Inadequate sight distance on horizontal curve	20	2	n	4340

Table 5-2 gives example checks with corresponding attributes in the format used only in the development phase. Check “Inadequate sight distance on horizontal curve” has the following parameters: a) Probability equal to 20 [%], explains that this condition occurs in 20 % cases; b) Cost level 2 indicates that this check is moderately expensive,; c) Off-site “n” indicates that this check is NOT performed before the investigation but at the site, d) Reference “4340” provides a link to the Indiana Design Manual except (a pdf file) where relevant information can be found.

Also countermeasures have their own attributes needed for their ranking in the post-investigation phase:

- a) CRF
- b) Cost
- c) Road

The “CRF” (Crash Reduction Factor) describes the reduction in crashes possibly caused by a specific countermeasure. An extensive overview of available CRFs is presented in the last section of this chapter. The “Cost” attribute indicates the cost level of the countermeasure on the 1-5 scale with 5 indicating the highest cost level. The parameter “Road” tells to which types of roads this countermeasure can be applied.

Table 5-3 Countermeasure Table

	CRF	Cost	Road
Eliminate shoulder drop-off on #E1 exit	28	3	TWSC,AWSC
Eliminate shoulder drop-off on #R1 road	28	3	RS
Employ emergency vehicle preemption	70	3	SIGN
Enforce STOP sign compliance on #A1 approach	70	2	TWSC,AWSC
Enforce STOP sign compliance on #A2 approach	70	2	TWSC
Enhance delineation of sharp curves	16	3	RS
Groove pavement surface on #A1 approach	27	3	TWSC,AWSC
Groove pavement surface on #R1 road	27	3	RS

Example countermeasures with their attributes are presented in Table 5-3. For example, countermeasure “Groove pavement surface on #R1 approach” has the following parameters: a) CRF equal to 27 % indicates the percent of crash reduction expected to occur at locations where this countermeasure is needed and applied; b) Cost equal to 3 indicates that the countermeasures is moderately expensive, c) Road equal to “RS” tells that this countermeasure is applicable to road segments. The full list of conditions and countermeasures including associate parameters are attached in Appendix B and Appendix C.

5.3 Summary of RSIT2 Components

- 1) The user has access to the knowledge base in the form of conditions and conclusions through the KB Editor. The KB Editor allows viewing the KB, adding new rules, removing existing ones, or modifying them. The user is able to use existing conditions and countermeasures in new rules. Before adding new rules, the user checks if the needed conditions or countermeasures are already in the KB. The user has an option to add additional items if they are not included yet. The KB Editor includes a search tool for easy checking what is available before adding new items. All the existing attributes associated with the items in the KB are also displayed and subject to change, deletion, or addition.
- 2) Checklist Interface displays the current checklist and allows entering the results of check execution. It accepts the results at different levels of uncertainty. It allows

the user full control over what checks are skipped and what cannot be skipped at all. The checklist are arranged in a specific order that promotes skipping redundant checks and reducing the time and cost of the investigation. Two important functions of the Checklist Interface are optimization of the checks order and updating the checklist.

- 3) Countermeasures Selector calculates the expected effectiveness of the countermeasures based on the investigation results and a rough estimation of costs level. It is integrated with the Project Evaluator which allows packaging the selected countermeasures into projects and estimating the project effectiveness.
- 4) Report Generator creates a report including the investigation results, selected countermeasures with their effectiveness and one or more proposed safety projects with their effectiveness.

6 RSIT2 KNOWLEDGE BASE

The knowledge base development process contains three parts. First, the new concept of representing the knowledge base is introduced and the knowledge base for existing two-way stop-controlled intersection is revised and updated based on the feedback from the prototype of RSIT evaluation part and comments from SAC committee members. Next, the knowledge base for additional roadway entities including: all-way stop-controlled intersection, rail road crossing, road segment, and signalized intersection is developed. Finally, the existing crash reduction factors are reviewed and a final set of values developed.

6.1 Sources of Knowledge

The prototype RSIT includes the knowledge base for two-way stop-controlled intersections (TWSC). This knowledge base has been converted to rules as discussed in the previous chapter. This chapter described development of a new knowledge base for: road segments (RS), signalized intersections (SIG), rail road crossings (RRC), and all-way stop-controlled intersections (AWSC). First, an overview of the development method is presented. Then, a detail review of the individual part of the new knowledge base is provided.

As the TWSC knowledge base, the new knowledge base was developed by extracting useful information from multiple sources:

- a) Personal experience gained in past site investigations
- b) Existing reports of site investigations by others
- c) Short courses and workshops
- d) Guidelines, manuals, textbooks, and research reports

The NCHRP 500-series reports (NCHRP 500, 2004) were the primary source of information. These reports are a well-organized compendium of strategies for improving safety at various roadway entities. Specific safety improvement strategies are recommended for many safety objectives included in the source. Furthermore, the

NCHRP 500-series reports specify the confidence towards each of the proposed strategies represented by three levels: proven, tried, and experimental.

Other important sources included: NCHRP Report 383 (NCHRP 383, 1996), and NCHRP 457 (NCHRP 457, 2006). The NCHRP Report 383 provides a complete reference to an intersection sight distance analysis. It includes sight distance fundamentals that link the roadway geometry with the minimum sight-distance requirements for safe passing through intersection. The Intersection Diagnostics Review Model (Kindler et al. 2006), which uses the findings included in the NCHRP Report 383, provides a knowledge base relevant to sight conditions at intersections and the minimum stopping and decision sight distances drivers need. In addition, the NCHRP Report 457 provides additional information related to evaluation of intersection improvements.

Another source of information was the Traffic Engineering Handbook of the Institute of Transportation Engineers (Pline, 1999). This source gives a broad overview of various roadway elements as well as human factors that can affect safety. Traffic regulation study and guidance for using signs, traffic controls, and traffic calming devices are presented. The Traffic Engineering Handbook focuses on road users and addresses driver, pedestrian, and bicycle characteristics. Particularly useful for a safety investigation in this handbook are the safety countermeasures provided for specific accident patterns (pp. 206 – 209).

Human factors were taken into account during the process of developing the new knowledge base (Olson et al. 1996). After all, driver errors contribute in more than 90% of crashes. Driving involves many different tasks: “tracking, decision-making, navigation, adherence to regulations and warnings, tending environmental and mechanical system within the cab, communication, (...) watching for various events that may occur inside and outside the vehicle” (Proctor et al. 1994). Proctor et al. (Proctor et al. 1994) and Senders (Senders et al. 1991) distinguished three stages of human information processing: perception, cognition, and action. Olson (Olson et al. 1996) indicated that the perception stage is most important because how a driver perceives information determines the decision and action. Safety engineering can improve safety by applying various treatments that decrease the potential for driver perception errors. Improving the visibility of road signs and increasing the visibility of dangerous location

are among low-cost improvements that may help enhance driver perception. Because of that, most of the human factors elements used to build the new knowledge base are related to improving driver awareness and visibility. Human factors consideration is also present in analyzing drivers' behavior on the investigated road and by proposing engineering solutions and police enforcement to prevent or at least reduce undesirable behaviors.

The next section discusses development of each part of the new knowledge based is presented.

6.2 Knowledge Base Development

The new knowledge base is organized as a set of rules. Each rule links safety, road geometry, traffic, and road user behavior with the relevant countermeasure.

The knowledge based was developed for five different roadway entities: two-way stop-controlled intersections (TWSC), all-way stop-controlled intersections (AWSC), railroad crossing (RRC), road segments (RS), and signalized intersections (SIGN). More than 360 countermeasures, and 240 conditions were developed and more than 1000 rules assembled using these elements. The following text characterizes in general terms the knowledge base developed for the five types of roads (segments and intersections).

More than 280 rules were developed for the RS knowledge base. When identifying various road and traffic deficiencies, several types of collisions frequently observed on road segments were considered. The most frequent are off-road collisions; therefore, developed knowledge base for road segment collisions focuses mostly on off-road collisions (more than 50% rules). Moreover, the data analysis shows that off-road collisions are mostly related to horizontal curves, vertical curves, and to fixed object close to the travel way. The developed knowledge base addresses two general types of risk and corresponding remedies:

- (1) Conditions upon which a driver leaves the travel way and adequate safety improvements to reduce this risk, and
- (2) Conditions upon which the occupants of the out-of-control vehicle are exposed to severe consequences and countermeasures to reduce the risk of a severe outcome.

In addition to off-road collisions other collisions were addressed in the knowledge base developed for road segment and included pedestrian/bicycle collisions, weather-related collisions, night-time collisions, driveway collisions, speed-related and head-on collisions.

The knowledge base developed for the four types of intersections contains: 170 rules for two-way stop-controlled intersections, 100 rules for all-way stop-controlled intersections, 220 rules for signalized intersections and 140 rules for railroad crossings. Because crash patterns at all types of intersections exhibit similarities, they are described without distinguishing the intersection types where possible.

- a) Night-time collisions. This type of collisions was addressed in all established roadway entities. The deficiencies and countermeasures established for night-time collisions addresses mostly the visibility issue during night-time that affects perception stage of the driving task.
- b) Speed-related collisions. This type of collisions was addressed in all established roadway entities. Speed-related crashes are organized in such a way that first check if adequate speed limit is posted, secondly, if the adequate speed limit is posted proposed different technique to address the excessive speed issue.
- c) Adverse weather collisions. This type of collisions was addressed in all roadway entities. Adverse weather conditions are considered for winter separately from non-winter periods.
- d) Driveway collisions. This type of collision was addressed for TWSC, AWSC, and RS. The driveway collisions rules address mostly the insufficient visibility and geometry design issues.
- e) Right-angle collisions. This type of collisions was addressed for TWSC, SIGN intersections and RRC*. Right-angle collisions deserve a particularly strong focus at TWSC intersections where many rules address the geometry design and sight distance issues. The right-angle collision rules for SIGN intersections focus mostly on two cases where driver either does not notice the traffic lights or violate the traffic lights purposely. *The right-angle collisions at RRC are addressed through checking railroad crossing control devices (automatic gates vs. non-

automatic gates). Moreover, the sight distance issues are pointed out as well as proposed safety improvements.

- f) Rear-end collisions. This type of collisions is typical for SIGN intersections and to some extent for TWSC intersections. The knowledge base rules applied to these two types of intersections deal with the conditions and countermeasures addressing the rear-end collisions. The rear-end collision rules focus mainly on geometry design and, in case of SIGN intersections, on signal timing issues.
- g) Head-on collisions. This type of collisions has a particularly considerable number of rules in the RS knowledge base. There are also rules addressing this type of collisions at TWSC and SIGN intersections. The head-on collision rules focus on deficiencies in geometry design and marking.
- h) Pedestrian/bicycle collisions. This type of collision is possible on any road where pedestrians and bicycles are present. The rules addressing these collisions consider geometry design (crosswalk design, their placement, visibility, etc.) and, in the case of SIGN intersections, pedestrian/bicycle signals and their timing.
- i) Left-turn and right-turn collisions. Both the types of collisions have been addressed by the knowledge base for SIGN intersections while left-turn collisions have been addressed by the knowledge base for TWSC intersections (right-turn collisions at TWSC have been already considered among right-angle collisions).

The above description is brief and does not cover all the types of crashes and circumstances. The full list of rules included in the developed knowledge base is presented in Appendix D.

6.3 CRF Study

The developed knowledge base includes 684 countermeasures. The next important and laborious step was to determine the effectiveness of these countermeasures measured with crash reduction factors (CRF). Twenty five sources were carefully reviewed and the found information compiled to obtain a CRF list. The list of these sources is shown at the end of this section. The CRF values obtained from this study were assigned to relevant countermeasures included in the developed RSIT2 knowledge base. The study has

confirmed a significant discrepancy among reported values even for the same road improvements. In the case where several sources reported various CRF values for the same countermeasure, the average value was used as the final value. The reason for using this simple combining method was the lack of information about the reliability of individual CRF values.

An example result for the TWSC knowledge base is presented in Table 6-1. CRF values from different sources were placed in separate columns. Numbers in parenthesis refer to corresponding comments. In the presented example, the CRF value associated with the countermeasure: “Convert intersection into roundabout” has the following identified in our study values: 58, 72, 40, and 38. Two comments (5) and (6) were added to this result. The full list of the CRF values with corresponding comments is placed in Appendix E.

Out of 684 countermeasures included in the developed knowledge base, 424 have received corresponding CRF values and 260 had missing values. To overcome this gap, we matched the existing CRFs with countermeasures that were somehow similar to the CRF road improvements and used judgment to modify the CRF value. The values that were determined using this assessment are marked (*italic format*) as shown in Table 6-2.

The obtained CRFs values have been incorporated in the new RSIT2 knowledge base and used to rank countermeasures identified in the site investigation process. The ranking helps the safety analysts select the most promising countermeasures for implementation. The full list of CRF including list of comments is attached in Appendix E.

Table 6-1 CRF Isolated Examples

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Consider moving the right-turn lanes on the major road laterally																				
Consider traffic signals with protected left-turn phase																				
Construct Pedestrian Refuge Islands and Raised Medians		46	60 (4)	60 (4)	32	23										46				
Convert the intersection into a roundabout	58 (5)	72 (5)					40	40	40	40					58 (6)	72 (6)	58	72	38	38
Eliminate screening by physical objects													50 (7)	50 (7)					76 (8)	76 (8)
Eliminate shoulder drop-off											25	25							30 (9)	30 (9)
Enforce stop sign compliance																				
Extend "no parking" zone.					22	22					35 (10)	35 (10)							10	10
Groove pavement surface			21	21			14	14											46	46
Implement Road Narrowing Measures																				
Improve alignment/grade																				
Improve channelization/delineation											30 (11)	30 (11)	40	40					15	
Improve clear zone					25 (12)	25 (12)														
Improve existing street lights	30	30			50	50														
Improve lanes width	8 (13)														8					

Table 6-2 CRF Final Version (part of TWSC)

[illegible]

7 RSIT2 USER MANUAL

7.1 RSIT2 CONCEPTS

RSIT2 is based on a novel idea of an optimal checklist that is updated during site investigation. This approach makes the investigation process more time-effective and less expensive. RSIT2 uses rules as building blocks of the knowledge base which connects checks with countermeasures. The knowledge base can be updated by removing, adding, or modifying the rules.

The following part of the RSIT2 Concepts section introduces the background information which helps better understand the way RSIT2 works and may help read the next section describing the RSIT2 user interface.

Conventional Checklist

The traditional process of site investigation includes processing checks by following a list of checks, documenting the findings, and then identifying countermeasures that could be justified with the site investigation. The traditional checklist list checks sequentially: X1, X2...XN, where Xi is a check such as Signalized intersection, Divided roadway, Poor drainage, Insufficient sight distance, etc. The identified countermeasures C1, C2...CM are such as: Remove sight distance obstruction, Increase yellow signal, etc.

This process has several drawbacks:

1. The check list has to be customized by the user to remove checks that are not applicable to the investigated site.
2. Checks on the customized list are considered at the site even when some of them could be skipped.
3. The order of checks may affect the investigation time but this is not considered when building the checklists.

4. The checklist does not help keep track of the investigation progress when a check is applied multiple times to different road elements (approaches, exits, etc).
5. Checklists do not match the site investigation results with relevant countermeasures.

Rule-based Knowledge Representation

Rules are sometimes used to diagnose problems or/and to select relevant actions. An example rule may read:

IF Signalized Intersection AND Rear-end collisions on approach
 AND High speed on approach AND Short yellow signal on approach
 THEN Increase yellow signal on approach.

In a general case of if-then rules, this knowledge base can be organized in a table with two columns: the first column includes *conditions* (or *checks*) and the second column includes relevant *conclusions* (or *countermeasures*). Table 7-1 demonstrates this structure where X_i is a conditions or check such as: Signalized intersection, Divided roadway, Insufficient sight distance, etc. and C_i is a countermeasure such as: Remove sight distance obstruction, Increase yellow signal, etc.

Table 7-1 Example of a rule-based checklist

IF	THEN
X_1 and X_2	C_1
X_1 and X_3 and X_4	C_2
X_2 and X_4	C_2
.....	
X_1 and X_{23} and X_{24}	C_M

The rule-based knowledge representation is intuitive and provides an inventory of relevant knowledge. This inventory of rules (called Knowledge Base) is easy to update by

adding or removing rules. The rules explicitly link checks with relevant countermeasures which addresses the last drawback of conventional checklists. On the other hand, other drawbacks of conventional checklists used in safety investigation remain and some of them are even get worse due to multiple appearances of checks (for example, X1 in Table 7-1).

RSIT2 Knowledge Base

RST2 checks and countermeasures have added road component names to make them more specific. The example rule in the Rule-based Checklist section becomes:

IF Signalized Intersection AND Rear-end collisions on *Main Street NB* approach
 AND High speed on *Main Street NB* approach
 AND Short yellow signal on *Main Street NB* approach
THEN Increase yellow signal on *Main Street NB* approach.

The name of the approach added to the original rule is *Main Street NB*. To make the above rule applicable to any intersection, a variable #A1 replaces the value *Main Street NB*:

IF Signalized Intersection AND Rear-end collisions on #A1 approach
 AND High speed on #A1 approach
 AND Short yellow signal on #A1 approach
THEN Increase yellow signal on #A1 approach.

This generic rule may be applied to each approach of any signalized intersection. It is multiplied the number of times equal the number of approaches, and then variable #A1 is replaced with the names of these approaches.

The first step in building and using the RSIT2 checklist is developing a generic knowledge base (KB) that includes all known valid generic rules for various types of

roads and intersections. RSIT2 offers a KB editor for that purpose which can be used to build a new KB or modify the one currently available.

RSIT2 Checklist

RSIT2 automatically converts the developed generic rule-based KB to a generic checklist by decomposing each rule into its elements, removing countermeasures, and removing multiple appearances of conditions.

RSIT2 customizes the generic checklist to a certain investigated site by multiplying checks to be used for multiple road components and replacing name variables with actual names of the road components. The second stage of the checklist customization is removing these conditions that can be claimed false based on the basic information entered by the user (traffic control, layout of the intersection legs, one-way streets, etc.). For example, the condition: Signalized intersection is removed from the checklist if the investigated intersection is not signalized. The next step is to update the checklist by removing these checks that become redundant after identifying false conditions. For example some checks are needed only at signalized intersections thus removing the Signalized intersection check entails removing all these other checks as well.

To reduce the investigation cost, RTSIT2 orders the obtained checks in a way that increases the investigation convenience (reduced walking at the site) and decreases the investigation effort. Easy and inexpensive checks that may eliminate the need for more labor demanding checks are performed first. In the current version, the checks are sorted according to the following rules:

- 1) Off-site checks are grouped together and precede on-site checks.
- 2) Checks within the off-site and on-site groups are further grouped if they applied to the same road component (approach, exit, road).
- 3) Within each group created with rule 2, the checks are sorted by cost with less expensive checks preceding the more expensive checks.
- 4) Within each group of same-cost checks formed with rule 3, the checks are sorted by the probability of passing with the checks least probable to pass preceding the

checks more probable to pass (failing a check creates a chance for eliminating other checks).

RSIT2 Files

KB is stored in a file named *KBname.rs2* . The part *KBname* is provided by the user while the extension is fixed and cannot be changed. RSIT2 saves the KB file at a location selected by the user.

The user may also add reference files that include additional information helpful during a site investigation. These reference files are stored in a reference folder named *KBname_files*. Each KB file must have one reference folder. The KB file and the corresponding reference folder are associated by the common part *KBname* in their names and by saving the *KBname.rs2* file and the *KBname_files* folder in the same directory.

A KB file can be converted to a text file to be seen by any text editor. The exported file has an extension *KBname.csv*.

During investigation, the user can save the current investigation log file to be able to stop the investigation and resume it later. The log file is named *investigation.rsg* where the name is provided by the user while the extension is fixed. This file is read by the RSIT2 to resume the investigation.

The investigation progress can be saved in the form of a checklist presented in the RSIT user interface with all the entries made by the user up to the time of saving the checklist. The name of the file is *checklist.csv*.

The investigation results including the identified countermeasures, the conditions supporting these countermeasures, and the assessed effectiveness of the countermeasures. This file is named *report.txt* and can be saved at any point of the investigation.

The KB file and the reference files, which are input files used in multiple investigations. Any updated versions of the KB should be saved in a new folder and under a new name that reflects the version. Including dates in the KB names may be useful.

A single investigation may generate several output files. The output files generated by RSIT2 include the investigation log, progress, and results. Files generated in a single investigation should be saved in one folder with a name that helps identify the investigation.

7.2 RSIT2 USER INTERFACE

RSIT2 includes three components: **Site Investigation** tool, **Knowledge Base** editor, and **Help** module. These components can be run by clicking on a proper item listed in the RSIT2 starting window (Figure 7-1).

Figure 7-1 RSIT2 starting window

Knowledge Base Editor

The Knowledge Base editor interface is shown in Figure 7-2. The size of the interface can be adjusted with a mouse. The interface includes three parts: command line, display area,

and editing area. These components are described in the following sections of the manual.

Figure 7-2 RSIT2 Editor

Command Line

The command line includes two options: **File**, and **Help**. The **File** pull-down list allows the following input-output file operations:

- **New** initiates development of a new knowledge base (KB)
- **Open** opens an existing KB file
- **Save** saves a currently opened KB file under the same name and in the same location. The extension of the KB file is *.rs2*.
- **Save As** saves a currently opened KB file under different name and/or in different location than the current
- **Export** converts a currently opened file into the text file format
- **Exit** ends the current KB editing session

The **Help** command opens the on-line user manual.

Figure 7-3 Display area

Display Area

The display area (Figure 7-3) includes a search tool that helps find in large knowledge bases conditions, countermeasures, and rules that include specific key words. Search can be performed on the entire knowledge base or on the results of the previous search. The key words are typed in the box after **Search for**. The user selects a radio to specify where the key words are to be looked for: in rules, in countermeasures, or in conditions. The **Show** button displays the results of the search while **Show All** resets the search. Figure 7-3 shows the result of searching the example KB for rules that include word *railway*.

Figure 7-4 Display window with a condition by found by key word: *railway*

Figure 7-5 The found condition with an unfolded list of corresponding rules

Figure 7-4 presents the results of a search for conditions that include word *railway*. The results are displayed in six columns. The third, fourth, fifth, and sixth columns contain the conditions' attributes.

1. **[+]** - clicking on this symbol shows the rules that include the found condition; the symbol changes to **[-]** if the rules are displayed (Figure 7-5).
2. **Conditions** – description of the condition.
3. **Probability** – chance in percent that the condition takes place at an investigated site (or that a corresponding check passes).
4. **Cost** – categorical assessment of the cost of the check measured on a scale from 1 to 5 with 1 being the least expensive check and 5 being the most expensive check
5. **Off-Site** – 1 indicates that the condition is checked in the office and before the site investigation, 0 indicates otherwise.
6. **Reference** provides the name of the file that includes additional information relevant to the condition. This file is available for reading during the site investigation if needed. By convention, the reference files are stored in a folder named

A search results for countermeasures are displayed in four columns. The third and fourth columns include the countermeasures' attributes.

1. **[+]** - clicking on this symbol shows the rules that include the found countermeasure; the symbol changes to **[-]** if the rules are displayed.
2. **Countermeasures** – description of the countermeasure.
3. **CRF** – crash reduction factor in percent applicable to all crashes.
4. **Cost** - categorical assessment of the cost of the countermeasure measured on a scale from 1 to 5 with 1 being the least expensive countermeasure and 5 being the most expensive countermeasure.

Editing Area

The third component of the KB Editor interface is the editing area which provides the functionality required for entering and editing knowledge bases (**Error! Reference**

source not found.). The editing in the current version of RSIT can be done only through rules. The user has to select **Start Editing** button (Figure 7-2) to activate the KB Editor.

When the KB Editor is active, the user can simply drag any rule displayed in the display area to the editing area or type a new rule directly in the lines of the editor. Another option is to drag some existing conditions from the list of currently displayed conditions above and type additional ones directly in the editor. The user has also an option of displaying countermeasures in the display window and drag a selected one to avoid typing of the countermeasure exists. This feature allows reusing conditions and countermeasures already presented in the current KB to avoid re-typing and associated risk of making mistakes.

Once the KB Editor detects non-empty countermeasure line and at least one non-empty condition line, the rule can be saved by pressing the enabled **Update** button. A rule dragged from the list of existing ones can be deleted right after dragging. Making any change to the rule disables the **Delete** button and enables the **Update** button. The updating operation replaces the old rule with the modified rule if some countermeasure attributes or condition attributes have changed while the text of countermeasure and conditions remained the same. The updating operation adds the new rule without deleting the old one if the countermeasure or condition text has changed. In this case, the new rule has to be saved and the **End Editing** button pressed. Then, the editing has to be again initiated by pressing the **Start Editing** button and the old rule dragged and deleted if not needed.

After the current KB is edited, it can be saved using the **File** operations. The window can be closed by pressing the cross button in the upper right corner. Selecting the **Exit** option in the **File** operations closes the window and shuts down the RSIT tool.

Pressing arrows in the editing area moves the current condition up or down the list of conditions. This feature is used to change the order of conditions without re-typing them.

Figure 7-6 Editing area with a rule dragged from the display area

Site Investigation Tool

The **Site Investigation** tool facilitates functions needed to plan and execute a site investigation. The investigation tool has four windows:

- (1) **Project Information** window,
- (2) **Intersection Diagram** window,
- (3) **Checklist** window, and
- (4) **Countermeasures** window.

The top line in all the four windows has two buttons: **Investigation** and **Help**. The **Investigation** button allows two operations:

1. Initiation of a new investigation (option **New**) by loading a knowledge base, and
2. Resuming a past investigation (option **Open**) by loading a log file of a previous investigation.

The currently conducted investigation can be saved in a log file by using options **Save** or **Save As**. The **Exit** option exits the RSIT. The **Help** button opens the on-line user help.

Project Information

The **Project Information** window allows entering all the major information about the investigation site: its name, jurisdiction, location, and the type of road (Figure 7-7). The names of the investigators, date, time, light conditions, and additional comments can be entered and saved as well.

The screenshot shows a software window titled "Site Investigation" with a menu bar containing "Investigation" and "Help". The main area is titled "Project Information" with the instruction "Enter the details of the project." Below this, there are several input fields: "Project", "Jurisdiction", "Location", "Facility type", "Investigators", "Date" (with a dropdown menu showing "Apr /28/2009"), "Time" (with a dropdown menu showing "05:20 AM"), "Light conditions", and "Comments". At the bottom, there are radio buttons for "Confidence levels (%)" with options "High", "Limited", and "Low", each followed by a numerical value (100, 80, 60 respectively) and a "Change" button. At the very bottom, there are three buttons: "< Back", "Next >", and "Exit".

Figure 7-7 Project Information window

Figure 7-8 Changing the percent values associated with the three confidence levels

Figure 7-8 illustrates changing the percent values associated with the confidence levels at which checks can be passed. The 80 percent value assigned to the **Limited Confidence Level** means that when this passing level is selected, 80 percent of times the passing is correct and in 20 % of cases the passing is not justified. Although this interpretation is based on frequency, the value reflects the user’s preference. It is recommended, that the confidence levels are kept fixed across investigations to allow comparison of the results.

The **Back** and **Next** buttons facilitate navigation between the windows. Although most of the entries can be changed during the investigation and the tool will update the results, in some cases this updating is not possible and the current results may be erased. Proper warnings are issued in such cases.

Intersection Diagram

The **Intersection Diagram** window is used to specify major components of the investigated road and to name the road components (Figure 7-9). This information is used

Figure 7-9 Intersection Diagram window

Figure 7-10 Activated editor of the Intersection Diagram

to customize the initial generic checklist by eliminating checks not applicable to the investigated road and by multiplying other checks applicable to multiple approaches,

exits, crossing roads, etc. The names of the approaches and roads entered by the user in the Intersection Diagram are added to these checks to allow identification of the road components during the site investigation.

Pressing the **Edit** button in the bottom right corner activates the diagram editor. A simplified intersection diagram appears as the one shown in Figure 7-10. Defining the road components is done in several steps:

- (1) Click with the mouse left button on any of the dashed lines to enter the intersection leg. Repeated clicking switches between two-way leg, one-way approach, one-way exit, and no-leg options.
- (2) Click with the mouse left button on the name by any of the legs to modify the name. Press **OK** below the text box to accept the new name or press **Cancel** to bring to the previous name (Figure 7-11).
- (3) Click with the mouse right button on the already entered leg to switch between minor and major roads. A major leg is coded with a thick line (Figure 7-12). A minor leg is coded with a thin line and a number between 1 and 4. In some cases all legs may remain minor. If entering major legs is needed, then exactly two legs must be major.
- (4) The two major legs form a road. A road passes an intersection on a straight or a sufficiently flat horizontal curve. A site investigation includes checks applied to such a pair of legs as a single road entity. The user has an option to define roads made of minor legs as well. This may be useful for signalized intersections. Two minor legs with the same number between 1 and 4 form a road. The numbers can be switched by clicking on them with the mouse left button.
- (5) Click with the mouse left button on the traffic control sign by any of the approaches to switch between stop sign, yield sign, signal head, and no control (point).
- (6) Click **OK** button in the bottom right corner of the diagram window to accept the current diagram and to exit the edit mode.

Figure 7-11 Opened text box to modify the road name in the Intersection Diagram window

Figure 7-12 Intersection with a major and minor roads

Figure 7-13 Intersection with a road that is not major

Figure 7-14 An example two-way stop-controlled intersection

Figure 7-15 An example signalized intersection

RSIT2 checks the entered diagram to classify the type of road. The recognized type is displayed. In some cases, a message about an unrecognized type of road is displayed and the user must correct the entered diagram. Two examples of correct diagrams are shown in Figure 7-14 and Figure 7-15.

As mentioned earlier, correctly drawing a road/intersection diagram is important. It defines the type of the investigated road site, and the names the road components. These names are entered to the knowledge base rules to give them local/current meaning relevant for the site investigation. The knowledge base is then pre-processed based on the information entered in the road/intersection diagram and irrelevant checks removed from the generic knowledge base. The customized checklist is to be displayed in the checklist interface ready for use.

After successful entering the diagram, the user presses the **Next** button.

Checklist

An example checklist displayed to the user after leaving the Intersection Diagram is shown in Figure 7-16. The user can perform checks in any order although the displayed order improves the investigation efficiency (reduces the number of checks required to complete the investigation). The savings are accomplished by eliminating checks that are not needed any longer because all the countermeasures supported by these checks have already been eliminated based on other checks performed earlier.

The checklist may be used in two modes: **Hide** mode (recommended) and **Show All** mode. In the **Hide** mode all processed and eliminated by RSIT checks are immediately removed from the display. The user sees only the checks that are currently remaining for processing.

The user can switch to the **Show All** mode at any time by pressing the **Show All** button. An example list in this mode is shown in Figure 7-17. The checks in shaded area are off-

Lock	User Skip	Skip	Pass	Confidence	Ref.	Comments
				High Limited Low		
☐	☐	☐	☐	☐	☐	Adverse-weather collisions
☐	☐	☐	☐	☐	☐	Angle collisions
☐	☐	☐	☐	☐	☐	Bicycle collisions at intersection
☐	☐	☐	☐	☐	☐	Collisions involving large vehicles
☐	☐	☐	☐	☐	☐	Intersection near to railroad crossing
☐	☐	☐	☐	☐	☐	Night time collisions at intersection
☐	☐	☐	☐	☐	☐	Pedestrian collisions at intersection
☐	☐	☐	☐	☐	☐	Right-turn collisions
☐	☐	☐	☐	☐	☐	School zone present
☐	☐	☐	☐	☐	☐	Head-on collisions on Main Road EB approach
☐	☐	☐	☐	☐	☐	Rear-end collisions on Main Road EB approach

Figure 7-16 RSIT2 checklist interface with an example checklist

Lock	User Skip	Skip	Hide	Text Size	Save Checklist	Pass - Confidence	Ref.	Comments
				+	-	High Limited Low		
☐	☐	☐				☒		
☐	☐	☐				☒		
☐	☐	☐				☒		
☐	☐	☐				☒		
☐	☐	☐				☒		
☐	☐	☐				☒		
☐	☐	☐				☐		This is a demonstration
☐	☐	☐				☒		
☐	☐	☐				☐		
☐	☐	☐				☒		
☐	☐	☐				☐		
☐	☐	☐				☒		

Figure 7-17 Checklist in the Show All mode

site checks that are typically processed before the investigation in the field. These checks appear on the list before other checks. All the checks are displayed together with user's passing/failing decision documented through marking proper boxes. These decisions can be changed by simply selecting different boxes. RSIT reprocesses the checklist immediately after each change is made to eliminate from processing or bring back checks for processing. Pressing the **Hide** button again hides both the already processed checks and the unneeded checks.

The **Lock** and **User Skip** columns of boxes in the front of the checklist give the user additional control over the checking process. A marked **Lock** box does not allow elimination of the marked check even if the check is not needed. A marked **User Skip** box eliminates the check regardless if it is needed or not. The third **Skip** column indicates if a given check has been skipped by RSIT2 based on checks already processed. Marks in this column are made by RSIT2 and not by the user.

A check is performed if it has not been skipped by the time of its processing. The outcome is entered by selecting one of the four options following the check: **No Pass**, **Pass – Confidence High**, **Pass – Confidence Limited**, or **Pass – Confidence Low**. If the checked condition does not occur at the investigated site, then the **No Pass** option is selected, the other three options confirm the condition although at different levels of confidence. These values are set by the user in the Intersection Information window. These values are used to estimate the expected percent crash reduction as described in the following part of this manual.

If the user needs additional guidance before performing a check, he/she may call relevant references by selecting the button **Ref** (Reference) in the column next to the **Pass** boxes. A pop-up window will appear with available materials. No reference is available if the button is disabled.

The **Comments** column allows the user add any comments related to performed checks. All the user-entered comments are retained for future reference in a saved checklist. A

Figure 7-18 Warning triggered by the user's attempt to load another existing investigation log file

Figure 7-19 The top of the list of identified countermeasures

Figure 7-20 Example countermeasures identified by RSIT2

comment appears also in the investigation report if the corresponding condition passes and the countermeasure supported by this condition is selected.

The user has an option to save the current investigation state for future continuation by pressing the **Investigation** option and use **Save** or **Save As** options. Any other actions such as initiating a new investigation or loading another existing one triggers a warning as the one shown in Figure 7-18.

The user has an option to save the current checklist with documented all operations on the checklist including the user comments in the last column by pressing the **Save Checklist** button. The saved file is the comma delimited text and can be opened with any text editor and by Excel.

The user can move to the previous window with the **Intersection Diagram** but any attempt to edit the diagram will cause losing the current investigation if it is not saved because the checklist has to be recreated each time the diagram changes. The user can also move to the next window to learn what countermeasures have been identified so far (Figure 7-19). The format of the text in the **Countermeasures** window is exactly the same as the investigation report saved by the user.

Site Investigation Report

After the investigation is completed, the rules included in the knowledge base are used jointly with the results of the investigation (passed checks) to identify the countermeasures that are supported with the investigation results. A list of these countermeasures is displayed together with the successfully passed checks that support these countermeasures (Figure 7-19 and Figure 7-20).

The user can save the investigation results in the format displayed in Figure 7-19 and Figure 7-20 by pressing the **Save Report** button. RSIT2-generated report includes four components:

- 1) The identification information including the location, investigators information, date, time of investigation, weather and other pertaining details.
- 2) The identified countermeasures with the local conditions that support these countermeasures. The confidence P that the countermeasure is justified is the product of confidence levels of supporting conditions. A low value of P indicates that the local conditions weakly support the identified countermeasure because of the investigator's uncertainty about the conditions. If the investigator is fully convinced that all the supporting conditions appear at the investigated site then P is high and close to 100 percent.
- 3) The estimated effectiveness of the identified countermeasure expressed with the expected crash reduction. The expected crash reduction is the crash reduction factor times the confidence about the countermeasure P divided by 100. This expectancy reflects both the effectiveness of the countermeasure and the level of confidence that the countermeasure is justified. The assumption behind this calculation is that if the countermeasure is not justified then no crash reduction is expected.

The report is in the text format and is editable by any available text editor.

8 CONCLUSIONS

A summary of the research findings, conclusion and recommendations for future research are presented in this chapter.

The analysis of the existing tools of high-crash site investigation revealed a need for a more advanced tool than checklists. Although checklists help investigate sites in a more organized manner than ad hoc investigation, they may lead to wasted time and incorrect findings if a considerable number of redundant checks are performed.

The proposed prototype of RSIT guides an investigation team through a sequence of checks and determines the probable roadway factors contributing to crash occurrence. The limited to two-way stop-controlled intersection knowledge base was developed and evaluated. The knowledge structure and functionality of the GUI are easy to understand even for non-experts. The developed knowledge base provides a more detailed explanation for each individual roadway deficiency compared to the findings from the road safety report, which confirms the previous statement that even experienced investigators can overlook important factors. The prototype evaluation part confirmed usefulness of the proposed prototype of RSIT. Moreover, the feedback from evaluation part as well as SAC members' comments emphasized the need to create more flexible and improve version with extended knowledge base. As a result, the RSIT 2 was developed.

The RSIT 2 contains significant improvements over the prototype of RSIT. First, the extended knowledge base for: all-way stop controlled intersection, signalized intersection, road segment and rail road crossing was developed. Secondly, a new structure of representing developed knowledge was established. The rule-base structure allows for more flexible and user friendly knowledge representation. Next, the editor was developed. This editor is a very useful tool and allows creating a new knowledge or easily updating existing knowledge. In addition, list of conditions and countermeasures used in the process of building the knowledge base is introduced. This list contains set of parameters associate with each condition and countermeasure. As a result, the efficiency

evaluation under uncertain condition is introduced. This approach allows evaluating countermeasure safety by using reviewed CRFs values, and providing a safety ranking of proposed conditions.

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APPENDICES

Appendix A

Indiana Safety Review Checklist

Safety Review Checklist		Form F4.1
Facility Type _____ Location _____		
Date: _____ Time _____ Weather _____		

Possible causes Probable causes

Group A

Moving lanes

Lane widths are inadequate for vehicle classes that are common to the location _____

Number of lanes inadequate for traffic _____

Readability

Lanes end abruptly without prior warning (lanes are not aligned) _____

Auxiliary/Turning Lanes

Inadequate advance warning of lane drops _____

Driveways

Improper location of driveways(e.g. driveways are too close to the intersection) _____

Driveways are closely spaced _____

Inadequate visibility of driveways _____

Shoulders

Shoulder width inadequate for vehicle classes that are common to the intersection _____

Inappropriate shoulder surfacing _____

Rumble strips not installed where warranted _____

Shoulders are poorly maintained _____

Insufficient contrast of shoulders _____

Horizontal and vertical alignment

Horizontal or vertical alignment affect the visibility of the intersection _____

Abrupt changes in elevation _____

Inadequate visibility at sag and crest curves _____

Location at high side/low side of superelevation _____

Excessive curves that cause sliding in adverse weather condition _____

Excessive grades present, which could be unsafe in adverse weather conditions _____

Pavement markings / Delineation

Pavement markings (center lines, edge lines etc) are not clearly visible in day or night time conditions _____

Safety Review Checklist		Form F4.2
Facility Type _____	Location _____	

Date: _____	Time _____	Weather _____

	Possible causes	Probable causes
All necessary pavement markings not present	_____	_____
Presence of too many markings confusing the users	_____	_____
Pavement markings are inappropriate for the location	_____	_____
Old pavement markings have not been removed which may cause safety problems	_____	_____
Inadequate retroreflectivity of existing markings.	_____	_____
Road markings do not have sufficient contrast with the surfacing	_____	_____
Light conditions		
Inadequate visibility during night time conditions	_____	_____
Severe headlight glares during night time operations	_____	_____
Luminaries create glare for road users on adjacent roads	_____	_____
Adjacent road lighting affects driver perception of road	_____	_____
Lighting interferes with traffic signs	_____	_____
Inadequate lighting for signs	_____	_____
Signs		
Inadequate visibility of necessary, regulatory, warning and guide signs in normal and adverse weather conditions	_____	_____
Incorrect location of regulatory, warning and directory signs (i.e., proper height, offset, distance in advance of hazard)	_____	_____
Signs obstruct visibility	_____	_____
Signs are missing/redundant/broken	_____	_____
Signs are not maintained properly	_____	_____
Signs contradict each other	_____	_____
Any existing signs present those are no longer applicable	_____	_____
Signs are inconsistent with respect to standard fonts and phrases	_____	_____
Signs cannot be read from adequate safe distance	_____	_____
Sight distance		
Inadequate sight distance, stopping sight distance or decision sight distance	_____	_____
Sight lines are obstructed by signs, buildings, landscaping, vegetation etc.	_____	_____

Safety Review Checklist		Form F4.3
Facility Type _____ Location _____		
Date: _____ Time _____ Weather _____		

	Possible causes	Probable causes
Sight lines are obstructed temporarily by parked vehicles, snow storage, seasonal foliage, etc.	_____	_____
Opportunity for passing is insufficient	_____	_____
Pavement conditions		
Abrupt changes in pavement condition	_____	_____
Skid resistance		
Presence of locations that have inadequate skid resistance	_____	_____
Pavement defects		
Pavement has defects, which could result in safety problems(e.g. loss of steering control)	_____	_____
Pavement is not free of distresses (i.e. potholes, rutting, etc)	_____	_____
Changes in surface type (e.g. pavement ends) have drop offs / poor transitions	_____	_____
Presence of loose aggregate/gravel in pavement	_____	_____
Presence of bleeding in pavement due to excess asphalt	_____	_____
Drainage		
Presence of areas in pavement where ponding or sheet flow of water occurs resulting in safety problems	_____	_____
Drainage channel inappropriate for topography	_____	_____
Possibility of surface flooding or overflow from surrounding or intersecting drains and water courses	_____	_____
Presence of accumulated water during rainy conditions	_____	_____
Culverts are not protected	_____	_____
Embankments are too steep	_____	_____
Barriers		
Clear zone is narrow	_____	_____
Guiderails are not designed properly	_____	_____
Inappropriate transition from one barrier to another	_____	_____

Safety Review Checklist		Form F4.4
Facility Type _____ Location _____		
Date: _____ Time _____ Weather _____		

	Possible causes	Probable causes
Inadequate retro reflectivity of barriers	_____	_____
Inappropriate treatment of barrier ends	_____	_____
Median barriers sufficiently offset from roadway	_____	_____
Medians		
Inappropriate spacing between median crossovers	_____	_____
Inadequate slopes of grass median	_____	_____
Special Road Users		
Travel paths for pedestrians and cyclists are not properly signed and / or marked	_____	_____
Bus stops are not safely located with adequate clearance and visibility from the traffic lane	_____	_____
Driver behavior indicating potential safety problems		
Overrepresentation of a particular age group as users raising safety concerns	_____	_____
Too many drivers violating the speed limit	_____	_____
Skid marks	_____	_____
Frequent off tracking	_____	_____
Illegal parking	_____	_____
Pedestrians crossing illegally (jaywalking)	_____	_____
Group B		
Readability		
Confusing geometry which encourages wrong way entry	_____	_____
Layout is not consistent with adjacent interchanges	_____	_____
Auxiliary/Turning Lanes		
Queues stretch beyond the auxiliary lanes	_____	_____
Deceleration length is short	_____	_____
Tapers are not marked properly	_____	_____
Tapers are not designed properly	_____	_____

Safety Review Checklist		Form F4.5
Facility Type _____	Location _____	

Date: _____	Time _____	Weather _____

Possible **Probable**
causes **causes**

Signs

Inconsistency of signs and markings with adjacent interchanges _____

Driver behavior indicating potential safety problems

Presence of congestion (excessive queues and delays) leading to safety problems _____

Erratic maneuvers _____

Rapid breaking _____

Traffic conflicts _____

Wrong way entry _____

Violation of right of way _____

Group C

Readability

Intersection layout is complex (e.g. 5 leg intersection) _____

Layout is not consistent with adjacent intersections _____

Channelization

Presence of large unused area at the intersection _____

Island required to channel traffic at the intersection _____

Inadequate dimensions of the island _____

Inadequate visibility of the island _____

Confusing layout of islands _____

Horizontal and vertical alignment

Location of intersection (before, inside or after) a curve _____

Presence of sharp corners _____

Curvature for turning movements

Minimum design not provided for left and right turns(Insufficient widths and curves) _____

Markings

Stop bar not marked properly _____

Safety Review Checklist		Form F4.6
Facility Type _____	Location _____	

Date: _____	Time _____	Weather _____

	Possible causes	Probable causes
Signs		
Inconsistency of signs and markings with adjacent intersections	_____	_____
Sight distance		
Sight triangle is insufficient	_____	_____
Median		
Excessively wide median	_____	_____
Special Road Users		
Crossing points for pedestrians and cyclists not properly signed and / or marked	_____	_____
Driver behavior indicating potential safety problems		
Violation of stop signs	_____	_____
Incorrect stopping position	_____	_____
Frequent blocking of continuous lanes by queues where auxiliary lanes do not exist	_____	_____

Group D

Light conditions

Lighting interferes with traffic signals	_____	_____
--	-------	-------

Signals

Inadequate warning for signals not visible from an appropriate sight distance? (i.e., signs, flashing light, etc.)	_____	_____
High intensity signals/shields are not provided where sunset and sunrise glare may be a problem	_____	_____
Inadequate visibility of signals due to presence of billboards etc. (visual clutter)	_____	_____
Traffic signals adjacent to roads affect driver perception of the intersection.	_____	_____
Primary and secondary signal heads are not properly positioned	_____	_____
Confusing signals for left turning vehicles (yellow trap, conjunction of permitted-protected phasing and lagging left-turns, lead lag phasing)	_____	_____
Auxiliary heads not provided where necessary	_____	_____
Bases not installed at the proper height	_____	_____

Safety Review Checklist		Form F4.7
Facility Type _____ Location _____		
Date: _____ Time _____ Weather _____		

Possible	Probable
causes	causes

Signal Phasing

Minimal green and clearance phases are not provided

_____	_____
-------	-------

Signal phasing plan inconsistent with adjacent intersections

_____	_____
-------	-------

A dedicated left turn signal is required

_____	_____
-------	-------

Light conditions

Light interferes with traffic signals

_____	_____
-------	-------

Driver behavior indicating potential safety problems

Significant number of people running on red

_____	_____
-------	-------

Group E

Railroad crossings

Absence of railroad crossing signs on each approach to railroad crossings

_____	_____
-------	-------

Absence of advance warning signs at railroad crossing approaches

_____	_____
-------	-------

Presence of obstructions at rail road crossings which restrict sight distance

_____	_____
-------	-------

Grades of roadway approach to railroad crossings are not flat enough and encourage prevent vehicle snagging

_____	_____
-------	-------

Appendix B

Countermeasures List

Countermeasures	CRF	Cost	Road
Install overhead STOP signs on #A1 approach	20	2	RRC
Install overhead STOP signs on #A2 approach	20	2	TWSC,AWSC
Add sign warning about off-road collisions on #A1 approach	10	1	TWSC,AWSC
Add sign warning about off-road collisions on #E1 exit	10	1	TWSC,AWSC
Add special signing	10	1	RS
Add stop-lines in median opening on #R1 road	10	1	TWSC
Adjust minimum green or extension time	10	2	SIGN
Adjust phase time and cycle time	15	2	SIGN
Adjust yellow change interval	8	2	SIGN
Adjust signal offsets at upstream signalized intersection(s) on #R1 road to create more gaps	20	3	TWSC
Channelize driveway(s) on #A1 approach	50	4	TWSC,AWSC
Channelize driveway(s) on #E1 exit	50	4	TWSC,AWSC
Channelize driveway(s) on #R1 road	50	4	RS
Change horizontal/vertical alignment on #A1 approach	42	5	RRC,SIGN
Change horizontal/vertical alignment on #A2 approach	42	5	TWSC,AWSC
Change horizontal/vertical alignment on #R1 road	42	5	TWSC,AWSC
Apply chip seal or slurry seal on #A1 approach	10	4	TWSC,AWSC
Apply ship seal or slurry seal on #E1 exit	10	4	TWSC,AWSC
Apply ship seal or slurry seal on #R1 road	10	4	RS
Close intersection leg or convert to one-way street	40	4	SIGN
Close or relocate driveway(s) on #A1 approach	50	3	TWSC,AWSC
Close or relocate driveway(s) on #R1 road	50	3	RS
Close or relocate driveway(s) on #E1 exit	50	3	TWSC,AWSC
Close rail-road crossing point or install overpas	90	5	RRC
Consider indirect left-turns on #R1 road	35	5	TWSC

Countermeasures	CRF	Cost	Road
Consider a lateral relocation of right-turn lanes on #A1 approach	20	3	TWSC
Consider traffic signals with protected left-turn phase	40	4	TWSC
Construct interchanges	50	5	SIGN
Construct pedestrian refuge islands and raised medians	45	3	TWSC,AWSC
Convert a four-leg intersection to two T intersection	57	5	SIGN
Convert two-way streets to a one-way pair	35	5	SIGN
Convert two T intersection to one four-leg intersection	15	5	SIGN
Convert intersection into roundabout	52	5	TWSC,AWSC
Coordinate the railroad and traffic signal to provide preemption to the traffic signal when trains are approaching the intersection	28	3	SIGN
Create one way streets	45	4	SIGN
Cut trees and other roadside vegetation obstruct the view	25	3	RS
Create additional parking spaces	10	3	RS
Eliminating compound curves	25	4	RS
Eliminate screening of RRC by physical objects	63	4	RRC
Eliminate screening by physical objects of crosswalk at intersection	63	3	RRC
Eliminate screening by physical objects on #R1 road	62	3	RS
Eliminate shoulder drop-off on #A1 approach	28	3	TWSC,AWSC
Eliminate shoulder drop-off on #E1 exit	28	3	TWSC,AWSC
Eliminate shoulder drop-off on #R1 road	28	3	RS
Employ emergency vehicle preemption	70	3	SIGN
Enforce STOP sign compliance on #A1 approach	70	2	TWSC,AWSC
Enforce STOP sign compliance on #A2 approach	70	2	TWSC
Enhance delineation of sharp curves	16	3	RS
Groove pavement surface on #A1 approach	27	3	TWSC,AWSC
Groove pavement surface on #R1 road	27	3	RS
Consider traffic calming through narrowing #R1 road	30	3	TWSC,AWSC
Implement automated enforcement of red-light running (cameras)	14	2	SIGN
Implement lighting / illumination measures on #R1 road	30	3	RS
Improve (add) coordinating signals	25	3	SIGN
Improve (add) phases (length)	30	3	SIGN

Countermeasures	CRF	Cost	Road
Improve channelization/delineation on #A1 approach	31	3	TWSC,AWSC
Improve clear zone on #R1 road	25	3	TWSC,AWSC,RS
Improve existing street lights at the rail-road crossing points	40	3	RRC
Improve gates visibility/reflectivity (flashing lights along the gate)	75	2	RRC
Improve intersection skew angle	40	3	SIGN
Improve maintenance of rail infrastructure (Motion Sensitive Devices Constant Warning Time)	50	4	RRC
Improve maintenance of train detective devices	10	3	RRC
Improve maintenance of visual/audio signals	15	2	RRC
Improve maintenance/work of existing gates	35	2	RRC
Improve or restore superelevation	26	3	RS
Improve street lighting	40	3	TWSC,AWSC,SIGN
Correct lane width on #A1 approach	8	3	TWSC,AWSC
Improve pavement marking in median opening on #R1 road	21	3	TWSC
Improve pavement markings along the curve on #R1 road	16	2	RS
Improve pavement markings and texturing	16	3	AWSC,TWSC,RRC
Improve pavement marking on #A1 approach	21	3	AWSC,TWSC,RRC,SIGN
Provide photo video enforcement	56	3	AWSC,TWSC,RRC
Improve signage and/or marking of crosswalk(s)	25	2	TWSC,AWSC
Increase skid resistance on #R1 road	9	3	TWSC,AWSC
Improve traffic visibility from median opening toward #A1 approach	10	2	TWSC
Improve visibility of stop bar on #A2 approach	20	2	TWSC
Improve visibility of traffic signals	30	2	SIGN
Improve visibility of the splitter-island	25	2	SIGN
Improve visibility of intersection by providing enhanced signing and delineation	30	3	TWSC,AWSC,SIGN
Install street lighting	36	4	TWSC,AWSC
Improve winter maintenance	25	3	TWSC,AWSC
Improve timeliness of winter maintenance	20	3	TWSC,AWSC
Improve/install reflective signs on #R1 road	15	2	TWSC,AWSC,SIGN
Improve/install reflectorized pavement markers on #R1 approach	12	2	TWSC
Increase efficiency of use of existing parking spaces	10	2	RS

Countermeasures	CRF	Cost	Road
Increase radius of corner curves	14	4	TWSC
Increase crosswalk setback on #A1 approach	15	3	SIGN
Increase crosswalk setback on #E2 exit	15	3	TWSC
Increase length of left-turn bay on #A1 approach	30	4	TWSC
Increase width of shoulders on #A1 approach	14	3	TWSC,AWSC
Increase width of shoulders on #R1 road	14	3	TWSC,AWSC
Install barrier curb or a guardrail on #A1 approach	33	3	TWSC,AWSC
Install barrier curb or a guardrail on #E1 exit	33	3	TWSC,AWSC
Install barrier curb or a guardrail on #R1 road	33	3	RS
Install a bicycles overpass or underpass	90	5	RRC
Install pedestrian overpass or underpass	90	5	RRC
Install triangular island on #A2 approach	25	3	TWSC,AWSC
Install acceleration lane on #E1 exit sufficiently long for trucks	26	5	TWSC
Install additional signal head on #A1 approach	41	2	SIGN
Install advance guide signs on #A1 approach	30	2	SIGN
Install advance warning sign on #A1 approach	26	2	TWSC,AWSC,SIGN
Install advance warning sign on #A2 approach	26	2	TWSC
Install advance warning sign on #R1 road	26	2	RS
Install advance warning sign of horizontal/vertical curve on #R1 road	26	2	RS
Install advisor speed sign	26	1	RS
Install acceleration lane on #E1 exit	15	5	TWSC
Install active control devices	50	4	RRC
Install utility polet marker	16	1	RS
Install audible signals (warning bell)	20	2	RRC
Install automated bicycles gates	50	3	RRC
Install automated pedestrian gates	30	3	RRC
Install automatic gates	75	4	RRC
Install backplates	15	2	SIGN
Install bicycles signals	20	3	RRC,SIGN
Install brdige warning sign	28	1	RS
Install cantilever flashing-light signal	33	3	RRC

Countermeasures	CRF	Cost	Road
Install DO NOT STOP ON TRACKS signal	10	1	RRC
Install fence or chicane to prevent bicycles running across the track	30	2	RRC
Install fence or chicane to prevent pedestrians running across the track	30	2	RRC
Install fixed warning message signs	10	1	RRC
Install object marker on #A1 approach	16	1	TWSC,AWSC
Install overhead signs	10	2	RRC,RS
Install object marker on #E1 exit	16	1	TWSC,AWSC
Install centerline rumble strips	25	3	RS
Install corner mirrors (Local road/Low speed traffic)	10	1	TWSC
Install "Cross only at Crosswalk" signs	5	1	RS
Install curbing to define driveway(s) location on #A1 approach	20	3	TWSC,AWSC
Install curbing to define driveway(s) location on #E1 exit	20	3	TWSC,AWSC
Install curbing to define driveway(s) location on #R1 road	20	3	RS
Install curb-ramps	15	3	TWSC,AWSC
Install flashing beacons on #A1 approach	35	2	TWSC,AWSC,SIGN
Install flashing beacons on #R1 road	35	2	RS
Install flashing beacons above STOP sign on #A2 approach	35	2	TWSC,AWSC
Install flashing light activated by queuing traffic in the exit lane(s) from the crossing	25	2	RRC
Install fog-warning signs	35	2	TWSC
Install four-quadrant gate arms	25	2	TWSC,AWSC
Install gates with self deploying extension sections	20	4	RRC
Install guardrails on #A1 approach	40	4	TWSC,AWSC
Install guardrails on #E1 exit	40	4	TWSC,AWSC
Install in-pavement luminaires	20	2	RS
Install indirect left-turn lanes on #A1 approach	35	4	TWSC
Install indirect right-turn lanes on #A1 approach	30	4	TWSC
Install interactive truck rollover signing	10	1	RS
Install larger regulatory signs	25	2	TWSC,AWSC
Install larger signal lenses at the intersection	11	2	SIGN
Install larger regulatory signs on both sides of road on #A1 approach	35	2	TWSC,AWSC,SIGN

Countermeasures	CRF	Cost	Road
Install larger warning signs on #A1 approach	25	2	TWSC,AWSC
Install LED barrier-mounted guidance tubes	20	2	RS
Install light-emitting diode (LED)	20	2	RS
Install left-turn bay on #A1 approach	25	4	TWSC
Install left-turn lane on #A1 approach	27	4	SIGN
Install median barriers	35	3	RRC
Install median divider on #A1 approach to prevent left-turns from/to driveway(s)	15	3	TWSC
Install median divider on #E1 exit to prevent left-turns from/to driveway(s)	15	3	TWSC
Install median divider on #R1 road to prevent left-turns from/to driveway(s)	15	3	RS
Install median retroreflective post delineators on the approach	15	2	RRC
Install multi-dial controller	10	2	SIGN
Install non-mountable curb islands	20	2	RRC
Install overhead flashing beacon lights on #A1 approach	33	2	TWSC,AWSC
Install overhead flashing beacon lights on #R1 road	33	2	RS
Install pavement markings	16	2	TWSC,AWSC,RRC
Install pedestrian actuated signals	35	4	TWSC,AWSC
Install pedestrian barriers	60	3	TWSC,AWSC
Install pedestrian crosswalks	25	2	TWSC,AWSC
Install physical barriers to restrict pedestrian crossing maneuvers at higher-risk locations	60	3	SIGN
Install post-mounted delineators	22	2	RS
Install pre-signals	50	4	TWSC,AWSC
Install raised crosswalks	25	3	TWSC,AWSC
Install right right-turn lane on #A1 approach	13	4	SIGN
Install rumble strips on #A1 approach	32	2	RRC,SIGN
Install rumble strips on #A2 approach	32	2	TWSC,AWSC
Install rumble strips on #R1 road	32	2	RS
Install school crossing sign on #R1 road	16	1	TWSC,AWSC
Install school zone markings on #R1 road	20	1	TWSC,AWSC
Install school zone speed limit sign on #R1 road	25	1	TWSC,AWSC
Install shoulder rumble strips on #A1 approach	28	2	TWSC,AWSC

Countermeasures	CRF	Cost	Road
Install sidewalks	70	4	RS
Install sidewalk set-backs on #R1 road	20	2	TWSC,AWSC
Install speed humps	40	2	RRC
Install static or variable message signs displaying weather information on #A1 approach	15	3	RRC
Install static or variable message signs displaying weather information on #R1 road	15	3	RS
Install stop sign on #A1 approach	40	1	RRC
Install street lights at intersection	40	4	TWSC,AWSC
Install street lights at RRC	40	4	TWSC,AWSC
Install street lights on #R1 road	40	4	TWSC,AWSC
Install street name signs at intersection	25	2	TWSC,AWSC,SIGN
Install symbol storage space sign	10	1	RRC
Install swing gates	25	2	RRC
Install traffic actuated signal	22	4	SIGN
Install traffic signals at intersection	26	5	TWSC,AWSC
Install tree marker	16	1	RS
Install utility poles marker	5	1	SIGN
Install variable message signs and blank out signs	20	2	RRC
Install vehicle-arresting barriers	25	3	RRC
Install warning signs in advance of rail-road crossing	45	1	RRC
Install warning signs on both side of road on #A1 approach	20	1	AWSC,TWSC,RRC
Install queue detection system	22	3	SIGN
Install yield sign	10	1	RRC
Install/improve center line markings	34	2	SIGN
Install/improve signing or marking of pedestrian crosswalks at intersection	16	2	TWSC,AWSC
Install/improve signing or marking of bicycles at intersection	15	2	SIGN
Installing snow screens in areas exposed to snowdrifts on #R1 road	53	3	TWSC,AWSC
Lengthening clearance intervals	12	2	SIGN
Optimize clearance interval	9	2	SIGN
Overlay pavement on #E1 exit	21	4	TWSC,AWSC
Overlay pavement on #R1 road	21	4	RS

Countermeasures	CRF	Cost	Road
Place utilities underground	60	5	RS
Post adequate speed limit on #R1 approach	24	2	TWSC,AWSC,RS
Post adequate truck speed limit on #R1 approach	24	2	TWSC,AWSC
Post dynamic message sign to display speed of vehicles on #A1 approach	74	2	TWSC,AWSC
Post dynamic message sign to display speed of vehicles on #R1 road	74	2	RS
Prohibit/Restrict trucks with very Long semitrailers on roads with horizontal curves that cannot accommodate truck offtracking	60	3	RS
Prohibit right turn on red	33	1	SIGN
Properly maintain striping on median on #R1 road	10	2	TWSC,AWSC
Provide bypass lane on #A1 approach with left-turn traffic	10	3	TWSC,AWSC
Provide double yellow centerline on median opening of divided highway at intersections	5	2	TWSC
Provide acceleration and deceleration lanes on #A1 approach	15	5	TWSC
Provide acceleration and deceleration lanes on #E1 exit	15	5	TWSC
Provide acceleration and deceleration lanes on #R1 road	15	5	RS
Provide adequate coordination between signals	20	3	SIGN
Provide adequate delineation and channelization for trucks left/right turn at intersection	30	3	SIGN
Provide adequate delineation for left-turns at intersection (markers or lines)	30	3	TWSC
Provide adequate delineation for right-turns at intersection (markers or lines)	30	3	SIGN
Provide adequate drainage on #R1 road	20	4	TWSC,AWSC
Provide adequate gates delay	33	3	RRC
Provide adequate information to train operator (for example: location of the whistle post)	15	2	RRC
Provide appropriate signal intervals for pedestrians crossing and minimize wait time	35	2	SIGN
Provide adequate signals for handicapped	25	2	SIGN
Provide adequate truck signing	26	1	RS
Provide all-red clearance interval	15	2	SIGN
Provide information of the crossing type	10	1	RRC
Provide adequate lanes signing or marking on #A1 approach	21	3	TWSC,AWSC
Provide adequate turning markers or pavement markings for turning vehicle on	14	2	TWSC,AWSC

Countermeasures	CRF	Cost	Road
Provide breakaway and crashworthy mail box	15	2	RS
Provide breakaway and crashworthy sign supports	30	2	RS
Provide dashed markings (extended left edgelines) for #A1 approach continuity across median opening at divided highway intersections	22	2	TWSC,AWSC
Provide dynamic curve warning system on #R1 road	29	2	RS
Provide far-side left-turn signal on #A1 approach	28	3	SIGN
Provide/improve progression through a set of signalized intersections	25	3	SIGN
Provide independent bicycle path on #R1 road	20	3	TWSC,AWSC
Provide louvers visors or special lenses on #A1 approach	10	2	SIGN
Provide median refuges at intersection	46	3	TWSC
Provide median refuges on #R1 road	46	3	RS
Provide offset for left turn lanes on #R1 road	10	3	TWSC
Provide warning pavement marking on #A1 approach	10	2	TWSC,AWSC
Provide on-pavement horizontal signing on #R1 road	10	2	RS
Provide "Slippery when wet" signs on #A1 approach	10	1	TWSC,AWSC
Provide "Slippery when wet" signs on #R1 road	10	1	TWSC,AWSC
Provide pedestrian-only phase or pedestrian-lead phase during signal operation	31	2	SIGN
Provide pavement marking (stop sign/chevron/etc.) on #A2 approach	30	2	TWSC
Provide pavement marking (stop sign/chevron/etc.) on #R1 road	30	2	RS
Provide protected left-turn phase for #R1 road	44	3	SIGN
Provide protected/permitted phase for #R1 road	10	3	SIGN
Provide split phases for #R1 road	25	3	SIGN
Provide roadside markers or pavement markings on #A1 approach to assist drivers in judging suitability of available gaps for making turning and crossing maneuvers	10	2	TWSC,AWSC
Provide smooth paved shoulders on #A1 approach	24	3	TWSC,AWSC
Provide smooth paved shoulders on #E1 exit	24	3	TWSC,AWSC
Provide smooth paved shoulders on #R1 road	24	3	RS
Provide splitter islands on #A2 approach	35	3	TWSC
Provide spiral transition curves	20	4	RS
Provide stop signs on #A1 approach	37	1	TWSC,AWSC

Countermeasures	CRF	Cost	Road
Provide targeted speed enforcement on #A1 approach	70	3	TWSC,AWSC
Provide targeted speed enforcement on #R1 road	70	3	RS
Provide/Improve pavement surface (improve transitions/drop offs/fixed potholes/rutting/etc) on #R1 road	28	4	TWSC,AWSC
Provide visors to shade signal lenses from sunlight	20	2	SIGN
Provide wider cross sections on two-lane roads	20	4	RS
Reallocate total two-lane roadway width (lane and shoulder) to include a narrow "buffer median"	50	4	RS
Reconstruct intersection	45	4	SIGN
Redesign left-turning path from #R1 road	14	3	TWSC,AWSC,SIGN
Redesign right-turning path from #R1 road	14	3	TWSC,AWSC,SIGN
Reduce speed limit on #A1 approach	20	2	TWSC,AWSC,SIGN
Reduce speed limit on #R1 road	20	2	RS
Reduce number of lanes on #A2 approach if allowed by capacity	15	4	TWSC
Relocate control device away from the road	20	2	RRC
Relocate crossing section	30	5	RRC
Relocate driveway(s) from #E1 exit	33	4	TWSC,AWSC
Relocate driveway(s) from #A1 approach	33	4	TWSC,AWSC
Relocate driveway(s) from #R1 road	33	4	RS
Relocate or split stopping line on #A2 approach	10	1	TWSC
Relocate signal hardware out of clear zone	62	3	SIGN
Relocate stop bar on #A2 approach	10	1	TWSC,AWSC
Relocate stop sign on #A1 approach	15	1	TWSC,AWSC,RRC
Relocate stop sign on #A2 approach	15	1	TWSC,AWSC
Relocate sign on #A1 approach to make it visible	20	1	TWSC,AWSC
Relocate sign on #R1 road to make it visible	20	1	RS
Relocate transit stop	15	2	SIGN
Relocate traffic signals structure elements	20	3	SIGN
Remove deflection in through-vehicle travel path	20	2	SIGN
Remove distracting commercial lighting or other source of glare at intersection	15	3	TWSC,AWSC
Remove distracting commercial lighting or other source of glare on #R1 road	15	3	RS
Remove late night/early morning flashing operation	20	2	SIGN

Countermeasures	CRF	Cost	Road
Remove or relocate object on #A1 approach	42	3	TWSC,AWSC
Remove or relocate object on #E1 exit	42	3	TWSC,AWSC
Remove or relocate sign	29	2	RS,SIGN
Remove or relocate mail box on #R1 road	29	2	RS
Remove or relocate trees along #R1 road	46	3	RS,SIGN
Removed or relocate unnecessary signs "visual clutter"	15	2	SIGN
Remove or relocate utility Pole along #R1 road	36	2	RS,SIGN
Remove sight obstruction on #A1 approach	13	2	TWSC,AWSC
Remove sight obstruction on #E1 exit	13	2	TWSC,AWSC
Remove sight obstruction on #R1 road	13	2	RS
Remove unwarranted signal	56	3	SIGN
Remove object obstructing sight of control device	20	3	RRC
Remove object obstructing sight of warning sign on #A1 approach	20	2	TWSC,AWSC
Remove object obstructing sight of warning sign on #R1 road	20	2	RS
Remove object obstructing sight of stop sign on #A1 approach	30	2	TWSC,AWSC
Remove object obstructing sight of stop sign on #A2 approach	30	2	TWSC,AWSC
Remove object obstructing sight triangle at RRC	24	2	RRC
Remove object obstructing sight triangle at intersection	16	2	TWSC,AWSC,SIGN
Replace poorly designed drain grates on #R1 road with bicycle-safe types	10	3	TWSC,AWSC
Replace / repair signals	10	2	RRC
Replace, repair or clean control device	20	2	RRC
Replace/Repair/Clean warning signs on #A1 approach	23	1	TWSC,AWSC
Reroute pedestrian paths at intersection	30	3	TWSC,AWSC
Restrict left-turn maneuver on #R1 road	40	3	TWSC
Restrict left-turning at access point on #A1 approach	90	3	TWSC
Restrict left-turning at access point on #E1 exit	90	3	TWSC
Restrict left-turning at access point on #R1 road	90	3	RS
Restrict or eliminate turning maneuver on #R1 road	60	3	SIGN
Restrict parking close to intersection	10	2	TWSC,AWSC,SIGN
Restrict parking close to RRC	22	2	RRC
Restrict parking near driveway(s) on #A1 approach	19	2	TWSC,AWSC

Countermeasures	CRF	Cost	Road
Restrict parking near driveway(s) on #R1 road	19	2	RS
Restrict parking near horizontal/vertical curves on #R1 road	18	2	RS
Signals to alert motorists that pedestrians are crossing at crossing point	16	2	TWSC,AWSC
Signals to alert motorists that pedestrians are crossing at intersection	16	2	TWSC,AWSC
Shield drivers from poles in hazardous locations	20	2	RS
Trim vegetation at RRC	35	2	RRC
Trim vegetation at intersection	35	2	TWSC,AWSC,SIGN
Upgrade signing on #R1 road	15	1	TWSC,AWSC,RRC
Use adequate methods to increase pavement friction on #R1 road	20	4	TWSC,AWSC
Use alternating passing lanes or four-lane sections at key locations	29	3	RS
Use break-away devices on #A1 approach	30	3	TWSC,AWSC
Use break-away devices on #R1 road	30	3	RS
Use break-away devices on #E1 exit	30	3	TWSC,AWSC
Use de-icing/anti-icing method to prevent snow or ice from forming or from sticking to #R1 road surface	30	3	TWSC,AWSC
Use two red signal sections	36	2	SIGN
Use school crossing guards at crossing point	50	2	TWSC,AWSC
Use school crossing guards at intersection	50	2	TWSC,AWSC
Widen lanes on #R1 road to adequate width	25	4	RS
Widen median at intersection to provide sufficient protection to crossing vehicles	5	4	TWSC,AWSC
Widen median width on #R1 road	13	4	TWSC,AWSC
Widen outside through lanes or add bike lanes on #R1 road	15	3	TWSC,AWSC
		1- LOW COST	
		5- HIGH COST	

Appendix C

List of Conditions

Conditions	Probability	Cost	Off-Site	Reference
#A1 and #A2 are right-angle approaches	50	1	y	N
#A1 major approach	50	1	y	N
#A2 minor approach	50	1	y	N
#E1 major exit	50	1	y	N
#E2 minor exit	50	1	y	N
#R1 major road	50	1	y	N
#R2 minor road	50	1	y	N
Advance warning sign posted on #A1 approach	70	1	n	N
Advance warning sign posted on #R1 road	70	1	n	N
Adverse-weather collisions	30	2	y	N
Angle collisions	30	1	y	N
Automatic gates	35	1	y	N
Automatic gates do not work properly	10	2	n	N
AWSC	-	1	y	N
Bicycle collisions at intersection	20	2	y	N
Bicycle collisions at RRC	20	2	y	N
Bicycle collisions on #A1 approach	20	2	y	N
Bicycle collisions on #E1 exit	20	2	y	N
Bicycle collisions on #R1 road	20	2	y	N
Bicycles crossing between already lowered gate arms	30	2	n	N
Bicycles running across the track	20	2	n	N
Collision on #R1 road	60	2	y	N
Control Device is visible on #A1 approach	70	2	n	N
Control Device is not visible on A1 approach	30	2	n	N
Control device obstruction	25	2	n	N
Crossing pedestrians at intersection are not adequate recognizable	10	3	n	N

Conditions	Probability	Cost	Off-Site	Reference
Crosswalk not recognizable by drivers on #R1 road	30	3	n	N
Divided #R1 road	40	1	n	N
Driver not aware of encroach into opposing lane	30	1	n	N
Drivers crossing between already lowered gate arms	50	1	n	N
Driveway(s) collisions on #A1 approach	20	2	y	N
Driveway(s) collisions on #E1 exit	20	2	y	N
Driveway(s) collisions on #R1 road	20	2	y	N
Driveway(s) design inadequate for high traffic on #A1 approach	20	4	n	N
Driveway(s) design inadequate for high traffic on #E1 exit	20	4	n	N
Driveway(s) design inadequate for high traffic on #R1 road	20	4	n	N
Driveway(s) on #A1 approach close to intersection	40	2	y	N
Driveway(s) on #E1 exit close to intersection	40	2	y	N
Edgedrops present on #A1 approach	40	2	n	N
Edgedrops present on #E1 approach	30	2	n	N
Excessive speed on #R1 road	30	3	n	N
Exclusive lanes for left turns on #A1 approach	30	2	n	N
Fix object close to traveled way on #A1 approach	40	2	n	49301
Fix object close to traveled way on #R1 road	40	2	n	49301
Fix object close to traveled way on #E1 exit	40	2	n	49301
Frequent stop sign violations on #A1 approach	40	3	n	N
Frequent stop sign violations on #A2 approach	40	3	n	N
Frequently speed violation on #R1 road	40	3	n	403
High turning volume on #R1 road	50	3	n	N
High traffic volume on #R1 road	50	3	n	N
Head-on collisions on #R1 road	20	2	y	N
Head-on collisions on #A1 approach	20	2	y	N
Horizontal curve	35	1	n	N
Improperly control device maintained	35	1	n	N
Improperly stop sign maintained on #A1 approach	20	2	n	N
Improperly stop sign maintained on #A2 approach	20	2	n	N
Inadequate advance warning of RRC	15	1	n	N

Conditions	Probability	Cost	Off-Site	Reference
Inadequate bicycles access design	25	3	n	517
Inadequate channelization of rail road crossing	30	2	n	N
Inadequate channelization on #A1 approach	25	3	n	N
Inadequate center line markings	15	1	n	N
Inadequate clearance interval	10	2	n	N
Inadequate control device	10	1	n	N
Inadequate coordination between signals	10	2	n	N
Too short pedestrian walk signal	10	2	n	N
Inadequate crosswalk placement at intersection	15	3	n	N
Inadequate design for handicap at intersection	20	2	n	51108
Inadequate design for high traffic volume	15	3	n	N
Inadequate design for considerable number of trucks entering #E1 exit from #A2 approach	20	3	n	N
Inadequate design for considerable turning volume on #A2 approach entering on #E1 exit	20	3	n	N
Inadequate design for high turning traffic on #A1 approach	20	4	n	462D
Inadequate design of existing crosswalk	15	3	n	N
Inadequate design of horizontal curve	20	3	n	432a-432b
Inadequate design of vertical curve	20	3	n	432a-432b
Inadequate gates visibility	25	2	n	N
Inadequate intersection skew angle	10	2	n	N
Inadequate lanes signing or marking on #A1 approach	25	2	n	76203
Inadequate lanes width on #A1 approach	25	2	n	5540501
Inadequate lanes width on #R1 road	25	2	n	5540501
Inadequate lighting of crosswalk at intersection	30	3	n	7830
Inadequate left-turning path from #R1 road	10	3	n	4640
Inadequate left turn channelization	10	2	n	N
Inadequate left turn channelization/delineation for turning trucks	10	2	n	N
Inadequate location of transit stop	5	1	n	N
Inadequate maintenance of striping on median on #R1 road	15	2	n	N
Inadequate pavement marking at intersection	15	2	n	76203
Inadequate pavement marking for turning vehicle on #R1 road	15	2	n	N

Conditions	Probability	Cost	Off-Site	Reference
Inadequate pavement width to accommodate turning trucks	10	2	n	N
Inadequate phases design	15	3	n	N
Inadequate protection for pedestrians at intersection	30	3	n	N
Inadequate protection for pedestrians on crosswalk at intersection	30	3	n	N
Inadequate protection of pedestrians on #R1 road	30	3	n	N
Inadequate rail infrastructure	15	2	n	N
Inadequate right turn channelization	15	2	n	N
Inadequate median width at intersection	20	2	n	45201
Inadequate road alignment on #R1 road	30	4	n	46102
Mail Boxes close to traveled way	35	1	n	511101
Missing double yellow centerline in the meadin opening on #R1 road	15	1	n	N
Missing stoplines in the median opening on #R1 road	15	1	n	N
Inadequate road marking on crossing median on #R1 road	25	2	n	N
Inadequate shoulders width on #A1 approach	30	3	n	82302
Inadequate shoulders width on #R1 road	30	3	n	82302
Inadequate signing for multi-lane approach	20	2	n	N
Inadequate space for merging vehicles into #A1 approach	15	2	n	N
Inadequate visibility of pedestrians	15	2	n	N
Inadequate sight distance toward approaching vehicle on #A1 approach	40	2	n	422a
Inadequate sight distance on horizontal curve	20	2	n	4340
Inadequate shoulder design on #A1 approach	20	3	n	5290206
Inadequate shoulder design on #E1 exit	20	3	n	5290206
Inadequate Snow/Slush/Ice maintenance	25	3	n	N
Inadequate Snow/Slush/Ice maintenance on #A1 approach	25	3	n	N
Inadequate Snow/Slush/Ice maintenance on #R1 road	25	3	n	N
Inadequate street lights at intersection	30	3	n	7830
Inadequate street lights at rail road crossing	30	3	n	7830
Inadequate street lights on #R1 road	30	3	n	7830
Inadequate traffic signal timing or type of signal	10	2	n	77507
Inadequate emergency vehicle preemption	5	2	n	N
Inadequate visibility on approaching train	25	2	n	N

Conditions	Probability	Cost	Off-Site	Reference
Inadequate visibility of driveway(s) on #E1 exit	35	3	n	N
Inadequate visibility of driveway(s) on #R1 road	35	3	n	N
Inadequate visibility of crosswalk at intersection	30	3	n	7620302
Inadequate visibility of traffic signals	20	2	n	77501
Inadequate warning on approaching train	15	2	n	N
Insufficient bridge visibility	10	2	n	N
Insufficient delineation along the curve	15	2	n	N
Insufficient gaps between vehicle on #A1 approach	50	3	n	4610h1
Insufficient gaps between vehicles on #R1 road	50	3	n	4610h1
Insufficient fog warning	20	2	n	N
Insufficient median width on #R1 road	25	2	n	4520
Insufficient school zone warning on #R1 road	15	2	n	N
Insufficient sight distance from #A1 approach toward #A2 approach	35	3	n	422a
Insufficient sight distance from #A2 approach	35	3	n	422a
Insufficient sight distance to the crossing	35	3	n	422a
Insufficient warning	20	2	n	N
Intersection near to railroad crossing	5	1	n	N
Intersection difficult to recognize for driver on #A1 approach	30	2	n	N
Intersection difficult to recognize for driver on #A2 approach	30	2	n	N
Intersection exhibit very high crash frequency	15	2	n	N
Intersection inconspicuous	45	2	n	N
Intersection inconspicuous from #A1 approach	45	2	n	N
Intersection inconspicuous from #A2 approach	45	2	n	N
Intersections too small to allow simultaneous left turns	10	2	n	N
Intersection type "T"	15	1	y	N
Intersections with significantly unbalanced opposing left-turn volumes	15	2	n	N
Large vehicle collision	5	1	y	N
Left-turn bay not present on #A1 approach	30	1	n	N
Left-turn bay present on #A1 approach	70	1	n	N
Left-turn collisions at intersection	30	2	y	N
Left-turn collisions on #E2 exit	30	2	y	N

Conditions	Probability	Cost	Off-Site	Reference
Limited storage space between a nearby highway intersection and the tracks	20	1	n	N
Long delay on #R2 road	20	2	n	N
Long distance between crosswalks on #R1 road	15	2	n	N
Long queues of left-turn vehicles at intersection	15	2	n	N
Median object obstructs sight distance on #R1 road	20	3	n	N
Multilane on #R1 road make difficult for bicycles to cross on #R1 road	15	3	n	N
Multilane on #R1 road make difficult for pedestrian to cross on #R1 road	15	3	n	N
Narrow clear zone on #R1 road	25	2	n	492A
Night time collisions at intersection	30	2	y	N
Night time collisions at rail road crossing	30	1	y	N
Night time collisions for drivers on #R1 road	30	2	y	N
No advance warning sign on #A1 approach	20	1	n	N
No advance warning sign on #R1 road	20	1	n	N
No bypass for left turn traffic on #A1 approach	30	1	n	N
No posted speed limit on #A1 approach	10	1	n	N
No posted speed limit on #R1 road	10	1	n	N
No sidewalk present	10	1	n	N
No school zone speed limit posted on #R1 road	5	1	n	N
No street name signs present at intersection	5	1	n	75505
Not Automatic gates	35	1	y	N
One left turn lane	5	1	n	N
Parking cars close to intersection	5	1	n	N
Pavement defects on #R1 road	45	2	n	5260
Pedestrian collisions at intersection	30	2	n	N
Pedestrian collisions at RRC	20	2	n	N
Pedestrian collisions on #R1 road	30	2	n	N
Pedestrians may block #E2 exits	20	2	n	N
Pedestrians running across the track	40	2	n	N
Pedestrians walking along road	20	2	n	N
Physical object obstruct view from a crosswalk at intersection	30	2	n	N
Percent of tall vehicles considerable on approach #A2	10	2	n	N

Conditions	Probability	Cost	Off-Site	Reference
Poor horizontal/vertical alignment on #A1 approach	30	3	n	432a-432b
Poor horizontal/vertical alignment on #A2 approach	30	3	n	432a-432b
Poor horizontal/vertical alignment on #R1 road	30	3	n	432a-432b
Poor pavement marking on #A1 approach	25	2	n	76203
Poor signs reflectivity for drivers on #R1 road	15	2	n	75203
Poor signs visibility on #R1 road	20	2	n	N
Poor skid resistance on #A1 approach	30	3	n	N
Poor skid resistance on #R1 road	30	3	n	N
Poor visibility of opposite vehicles	15	2	n	N
Poorly designed drain grates on R1 road	15	4	n	5550302
Posted speed limit on #R1 road	80	1	n	N
Off-road collisions on #A1 approach	40	2	y	N
Off-road collisions on #E1 exit	40	2	y	N
Off-road collisions on #R1 road	40	2	y	N
Opposite left turn vehicles on #R1 road obstruct each other sight distance	20	2	n	N
RRC	-	1	y	N
Rear-end collisions on #A1 approach	25	2	y	N
Rear-end collisions on #E1 exit	20	2	y	N
Red-light running	10	2	n	N
Red-light violation	10	2	n	N
Regulatory sign poorly visible/recognizable at intersection	15	1	n	N
Regulatory sign posted at intersection	70	1	n	N
Right-angle collisions between #A1 and #A2 vehicles	40	2	y	N
Right-angle collisions between #R1 and #R2 vehicles	40	2	y	N
Right turn collision	15	2	y	N
Right-turn lanes not present on #A1 approach	50	1	n	N
Right-turn lanes present on #A1 approach	50	1	n	N
Right-turning vehicles on #A1 approach obstruct sight of vehicles on #A2 approach	25	2	n	N
Road inadequate design for trucks	10	2	n	N
Roadside sight obstruction at intersection	30	3	n	422a
Roadside sight obstruction at RRC	30	3	n	422a

Conditions	Probability	Cost	Off-Site	Reference
Roadway inconspicuous	45	2	n	N
RS	-	1	y	N
School zone present	40	1	n	N
Sight distance obstructed by other vehicles on #A2 approach	20	2	n	N
Sight distance obstructed by other vehicles parked close to intersection	20	2	n	N
SIGN	-	1	y	N
Sign Supports close to traveled way	30	1	n	N
Signalized intersection(s) on #R1 coordinated with the investigated intersection	10	1	n	N
Significant high traffic volume turning from #A2 approach into #A1 approach	15	3	n	N
Significant number of pedestrian crossing at intersection	15	3	n	N
Significant number of bicycles on #R1 road	10	3	n	N
Significant number of pedestrian crossing intersection	15	3	n	N
Slippery pavement (no winter) on #A1 approach	20	3	n	ch52
Slippery pavement (no winter) on #E1 exit	20	3	n	ch52
Slippery pavement (winter) on #A1 approach	10	3	n	ch52
Slippery pavement (winter) on #R1 road	10	3	n	ch52
Speed violation on #R1 road	35	2	n	N
Stop sign not visible on #A2 approach	30	2	n	N
Stop sign not visible on #R2 road	30	2	n	N
Stop sign obstruction on #A1 approach	15	1	n	N
Stop sign obstruction on #A2 approach	20	2	n	N
Stop sign visible on #A2 approach	70	2	n	N
Stop sign(s) visible on #R2 road	70	2	n	N
Two or more left turn lanes	10	1	n	N
Trees close to traveled way	25	2	n	N
Trucks collisions	10	2	y	N
TWSC	-	1	n	N
Undivided #R1 road	60	1	n	N
Unwarranted traffic control	5	3	n	N
Utility Poles close to traveled way	20	2	n	N
Vehicles queues forming across the railroad tracks	5	1	n	N

Conditions	Probability	Cost	Off-Site	Reference
Vehicle queues extend beyond taper on #A1 approach	20	2	n	N
Vehicle queues extend beyond turning bay on #A1 approach	20	2	n	N
Vehicles slow down before entering turning bay on #A1 approach	60	2	n	N
Vertical curve	40	2	n	N
Visual/Audio warning signal does not work correctly	15	1	n	N
Visual distraction at intersection	60	2	n	N
Visual distraction on #A1 approach	60	2	n	N
Visual distraction on #R1 road	60	2	n	N
Warning sign obstruction on #A1 approach	10	1	n	N
Warning sign obstruction on #R1 road	10	1	n	N
Warning sign poorly visible/recognizable on #A1 approach	10	2	n	754a
Warning sign poorly visible/recognizable on #R1 road	10	2	n	754a
Wide median on #R1 road	10	2	n	N
		1-LOW COST	y-yes	N- NO DATA
		5-HIGH COST	n-no	

Appendix D

RSIT 2 Knowledge Base

Close or relocate driveway(s) on #A1 approach	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach		
Close or relocate driveway(s) on #E1 exit	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit		
Relocate driveway(s) from #E1 exit	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit		
Channelize driveway(s) on #A1 approach	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach		
Channelize driveway(s) on #E1 exit	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit		
Install curbing to define driveway(s) location on #A1 approach	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach		
Install curbing to define driveway(s) location on #E1 exit	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit		
Install median divider on #A1 approach to prevent left-turns from/to driveway(s)	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach		

Install median divider on #E1 exit to prevent left-turns from/to driveway(s)	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit		
Provide deceleration lane on #A1 approach	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach		
Provide acceleration lane on #E1 exit	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit		
Relocate driveway(s) from #A1 approach	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach		
Remove sight obstruction on #A1 approach	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach			
Remove sight obstruction on #E1 exit	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit			
Restrict left-turning at access point on #A1 approach	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach		
Restrict left-turning at access point on #E1 exit	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit		
Restrict parking near driveway(s) on #A1 approach	TWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach			

Restrict parking near driveway(s) on #E1 exit	TWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit				
Improve street lighting	TWSC	Night time collisions at intersection	Inadequate street lights at intersection					
Improve/install reflective signs on #R1 road	TWSC	Night time collisions on #R1 road	Poor signs reflectivity on #R1 road					
Improve/install reflectorized pavement markers on #R1 approach	TWSC	Night time collisions on #R1 road	Inadequate street lights on #R1 road					
Install street lights at intersection	TWSC	Night time collisions at intersection	Inadequate street lights at intersection					
Remove distracting commercial lighting or other source of glare at intersection	TWSC	Night time collisions at intersection	Inadequate street lights at intersection					
Add sign warning about off-road collisions on #A1 approach	TWSC	Off-road collisions on #A1 approach						
Add sign warning about off-road collisions on #E1 exit	TWSC	Off-road collisions on #E1 exit						
Eliminate shoulder drop-off on #A1 approach	TWSC	Off-road collisions on #A1 approach	Edge drop-off present on #A1 approach					

Eliminate shoulder drop-off on #E1 exit	TWSC	Off-road collisions on #E1 exit	Edge drop-off present on #E1 approach					
Install barrier curb or guardrail on #A1 approach	TWSC	Off-road collisions on #A1 approach	Fixed object close to traveled way on #A1 approach					
Install barrier curb or guardrail on #E1 exit	TWSC	Off-road collisions on #E1 exit	Fixed object close to traveled way on #E1 exit					
Install object marker on #A1 approach	TWSC	Off-road collisions on #A1 approach	Fixed object close to traveled way on #A1 approach					
Install object marker on #E1 exit	TWSC	Off-road collisions on #E1 exit	Fixed object close to traveled way on #E1 exit					
Install shoulder rumble strips on #A1 approach	TWSC	Off-road collisions on #A1 approach	Inadequate lane width on #A1 approach					
Remove or relocate object on #A1 approach	TWSC	Off-road collisions on #A1 approach	Fixed object close to traveled way on #A1 approach					
Remove or relocate object on #E1 exit	TWSC	Off-road collisions on #E1 exit	Fixed object close to traveled way on #E1 exit					
Use breakaway devices on #A1 approach	TWSC	Off-road collisions on #A1 approach	Fixed object close to traveled way on #A1 approach					

Use breakaway devices on #E1 exit	TWSC	Off-road collisions on #E1 exit	Fixed object close to traveled way on #E1 exit					
Install overhead STOP sign(s) on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Percent of tall vehicles considerable on approach #A2			
Add stoplines in median opening on #R1 road	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Divided #R1 road	Missing stoplines in the median opening on #R1 road	Wide median on #R1 road
Adjust signal offsets along #R1 road to create longer inter-vehicle gaps	TWSC	Right-angle collisions between #R1 and #R2 vehicles	#R1 major road	#R2 minor road	Stop sign(s) visible on #R2 road	Insufficient gaps between vehicles on #R1 road	Signalized intersection(s) on #R1 coordinated with the investigated intersection	
Consider intersection with indirect left-turns	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Divided #R1 road	Significant high traffic volume turning from #A2 approach into #E1 exit	
Consider a lateral relocation of right-turn lanes on #A1 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Right-turning vehicles on #A1 approach obstruct sight of vehicles on #A2 approach	
Convert intersection into roundabout	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient gaps between vehicle on #A1 approach		

Improve pavement marking in median opening on #R1 road	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Divided #R1 road	Inadequate road marking on crossing median on #R1 road	
Improve traffic visibility from median opening toward #A1 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Divided #R1 road	Inadequate sight distance toward vehicles approaching intersection on #A1 approach	
Improve visibility of stop bar on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Intersection difficult to comprehend for drivers on #A2 approach		
Install triangular island on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Sight distance obstructed by other vehicles on #A2 approach	
Install corner mirrors (local road/low speed)	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Roadside sight obstruction at intersection	
Install rumble strips on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Intersection difficult to comprehend for drivers on #A2 approach		

Install traffic signals at intersection	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Poor horizontal/vertical alignment on #A2 approach	
Install traffic signals at intersection	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Roadside sight obstruction at the intersection	
Install traffic signals at intersection	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient gaps between vehicle on #A1 approach		
Provide double yellow centerline in median opening at intersections	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Divided #R1 road	Missing double yellow centerline in median opening on #R1 road	Wide median on #R1 road
Provide pavement marking (stop sign/chevron/etc.) on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Intersection difficult to comprehend for drivers on #A2 approach		
Provide roadside markers or pavement markings on #A1 approach to assist drivers estimate available gaps	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient gaps between vehicle on #A1 approach		

Provide splitter islands on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Intersection difficult to comprehend for drivers on #A2 approach		
Reduce speed limit on #A1 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A1 approach toward #A2 approach	Roadside sight obstruction at intersection	
Reduce number of lanes on #A2 approach if allowed by capacity	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Sight distance obstructed by other vehicles on #A2 approach	
Relocate or split stopping line on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Sight distance obstructed by other vehicles on #A2 approach	
Relocate stop bar on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Roadside sight obstruction at intersection	
Relocate stop sign on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign NOT visible on #A2 approach	Stop sign obstruction on #A2 approach		

Remove object obstructing sight of stop sign on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign NOT visible on #A2 approach	Stop sign obstruction on #A2 approach		
Remove object obstructing sight triangle at intersection	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Roadside sight obstruction at intersection	
Replace/repair or clean stop sign on #A2 approach	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign NOT visible on #A2 approach	Stop sign on #A2 approach improperly maintained		
Restrict parking close to intersection	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Sight distance obstructed by other vehicles parked close to intersection	
Trim vegetation at intersection	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach	Roadside sight obstruction at intersection	
Widen median at intersection to provide sufficient protection to crossing vehicles	TWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 major approach	#A2 minor approach	Stop sign visible on #A2 approach	Divided #R1 road	Inadequate median width at intersection	
Convert intersection into roundabout	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane NOT present on #A1 approach	Vehicle queues extend beyond taper on #A1 approach			
Convert intersection into roundabout	TWSC	Rear-end collisions on	#A1 major approach	Left-turn lane present on #A1	Vehicle queues extend beyond turning bay on			

		#A1 approach		approach	#A1 approach		
Convert intersection into roundabout	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Long delay on #R2 road	#R2 minor road		
Increase length of right-turn bay on #A1 approach	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane NOT present on #A1 approach	Vehicles slow down before entering turning bay on #A1 approach		
Increase radius of corner curves	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane NOT present on #A1 approach	Vehicles slow down before entering turning bay on #A1 approach		
Increase length of left-turn bay on #A1 approach	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane present on #A1 approach	Vehicle queues extend beyond turning bay on #A1 approach		
Increase length of left-turn bay on #A1 approach	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane present on #A1 approach	Vehicles slow down before entering turning bay on #A1 approach		
Increase length of right-turn bay on #A1 approach	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane NOT present on #A1 approach	Vehicle queues extend beyond taper on #A1 approach		
Increase radius of corner curves	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Right-turn lanes NOT present on #A1 approach	Inadequate design for high turning traffic on #A1 approach		
Install acceleration lane on #E1 exit sufficiently long for trucks	TWSC	Rear-end collisions on #E1 exit	#E1 major exit	Inadequate design for trucks moving from #A2 approach to #E1 exit	#A2 minor approach		
Install acceleration lane on #E1 exit	TWSC	Rear-end collisions on	#E1 major exit	Inadequate design for high	#A2 minor approach		

		#E1 exit		traffic turning from #A2 approach towards #E1 exit				
Install indirect left-turn lanes on #A1 approach	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane present on #A1 approach	Vehicle queues extend beyond turning bay on #A1 approach			
Install indirect right-turn lanes on #A1 approach	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane NOT present on #A1 approach	Vehicle queues extend beyond taper on #A1 approach			
Install right-turn lane on #A1 approach	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Right-turn lanes NOT present on #A1 approach	Inadequate design for high turning traffic on #A1 approach			
Install traffic signals at intersection	TWSC	Collision on #R1 road	#R1 major road	Long delay on #R2 road	#R2 minor road			
Install traffic signals at intersection	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane present on #A1 approach	Vehicle queues extend beyond turning bay on #A1 approach			
Install traffic signals at intersection	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Left-turn lane NOT present on #A1 approach	Vehicle queues extend beyond taper on #A1 approach			
Install traffic signals at intersection	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Long delay on #R2 road	#R2 minor road			
Install/improve signing or marking of pedestrian crosswalks at intersection	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Significant number of pedestrian crossing at intersection				

Provide bypass lane on #A1 approach with left-turn traffic	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Intersection type T	No bypass for left turn traffic on #A1 approach		
Provide dashed markings for #A1 approach (extended left edgelines continued across median opening)	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Divided #R1 road	Inadequate design for high turning traffic on #A1 approach		
Provide stop signs on #A1 approach	TWSC	Rear-end collisions on #A1 approach	#A1 major approach	Long delay on #R2 road	#R2 minor road		
Apply chip seal or slurry seal on #A1 approach	TWSC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach				
Apply ship seal or slurry seal on #E1 exit	TWSC	Adverse-weather collisions	Slippery pavement (no winter) on #E1 exit				
Groove pavement surface on #A1 approach	TWSC	Adverse-weather collisions	Slippery pavement (winter) on #R1 road				
Improve timeliness of winter maintenance	TWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance				
Improve winter maintenance	TWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance				
Install fog-warning signs	TWSC	Adverse-weather collisions	Insufficient fog warning				

Install static or variable message signs displaying weather information on #A1 approach	TWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #A1 approach					
Install snow screens in areas exposed to snowdrifts on #R1 road	TWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road					
Overlay pavement on #A1 approach	TWSC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach					
Overlay pavement on #E1 exit	TWSC	Adverse-weather collisions	Slippery pavement (no winter) on #E1 exit					
Provide "Slippery when wet" signs on #A1 approach	TWSC	Adverse-weather collisions	Slippery pavement (winter) on #A1 approach					
Reduce speed limit on #A1 approach	TWSC	Adverse-weather collisions	Slippery pavement (winter) on #A1 approach					
Use adequate methods to increase pavement friction on #R1 road	TWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road					
Use deicing/antiicing methods to #R1 road surface	TWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road					
Consider traffic calming on #R1 road	TWSC	Pedestrian collisions at	Crosswalk not visible to drivers					

		intersection	on #R1 road					
Construct pedestrian refuge islands and/or raised medians	TWSC	Pedestrian collisions at intersection	Inadequate protection for pedestrians on crosswalk(s)					
Eliminate objects that obstruct sight to pedestrians entering crosswalk	TWSC	Pedestrian collisions at intersection	Fixed object obstructs view from a crosswalk at intersection					
Improve signage and/or marking of crosswalk(s)	TWSC	Pedestrian collisions at intersection	Inadequate visibility of crosswalk(s) at intersection					
Install curb-ramps	TWSC	Pedestrian collisions at intersection	Inadequate design for handicapped at intersection					
Install pedestrian actuated signals	TWSC	Pedestrian collisions at intersection	Significant number of pedestrian crossing intersection					
Install pedestrian barriers	TWSC	Pedestrian collisions at intersection	Inadequate protection for pedestrians at intersection					
Install pedestrian crosswalks	TWSC	Pedestrian collisions at intersection	Long distance between crosswalks on #R1 road					
Install pedestrian overpass or underpass	TWSC	Pedestrian collisions at intersection	Inadequate protection for pedestrians at intersection					
Install raised	TWSC	Pedestrian	Inadequate					

crosswalks		collisions at intersection	visibility of crosswalk(s) at intersection					
Install school crossing sign on #R1 road	TWSC	Pedestrian collisions at intersection	School zone present	Insufficient school zone warning on #R1 road				
Install school zone markings on #R1 road	TWSC	Pedestrian collisions at intersection	School zone present	Insufficient school zone warning on #R1 road				
Install school zone speed limit sign on #R1 road	TWSC	Pedestrian collisions at intersection	School zone present	No school zone speed limit posted on #R1 road				
Increase sidewalk setback on #R1 road	TWSC	Pedestrian collisions on #R1 road	Inadequate protection of pedestrians on #R1 road					
Install street lighting	TWSC	Pedestrian collisions at intersection	Inadequate lighting of crosswalk at intersection					
Provide separate bicycle path on #R1 road	TWSC	Bicycle collisions on #R1 road	Inadequate bicycles space on #R1 road					
Provide separate bicycle path on #R1 road	TWSC	Bicycle collisions on #R1 road	Significant number of bicycles on #R1 road					
Provide median refuges at intersection	TWSC	Bicycle collisions at intersection	High traffic volume on #R1 road					
Provide median refuges at intersection	TWSC	Bicycle collisions at intersection	Multiple lanes on #R1 road make difficult for bicycles to cross #R1 road					
Provide smooth paved shoulders on #A1 approach	TWSC	Bicycle collisions on #A1	Inadequate shoulder design on #A1					

		approach	approach					
Provide smooth paved shoulders on #E1 exit	TWSC	Bicycle collisions on #E1 exit	Inadequate shoulder design on #E1 exit					
Replace poorly designed drain grates on #R1 road with bicycle-safe types	TWSC	Bicycle collisions on #R1 road	Poorly designed drain grates on #R1 road					
Reroute pedestrian paths at intersection	TWSC	Pedestrian collisions at intersection	Inadequate crosswalk placement at intersection					
Install signals to alert motorists that pedestrians are crossing at intersection	TWSC	Pedestrian collisions at intersection	Crossing pedestrians at intersection are NOT visible at sufficient distance					
Use school crossing guards at intersection	TWSC	Pedestrian collisions at intersection	High traffic volume on #R1 road					
Use school crossing guards at intersection	TWSC	Pedestrian collisions at intersection	Insufficient school zone warning on #R1 road					
Widen outside through lanes or add bike lanes on #R1 road	TWSC	Bicycle collisions on #R1 road	Inadequate bicycles space on #R1 road					
Consider indirect left-turns on #R1 road	TWSC	Left-turn collisions on #R1 road	Divided #R1 road	Opposite left turn vehicles on #R1 road obstruct each other sight distance				
Consider indirect left-turns on #R1 road	TWSC	Left-turn collisions on #R1 road	Undivided #R1 road	Opposite left turn vehicles on #R1 road obstruct each other sight distance				
Consider indirect left-turns on #R1 road	TWSC	Left-turn collisions on #R1 road	Long queues of left-turn vehicles at					

			intersection					
Consider traffic signals with protected left-turn phase	TWSC	Left-turn collisions at intersection	Long queues of left-turn vehicles at intersection					
Convert intersection into roundabout	TWSC	Left-turn collisions at intersection	Long queues of left-turn vehicles at intersection					
Increase crosswalk setback on #E2 exit	TWSC	Left-turn collisions on #R1 road	Pedestrians may block #E2 exit	#E2 minor exit				
Provide adequate turning markers or pavement markings for turning vehicle on #R1 road	TWSC	Left-turn collisions on #R1 road	Inadequate pavement marking for turning vehicle on #R1 road					
Provide offset for left turn lanes on #R1 road	TWSC	Left-turn collisions on #R1 road	#R1 major road	Divided #R1 road	Opposite left turn vehicles on #R1 road obstruct each other sight distance			
Redesign left-turning path(s) from #R1 road	TWSC	Left-turn collisions on #R1 road	Inadequate left-turning path(s) from #R1 road					
Remove or relocate median object obstructing sight on #R1 road	TWSC	Left-turn collisions on #R1 road	Divided #R1 road	Opposite left turn vehicles on #R1 road obstruct each other sight distance	Object located in median obstructs sight distance on #R1 road			
Restrict left-turn maneuver on #R1 road	TWSC	Left-turn collisions on #R1 road	Divided #R1 road	Opposite left turn vehicles on #R1 road obstruct each other sight distance				
Restrict left-turn maneuver on #R1 road	TWSC	Left-turn collisions on #R1 road	Undivided #R1 road	Opposite left turn vehicles on #R1 road obstruct each other sight distance				

Enforce STOP sign compliance on #A2 approach	TWSC	#A2 minor approach	Frequent stop sign violations on #A2 approach					
Post adequate speed limit on #R1 road	TWSC	Excessive speed on #R1 road	No posted speed limit on #A1 approach					
Post adequate speed limit on #R1 road	TWSC	Excessive speed on #R1 road	Posted speed limit on #R1 road	Frequently speed violations on #R1 road				
Post dynamic message sign to display speed of vehicles on #A1 approach	TWSC	Excessive speed on #R1 road	Posted speed limit on #R1 road	Frequently speed violations on #R1 road				
Provide targeted speed enforcement on #A1 approach	TWSC	Posted speed limit on #R1 road	Frequently speed violations on #R1 road					
Consider traffic calming on #R1 road	TWSC	Posted speed limit on #R1 road	Frequently speed violations on #R1 road	#R1 Local Road				
Improve visibility of intersection by providing enhanced signing and delineation	TWSC	Intersection inconspicuous	Intersection difficult to comprehend for drivers on #A1 approach					
Install street lighting	TWSC	Intersection inconspicuous	Intersection difficult to comprehend for drivers on #A1 approach					
Install advance warning signs on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	No advance warning sign on #A1 approach					
Install advance warning	TWSC	Intersection	Poor					

signs on #A2 approach		inconspicuous from #A1 approach	horizontal/vertical alignment on #A1 approach					
Install advance warning signs on #A2 approach	TWSC	Intersection inconspicuous from #A1 approach	#A2 minor approach	Intersection difficult to comprehend for drivers on #A2 approach				
Install flashing beacons above STOP sign on #A2 approach	TWSC	Intersection inconspicuous from #A2 approach	#A2 minor approach	Intersection difficult to comprehend for drivers on #A2 approach				
Install larger regulatory signs	TWSC	Intersection inconspicuous	Regulatory sign posted at intersection	Regulatory sign poorly visible/recognizable at intersection	Visual distractions at intersection			
Install larger regulatory signs on both sides of road on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Regulatory sign posted at intersection	Regulatory sign poorly visible/recognizable at intersection				
Install larger regulatory signs on both sides of road on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Regulatory sign posted at intersection	Visual distractions at intersection				
Install larger warning signs on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach				
Install larger warning signs on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Visual distractions on #A1 approach				
Install overhead flashing beacon lights on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach				

Install street name signs at intersection	TWSC	Intersection inconspicuous	No street name signs present at intersection					
Install warning signs on both sides of road on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	Visual distractions on #A1 approach			
Provide warning pavement marking on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	Visual distractions on #A1 approach			
Relocate sign on #A1 approach to make it visible	TWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	Warning sign obstructed on #A1 approach			
Remove object obstructing sight of warning sign on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	Warning sign obstructed on #A1 approach			
Replace/repair/Clean warning signs on #A1 approach	TWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach				
Improve horizontal/vertical alignment on #A2 approach	Poor horizontal/vertical alignment on #A2 approach							
Change horizontal/vertical alignment on #R1 road	Poor horizontal/vertical alignment on #R1 road							

Improve horizontal/vertical alignment on #R1 road	Inadequate road alignment on #R1 road						
Improve channelization/delineation on #A1 approach	Inadequate channelization on #A1 approach						
Increase clear zone on #R1 road	Narrow clear zone on #R1 road						
Correct lane width on #A1 approach	Inadequate lane width on #A1 approach						
Improve pavement marking on #A1 approach	Poor pavement marking on #A1 approach						
Increase skid resistance on #R1 road	Poor skid resistance on #R1 road						
Increase width of shoulders on #A1 approach	Inadequate shoulders width on #A1 approach						
Properly maintain striping on median on #R1 road	Divided #R1 road	Inadequate maintenance of striping on median on #R1 road					
Provide adequate delineation for left-turns at intersection (markers or lines)	Inadequate pavement marking at intersection						
Provide adequate drainage on #R1 road	Poor drainage on #R1 road						
Provide adequate lane signing or marking on #A1 approach	Inadequate lanes signing or marking on #A1 approach						
Provide/Improve pavement surface (improve transitions/drop offs/fixed	Pavement defects on #R1 road						

potholes/rutting/etc) on #R1 road							
Widen lanes on #A1 approach to adequate width	Inadequate lane width on #A1 approach						
Widen median width on #R1 road	Insufficient median width on #R1 road						

All-way stop-controlled intersection

Close or relocate driveway(s) on #A1 approach	AWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach
Close or relocate driveway(s) on #E1 exit	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit
Relocate driveway(s) from #E1 exit	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit
Channelize driveway(s) on #A1 approach	AWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach
Channelize driveway(s) on #E1 exit	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit
Install curbing to define driveway(s) location on #A1 approach	AWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach
Install curbing to define driveway(s) location on #E1 exit	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit
Install median divider on #A1 approach to prevent left-turns from/to	AWSC	Driveway(s) collisions on #A1	Driveway(s) on #A1 approach close to	Inadequate visibility of driveway(s) on #A1	Driveway(s) design inadequate for high

driveway(s)		approach	intersection	approach	traffic on #A1 approach
Install median divider on #E1 exit to prevent left-turns from/to driveway(s)	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit
Provide deceleration lane on #A1 approach	AWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach
Provide acceleration lane on #E1 exit	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit
Relocate driveway(s) from #A1 approach	AWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach
Remove sight obstruction on #A1 approach	AWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	
Remove sight obstruction on #E1 exit	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	
Restrict left-turning at access point on #A1 approach	AWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	Driveway(s) design inadequate for high traffic on #A1 approach
Restrict left-turning at access point on #E1 exit	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	Driveway(s) design inadequate for high traffic on #E1 exit
Restrict parking near driveway(s) on #A1 approach	AWSC	Driveway(s) collisions on #A1 approach	Driveway(s) on #A1 approach close to intersection	Inadequate visibility of driveway(s) on #A1 approach	
Restrict parking near driveway(s) on #E1 exit	AWSC	Driveway(s) collisions on #E1 exit	Driveway(s) on #E1 exit close to intersection	Inadequate visibility of driveway(s) on #E1 exit	
Improve street lighting	AWSC	Night time collisions at intersection	Inadequate street lights at intersection		
Improve/install reflective signs on #R1 road	AWSC	Night time collisions on #R1 road	Poor signs reflectivity on #R1		

			road		
Improve/install reflectorized pavement markers on #R1 approach	AWSC	Night time collisions on #R1 road	Inadequate street lights on #R1 road		
Install street lights at intersection	AWSC	Night time collisions at intersection	Inadequate street lights at intersection		
Remove distracting commercial lighting or other source of glare at intersection	AWSC	Night time collisions at intersection	Inadequate street lights at intersection		
Add sign warning about off-road collisions on #A1 approach	AWSC	Off-road collisions on #A1 approach			
Add sign warning about off-road collisions on #E1 exit	AWSC	Off-road collisions on #E1 exit			
Eliminate shoulder drop-off on #A1 approach	AWSC	Off-road collisions on #A1 approach	Edge drop-off present on #A1 approach		
Eliminate shoulder drop-off on #E1 exit	AWSC	Off-road collisions on #E1 exit	Edge drop-off present on #E1 approach		
Install barrier curb or guardrail on #A1 approach	AWSC	Off-road collisions on #A1 approach	Fixed object close to traveled way on #A1 approach		
Install barrier curb or guardrail on #E1 exit	AWSC	Off-road collisions on #E1 exit	Fixed object close to traveled way on #E1 exit		
Install object marker on #A1 approach	AWSC	Off-road collisions on #A1 approach	Fixed object close to traveled way on #A1 approach		
Install object marker on #E1 exit	AWSC	Off-road collisions on #E1 exit	Fixed object close to traveled way on #E1 exit		
Install shoulder rumble strips on #A1 approach	AWSC	Off-road collisions on #A1 approach	Inadequate lane width on #A1 approach		
Remove or relocate object on #A1 approach	AWSC	Off-road collisions on #A1 approach	Fixed object close to traveled way on #A1 approach		
Remove or relocate object on #E1 exit	AWSC	Off-road collisions on #E1 exit	Fixed object close to traveled way on #E1 exit		
Use breakaway devices on #A1 approach	AWSC	Off-road collisions on #A1 approach	Fixed object close to traveled way on #A1 approach		

Use breakaway devices on #E1 exit	AWSC	Off-road collisions on #E1 exit	Fixed object close to traveled way on #E1 exit		
Install overhead STOP sign(s) on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Percent of tall vehicles considerable on approach #A2	
Improve visibility of stop bar on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Intersection difficult to comprehend for drivers on #A2 approach
Install triangular island on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach
Install rumble strips on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Intersection difficult to comprehend for drivers on #A2 approach
Install traffic signals at intersection	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach
Install traffic signals at intersection	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach
Provide pavement marking (stop sign/chevron/etc.) on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Intersection difficult to comprehend for drivers on #A2 approach
Provide splitter islands on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Intersection difficult to comprehend for drivers on #A2 approach
Relocate or split stopping line on #A2	AWSC	Right-angle	#A1 and #A2 right-	Stop sign visible on	Insufficient sight

approach		collisions between #A1 and #A2 vehicles	angle approaches	#A2 approach	distance from #A2 approach
Relocate stop bar on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach
Relocate stop sign on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign NOT visible on #A2 approach	Stop sign obstruction on #A2 approach
Remove object obstructing sight of stop sign on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign NOT visible on #A2 approach	Stop sign obstruction on #A2 approach
Remove object obstructing sight triangle at intersection	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach
Replace/repair or clean stop sign on #A2 approach	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign NOT visible on #A2 approach	Stop sign on #A2 approach improperly maintained
Restrict parking close to intersection	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach
Trim vegetation at intersection	AWSC	Right-angle collisions between #A1 and #A2 vehicles	#A1 and #A2 right-angle approaches	Stop sign visible on #A2 approach	Insufficient sight distance from #A2 approach
Apply chip seal or slurry seal on #A1 approach	AWSC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach		
Apply ship seal or slurry seal on #E1 exit	AWSC	Adverse-weather collisions	Slippery pavement (no winter) on #E1		

			exit		
Groove pavement surface on #A1 approach	AWSC	Adverse-weather collisions	Slippery pavement (winter) on #R1 road		
Improve winter maintenance	AWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance		
Improve timeliness of winter maintenance	AWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance		
Install fog-warning signs	AWSC	Adverse-weather collisions	Insufficient fog warning		
Install static or variable message signs displaying weather information on #A1 approach	AWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #A1 approach		
Install snow screens in areas exposed to snowdrifts on #R1 road	AWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Overlay pavement on #A1 approach	AWSC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach		
Overlay pavement on #E1 exit	AWSC	Adverse-weather collisions	Slippery pavement (no winter) on #E1 exit		
Provide "Slippery when wet" signs on #A1 approach	AWSC	Adverse-weather collisions	Slippery pavement (winter) on #A1 approach		
Reduce speed limit on #A1 approach	AWSC	Adverse-weather collisions	Slippery pavement (winter) on #A1 approach		
Use adequate methods to increase pavement friction on #R1 road	AWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Use deicing/antiicing methods to #R1 road surface	AWSC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Construct pedestrian refuge islands and/or raised medians	AWSC	Pedestrian collisions at intersection	Inadequate protection for pedestrians on crosswalk(s)		
Eliminate objects that obstruct sight to	AWSC	Pedestrian collisions	Fixed object obstructs view from a crosswalk		

pedestrians entering crosswalk		at intersection	at intersection		
Consider traffic calming on #R1 road	AWSC	Pedestrian collisions at intersection	Crosswalk not visible to drivers on #R1 road		
Improve signage and/or marking of crosswalk(s)	AWSC	Pedestrian collisions at intersection	Inadequate visibility of crosswalk(s) at intersection		
Install pedestrian overpass or underpass	AWSC	Pedestrian collisions at intersection	Inadequate protection for pedestrians at intersection		
Install curb-ramps	AWSC	Pedestrian collisions at intersection	Inadequate design for handicapped at intersection		
Install street lighting	AWSC	Pedestrian collisions at intersection	Inadequate lighting of crosswalk at intersection		
Install pedestrian actuated signals	AWSC	Pedestrian collisions at intersection	Significant number of pedestrian crossing intersection		
Install pedestrian barriers	AWSC	Pedestrian collisions at intersection	Inadequate protection for pedestrians at intersection		
Install pedestrian crosswalks	AWSC	Pedestrian collisions at intersection	Long distance between crosswalks on #R1 road		
Install raised crosswalks	AWSC	Pedestrian collisions at intersection	Inadequate visibility of crosswalk(s) at intersection		
Install school crossing sign on #R1 road	AWSC	Pedestrian collisions at intersection	Insufficient school zone warning on #R1 road		
Install school zone markings on #R1 road	AWSC	Pedestrian collisions at intersection	School zone present	Insufficient school zone warning on #R1 road	
Install school zone speed limit sign on #R1 road	AWSC	Pedestrian collisions at intersection	School zone present	No school zone speed limit posted on #R1 road	
Increase sidewalk setback on #R1 road	AWSC	Pedestrian collisions on #R1 road	Inadequate protection of pedestrians on #R1 road		
Provide separate bicycle path on #R1 road	AWSC	Bicycle collisions on #R1 road	Inadequate bicycles space on #R1 road		
Provide separate bicycle path on #R1 road	AWSC	Bicycle collisions on #R1 road	Significant number of bicycles on #R1 road		
Provide median refuges at	AWSC	Bicycle collisions at	High traffic volume		

intersection		intersection	on #R1 road		
Provide median refuges at intersection	AWSC	Bicycle collisions at intersection	Multiple lanes on #R1 road make difficult for bicycles to cross #R1 road		
Provide smooth paved shoulders on #A1 approach	AWSC	Bicycle collisions on #A1 approach	Inadequate shoulder design on #A1 approach		
Provide smooth paved shoulders on #E1 exit	AWSC	Bicycle collisions on #E1 exit	Inadequate shoulder design on #E1 exit		
Replace poorly designed drain grates on #R1 road with bicycle-safe types	AWSC	Bicycle collisions on #R1 road	Poorly designed drain grates on #R1 road		
Reroute pedestrian paths at intersection	AWSC	Pedestrian collisions at intersection	Inadequate crosswalk placement at intersection		
Install signals to alert motorists that pedestrians are crossing at intersection	AWSC	Pedestrian collisions at intersection	Crossing pedestrians at intersection are NOT visible at sufficient distance		
Use school crossing guards at intersection	AWSC	Pedestrian collisions at intersection	School zone present	Insufficient school zone warning on #R1 road	
Use school crossing guards at intersection	AWSC	Pedestrian collisions at intersection	School zone present	High traffic volume on #R1 road	
Widen outside through lanes or add bike lanes on #R1 road	AWSC	Bicycle collisions on #R1 road	Inadequate bicycles space on #R1 road		
Enforce STOP sign compliance on #A1 approach	AWSC	Frequent stop sign violations on #A1 approach			
Post adequate speed limit on #R1 road	AWSC	Excessive speed on #R1 road	No posted speed limit on #A1 approach		
Post adequate speed limit on #R1 road	AWSC	Excessive speed on #R1 road	Posted speed limit on #R1 road	Frequently speed violations on #R1 road	
Post dynamic message sign to display speed of vehicles on #A1 approach	AWSC	Excessive speed on #R1 road	Posted speed limit on #R1 road	Frequently speed violations on #R1 road	
Provide targeted speed enforcement on #A1 approach	AWSC	Posted speed limit on #R1 road	Frequently speed violations on #R1 road		

Consider traffic calming on #R1 road	AWSC	Posted speed limit on #R1 road	Frequently speed violations on #R1 road		
Improve visibility of intersection by providing enhanced signing and delineation	AWSC	Intersection inconspicuous	Intersection difficult to comprehend for drivers on #A1 approach		
Install street lighting	AWSC	Intersection inconspicuous	Intersection difficult to comprehend for drivers on #A1 approach		
Install advance warning signs on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	No advance warning sign on #A1 approach		
Install flashing beacons on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Intersection difficult to comprehend for drivers on #A1 approach		
Install larger regulatory signs	AWSC	Intersection inconspicuous	Regulatory sign posted at intersection	Regulatory sign poorly visible/recognizable at intersection	Visual distractions at intersection
Install larger regulatory signs on both sides of road on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Regulatory sign posted at intersection	Regulatory sign poorly visible/recognizable at intersection	
Install larger regulatory signs on both sides of road on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Regulatory sign posted at intersection	Visual distractions at intersection	
Install larger warning signs on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	
Install larger warning signs on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Visual distractions on #A1 approach	
Install overhead flashing beacon lights on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	
Install street name signs at intersection	AWSC	Intersection inconspicuous	No street name signs present at intersection		

Install warning signs on both sides of road on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	Visual distractions on #A1 approach
Provide warning pavement marking on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	Visual distractions on #A1 approach
Relocate sign on #A1 approach to make it visible	AWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	Warning sign obstructed on #A1 approach
Remove object obstructing sight of warning sign on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	Warning sign obstructed on #A1 approach
Replace/repair/Clean warning signs on #A1 approach	AWSC	Intersection inconspicuous from #A1 approach	Advance warning sign posted on #A1 approach	Warning sign poorly visible/recognizable on #A1 approach	
Improve horizontal/vertical alignment on #A2 approach	Poor horizontal/vertical alignment on #A2 approach				
Change horizontal/vertical alignment on #R1 road	Poor horizontal/vertical alignment on #R1 road				
Improve horizontal/vertical alignment on #R1 road	Inadequate road alignment on #R1 road				
Increase clear zone on #R1 road	Narrow clear zone on #R1 road				
Correct lane width on #A1 approach	Inadequate lane width on #A1 approach				
Improve pavement marking on #A1 approach	Poor pavement marking on #A1 approach				
Increase skid resistance on #R1 road	Poor skid resistance on #R1 road				
Increase width of shoulders on #A1 approach	Inadequate shoulders width on #A1 approach				
Provide adequate drainage on #R1 road	Poor drainage on #R1 road				
Provide adequate lane signing or marking on #A1 approach	Inadequate lanes signing or marking on #A1 approach				

Provide/Improve pavement surface (improve transitions/drop offs/fixed potholes/rutting/etc) on #R1 road	Pavement defects on #R1 road			
Widen lanes on #A1 approach to adequate width	Inadequate lane width on #A1 approach			
Convert intersection into roundabout	Inadequate design for high traffic volume			

Rail Road Crossing

Improve existing street lights at the rail-road crossing points	RRC	Night time collisions at railroad crossing	Inadequate street lights at rail road crossing		
Improve/install reflective signs on #R1 road	RRC	Night time collisions at railroad crossing	Poor signs visibility on #R1 road		
Improve/install reflectorized pavement markers on #R1 approach	RRC	Night time collisions at railroad crossing	Inadequate street lights at rail road crossing		
Install pavement marking	RRC	Night time collisions at railroad crossing	Inadequate channelization of rail road crossing		
Install street lights at RRC	RRC	Night time collisions at railroad crossing	Inadequate street lights at rail road crossing		
Remove distracting commercial lighting or other source of glare at intersection	RRC	Night time collisions at railroad crossing	Inadequate street lights at rail road crossing		
Upgrade signing on #R1 road	RRC	Night time collisions at railroad crossing	Poor signs visibility on #R1 road		
Apply chip seal or slurry seal on #A1 approach	RRC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach		
Groove pavement surface on #A1 approach	RRC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach		
Improve winter maintenance	RRC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance		
Install fog-warning signs	RRC	Adverse-weather collisions	Insufficient fog warning		
Install static or variable message signs displaying weather information on #A1	RRC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance		

approach					
Install snow screens in areas exposed to snowdrifts on #R1 road	RRC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance		
Overlay pavement on #A1 approach	RRC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach		
Post adequate speed limit on #R1 road	RRC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach		
Provide "Slippery when wet" signs on #A1 approach	RRC	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach		
Use deicing/antiicing methods to #R1 road surface	RRC	Adverse-weather collisions	Inadequate snow/slush/ice maintenance		
Post adequate speed limit on #R1 road	RRC	Excessive speed on #R1 road	No posted speed limit on #A1 approach		
Provide targeted speed enforcement on #A1 approach	RRC	Excessive speed on #R1 road	Posted speed limit on #R1 road	Speed violations on #R1 road	
Post dynamic message sign to display speed of vehicles on #A1 approach	RRC	Excessive speed on #R1 road	Posted speed limit on #R1 road	Speed violations on #R1 road	
Post adequate speed limit on #R1 road	RRC	Excessive speed on #R1 road	Posted speed limit on #R1 road	Speed violations on #R1 road	
Eliminate screening of RRC by physical objects	RRC	Bicycle collisions at RRC	Inadequate visibility on approaching train		
Improve pavement marking and texturing	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Improve signage and/or marking of crosswalk(s)	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Install bicycles overpass or underpass	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Install fence or chicane to prevent bicycles riding across track	RRC	Bicycle collisions at RRC	Bicycles running across the track		
Install active control devices	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Install audible signals (warning bell)	RRC	Bicycle collisions at RRC	Inadequate warning about approaching train		
Install automated bicycles gates	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		

Install bicycle signals	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Install fixed warning message signs	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Install flashing beacons on #A1 approach	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Install four-quadrant gate arms	RRC	Bicycle collisions at RRC	Automatic gates	Bicycles crossing between already lowered gate arms	
Install gates with self deploying extension sections	RRC	Bicycle collisions at RRC	Automatic gates	Bicycles crossing between already lowered gate arms	
Install street lighting	RRC	Bicycle collisions at RRC	Inadequate warning about approaching train		
Install median barriers	RRC	Bicycle collisions at RRC	Automatic gates	Bicycles crossing between already lowered gate arms	
Install non-mountable curb islands	RRC	Bicycle collisions at RRC	Automatic gates	Bicycles crossing between already lowered gate arms	
Install swing gates	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Install variable message signs and blank out signs	RRC	Bicycle collisions at RRC	Inadequate bicycles access design		
Install vehicle-arresting barriers	RRC	Bicycle collisions at RRC	Automatic gates	Bicycles crossing between already lowered gate arms	
Eliminate screening of RRC by physical objects	RRC	Pedestrian collisions at RRC	Inadequate visibility on approaching train		
Improve pavement marking and texturing	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Improve signage and/or marking of crosswalk(s)	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install fence or chicane to prevent pedestrians running across track	RRC	Pedestrian collisions at RRC	Pedestrians running across the track		
Install pedestrian overpass or underpass	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install active control devices	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install audible signals (warning bell)	RRC	Pedestrian collisions at RRC	Inadequate warning about approaching train		

Install automated pedestrian gates	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install fixed warning message signs	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install flashing beacons on #A1 approach	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install street lighting	RRC	Pedestrian collisions at RRC	Inadequate warning about approaching train		
Install pedestrian barriers	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install pedestrian barriers	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install swing gates	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install variable message signs and blank out signs	RRC	Pedestrian collisions at RRC	Inadequate design of existing crosswalk		
Install overhead STOP sign(s) on #A1 approach	RRC	Control device is visible on #A1 approach	No automatic gates	Stop sign obstruction on #A1 approach	
Install overhead STOP sign(s) on #A1 approach	RRC	Control device is NOT visible on #A1 approach	Control device obstruction		
Improve horizontal/vertical alignment on #A1 approach	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Poor horizontal/vertical alignment on #A1 approach	
Improve horizontal/vertical alignment on #A1 approach	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Poor horizontal/vertical alignment on #A1 approach	
Improve horizontal/vertical alignment on #A1 approach	RRC	Control device is NOT visible on #A1 approach	Poor horizontal/vertical alignment on #A1 approach		
Close at-grade rail-road crossing or install overpass	RRC	Control device is visible on #A1	No automatic gates	Inadequate design for high traffic	

		approach		volume	
Close at-grade rail-road crossing or install overpass	RRC	Control device is visible on #A1 approach	Automatic gates	Inadequate design for high traffic volume	
Restrict parking close to RRC	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Automatic gates	Roadside sight obstruction at RRC
Restrict parking close to RRC	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at RRC
Improve gates visibility/reflectivity (flashing lights along the gate)	RRC	Control device is visible on #A1 approach	Automatic gates	Inadequate gates visibility	
Install advanced warning devices on rail track sensitive to train motion	RRC	Control device is visible on #A1 approach	Inadequate rail infrastructure		
Improve maintenance of train detective devices	RRC	Control device is visible on #A1 approach	Automatic gates	Automatic gates do not work properly	
Improve maintenance of visual/audio signals	RRC	Control device is visible on #A1 approach	Visual/audio warning signal does NOT work correctly		
Improve maintenance/work of existing gates	RRC	Control device is visible on #A1 approach	Automatic gates	Automatic gates do not work properly	
Improve/install reflective signs on #R1 road	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate control device	
Install advance warning signs on #A1 approach	RRC	Control device is NOT visible on #A1 approach	Poor horizontal/vertical alignment on #A1 approach		
Install audible signals (warning bell)	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate control device	
Install automatic gates	RRC	Control device is visible on #A1	No automatic gates	Inadequate control device	

		approach			
Install automatic gates	RRC	Control device is visible on #A1 approach	No automatic gates	Frequent stop sign violations on #A1 approach	
Install cantilever flashing-light signal	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate control device	
Install cantilever flashing-light signal	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate signing for multi-lane approach	
Install corner mirrors (local road/low speed)	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at RRC
Install crossbuck	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate control device	
Install DO NOT STOP ON TRACKS signal	RRC	Control device is visible on #A1 approach	Limited storage space between highway intersection and railway crossing		
Install flashing beacons on #A1 approach	RRC	Control device is visible on #A1 approach	Inadequate advance warning of RRC		
Install flashing beacons on #A1 approach	RRC	Control device is visible on #A1 approach	Automatic gates	Inadequate gates visibility	
Install flashing beacons on #A1 approach	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate control device	
Install flashing light activated by vehicles stopped between railway crossing and intersection	RRC	Control device is visible on #A1 approach	Limited storage space between highway intersection and railway crossing		
Install four-quadrant gate arms	RRC	Control device is visible on #A1 approach	Automatic gates	Drivers crossing between already lowered gate arms	
Install automatic gates	RRC	Control device is visible on #A1	No automatic gates	Inadequate design for high traffic	

		approach		volume	
Install gates with self deploying extension sections	RRC	Control device is visible on #A1 approach	Automatic gates	Drivers crossing between already lowered gate arms	
Install median barriers	RRC	Control device is visible on #A1 approach	Automatic gates	Drivers crossing between already lowered gate arms	
Install median retroreflective post delineators on the approach	RRC	Control device is visible on #A1 approach	Automatic gates	Drivers crossing between already lowered gate arms	
Install non-mountable curb islands	RRC	Control device is visible on #A1 approach	Automatic gates	Drivers crossing between already lowered gate arms	
Install overhead signs	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate signing for multi-lane approach	
Install pre-signals	RRC	Control device is visible on #A1 approach	Limited storage space between highway intersection and railway crossing		
Install rumble strips on #A1 approach	RRC	Control device is visible on #A1 approach	Inadequate advance warning of RRC		
Install warning signs on both sides of road on #A1 approach	RRC	Control device is visible on #A1 approach	Inadequate advance warning of RRC		
Install speed humps	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Automatic gates	Roadside sight obstruction at RRC
Install speed humps	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at RRC
Install stop sign on #A1 approach	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at RRC
Install stop sign on #A1 approach	RRC	Control device is visible on #A1	No automatic gates	Inadequate control device	

		approach			
Install symbol storage space sign	RRC	Control device is visible on #A1 approach	Limited storage space between highway intersection and railway crossing		
Install vehicle-arresting barriers	RRC	Control device is visible on #A1 approach	Automatic gates	Drivers crossing between already lowered gate arms	
Install warning signs in advance of rail-road crossing	RRC	Control device is visible on #A1 approach	Inadequate advance warning of RRC		
Install yield sign	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate control device	
Post adequate speed limit on #R1 road	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Roadside sight obstruction at RRC	
Provide adequate gates delay	RRC	Control device is visible on #A1 approach	Automatic gates	Automatic gates do not work properly	
Provide adequate information to train operator (for example: location of the whistle post)	RRC	Control device is visible on #A1 approach	Inadequate rail infrastructure		
Provide information of crossing type	RRC	Control device is visible on #A1 approach	Inadequate advance warning of RRC		
Improve pavement marking on #A1 approach	RRC	Control device is visible on #A1 approach	Inadequate advance warning of RRC		
Provide photo/video enforcement	RRC	Control device is visible on #A1 approach	Automatic gates	Drivers crossing between already lowered gate arms	
Reduce speed limit on #A1 approach	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Automatic gates	Roadside sight obstruction at RRC
Reduce speed limit on #A1 approach	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at

		approach			RRC
Relocate control device away from the road	RRC	Control device is NOT visible on #A1 approach	Control device obstruction		
Relocate stop bar on #A1 approach	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at RRC
Relocate stop sign on #A1 approach	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at RRC
Relocate stop sign on #A1 approach	RRC	Control device is visible on #A1 approach	No automatic gates	Stop sign obstruction on #A1 approach	
Relocate crossing section	RRC	Control device is visible on #A1 approach	No automatic gates	Inadequate design for high traffic volume	
Remove object obstructing sight of control device	RRC	Control device is NOT visible on #A1 approach	Control device obstruction		
Remove object obstructing sight of stop sign on #A1 approach	RRC	Control device is visible on #A1 approach	No automatic gates	Stop sign obstruction on #A1 approach	
Remove object obstructing sight triangle at RRC	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Automatic gates	Roadside sight obstruction at RRC
Remove object obstructing sight triangle at RRC	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at RRC
Replace/repair signals	RRC	Control device is visible on #A1 approach	Visual/audio warning signal does NOT work correctly		
Replace, repair or clean control device	RRC	Control device is NOT visible on #A1 approach	Control device improperly maintained		
Replace/repair signals	RRC	Control device is visible on #A1	No automatic gates	Stop sign on #A1 approach improperly maintained	

		approach			
Trim vegetation at RRC	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Roadside sight obstruction at RRC	
Trim vegetation at RRC	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	Automatic gates	Roadside sight obstruction at RRC
Trim vegetation at RRC	RRC	Control device is visible on #A1 approach	Insufficient sight distance to the crossing	No automatic gates	Roadside sight obstruction at RRC
Provide photo/video enforcement	RRC	Control device is visible on #A1 approach	No automatic gates	Frequent stop sign violations on #A1 approach	
Increase skid resistance on #R1 road	Poor skid resistance on #R1 road				
Provide adequate drainage on #R1 road	Poor drainage on #R1 road				
Provide/Improve pavement surface (improve transitions/drop offs/fixed potholes/rutting/etc) on #R1 road	Pavement defects on #R1 road				
Improve channelization/delineation on #A1 approach	Inadequate channelization of rail road crossing				
Improve horizontal/vertical alignment on #A1 approach	Poor horizontal/vertical alignment on #A1 approach				
Improve horizontal/vertical alignment on #R1 road	Inadequate road alignment on #R1 road				
Improve pavement marking on #A1 approach	Poor pavement marking on #A1 approach				
Provide adequate drainage on #R1 road	Poor drainage on #R1 road				

Signalized Intersection

Improve visibility of intersection by providing enhanced signing and delineation	SIGN	Inadequate lanes signing or marking on #A1 approach			
Install advance guide signs on #A1 approach	SIGN	Inadequate lanes signing or marking on #A1 approach			
Install street name signs at intersection	SIGN	Inadequate lanes signing or marking on #A1 approach			
Install advance warning signs on #A1 approach	SIGN	Inadequate lanes signing or marking on #A1 approach			
Improve pavement marking on #A1 approach	SIGN	Inadequate lanes signing or marking on #A1 approach			
Install overhead signs	SIGN	Inadequate lanes signing or marking on #A1 approach			
Install post-mounted delineators	SIGN	Inadequate lanes signing or marking on #A1 approach			
Install flashing beacons on #A1 approach	SIGN	Inadequate lanes signing or marking on #A1 approach			
Install larger regulatory signs on both sides of road on #A1 approach	SIGN	Inadequate lanes signing or marking on #A1 approach			
Improve/install reflective signs on #R1 road	SIGN	Inadequate lanes signing or marking on #A1 approach			
Remove object obstructing sight triangle at intersection	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach			
Trim vegetation at intersection	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach			

Post adequate speed limit on #R1 road	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach		
Restrict parking close to intersection	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach		
Improve street lighting	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach		
Install rumble strips on #A1 approach	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach		
Install queue detection system	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach		
Improve horizontal/vertical alignment on #A1 approach	SIGN	Poor horizontal/vertical alignment on #A1 approach		
Improve intersection skew angle	SIGN	Poor horizontal/vertical alignment on #A1 approach		
Add special signing	SIGN	Fixed object close to traveled way on #A1 approach	Trees close to traveled way	
Add special signing	SIGN	Fixed object close to traveled way on #A1 approach	Utility poles close to traveled way	
Install barrier curb or guardrail on #A1 approach	SIGN	Fixed object close to traveled way on #A1 approach	Trees close to traveled way	
Install barrier curb or guardrail on #A1 approach	SIGN	Fixed object close to traveled way on #A1 approach	Utility poles close to traveled way	
Install tree marker	SIGN	Fixed object close to traveled way on #A1 approach	Trees close to traveled way	
Install utility poles marker	SIGN	Fixed object close to traveled way on #A1 approach	Utility poles close to traveled way	

		approach			
Increase clear zone on #R1 road	SIGN	Fixed object close to traveled way on #A1 approach	Trees close to traveled way		
Place utilities underground	SIGN	Fixed object close to traveled way on #A1 approach	Utility poles close to traveled way		
Provide breakaway and crashworthy sign supports	SIGN	Fixed object close to traveled way on #A1 approach	Sign supports close to traveled way		
Relocate signal hardware out of clear zone	SIGN	Fixed object close to traveled way on #A1 approach	Signal hardware close to traveled way		
Remove or relocate sign	SIGN	Fixed object close to traveled way on #A1 approach	Sign supports close to traveled way		
Remove or relocate trees along #R1 road	SIGN	Fixed object close to traveled way on #A1 approach	Trees close to traveled way		
Remove or relocate utility pole along #R1 road	SIGN	Fixed object close to traveled way on #A1 approach	Utility poles close to traveled way		
Shield drivers from poles in hazardous locations	SIGN	Fixed object close to traveled way on #A1 approach	Utility poles close to traveled way		
Use breakaway devices on #A1 approach	SIGN	Fixed object close to traveled way on #A1 approach	Utility poles close to traveled way		
Widen lanes on #A1 approach to adequate width	SIGN	Inadequate lane width on #A1 approach			
Increase skid resistance on #R1 road	SIGN	Poor skid resistance on #R1 road			
Groove pavement surface on #A1 approach	SIGN	Poor skid resistance on #A1 approach			
Provide/Improve pavement surface (improve transitions/drop offs/fixed	SIGN	Pavement defects on #R1 road			

potholes/rutting/etc) on #R1 road					
Remove object obstructing sight triangle at intersection	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach			
Redesign left-turning path(s) from #R1 road	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach			
Redesign intersection approaches	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach			
Reduce speed limit on #A1 approach	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach			
Restrict parking close to intersection	SIGN	Inadequate sight distance toward vehicles approaching intersection on #A1 approach			
Adjust minimum green or extension time	SIGN	Inadequate traffic signal timing or type of signal			
Adjust yellow change interval	SIGN	Inadequate traffic signal timing or type of signal			
Improve signal phases (increase lengths, add new phases)	SIGN	Inadequate traffic signal timing or type of signal			
Install multi-dial controller	SIGN	Inadequate traffic signal timing or type of signal			
Install traffic actuated signal	SIGN	Inadequate traffic signal timing or type of signal			
Increase clearance intervals	SIGN	Inadequate traffic signal timing or type of signal			
Provide all-red clearance interval	SIGN	Inadequate traffic signal timing or type of signal			
Improve (add) signal coordination	SIGN	Inadequate traffic signal timing or type of signal			
Remove late night/early morning	SIGN	Inadequate traffic			

flashing operation		signal timing or type of signal			
Improve (add) signal coordination	SIGN	Inadequate traffic signal timing or type of signal			
Install additional signal head on #A1 approach	SIGN	Inadequate visibility of traffic signals			
Install backplates	SIGN	Inadequate visibility of traffic signals			
Install larger signal lenses	SIGN	Inadequate visibility of traffic signals			
Provide far-side left-turn signal on #A1 approach	SIGN	Inadequate visibility of traffic signals			
Provide louvers visors or special lenses on #A1 approach	SIGN	Inadequate visibility of traffic signals			
Reduce speed limit on #A1 approach	SIGN	Inadequate visibility of traffic signals			
Relocate traffic signals structure elements	SIGN	Inadequate visibility of traffic signals			
Removed or relocate unnecessary signs "visual clutter"	SIGN	Inadequate visibility of traffic signals			
Use two red signal sections	SIGN	Inadequate visibility of traffic signals			
Provide visors to shade signal lenses from sunlight	SIGN	Inadequate visibility of traffic signals			
Provide adequate drainage on #R1 road	SIGN	Poor drainage on #R1 road			
Remove unwarranted signal	SIGN	Unwarranted traffic control			
Improve horizontal/vertical alignment on #A1 approach	SIGN	Angle collisions	Left-turn collisions on #R1 road	Poor visibility of opposite vehicles	Poor horizontal/vertical alignment on #A1 approach
Consider indirect left-turns on #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	High turning volume on #R1 road	

Consider indirect left-turns on #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Poor visibility of opposite vehicles	Opposite left turn vehicles on #R1 road obstruct each other sight distance
Increase length of left-turn bay on #A1 approach	SIGN	Angle collisions	Left-turn collisions on #R1 road	Inadequate left turn channelization	
Increase length of right-turn bay on #A1 approach	SIGN	Angle collisions	Right-turn collisions	Inadequate right turn channelization	
Install advance warning signs on #A1 approach	SIGN	Angle collisions	Right-turn collisions	Inadequate sight distance toward vehicles approaching intersection on #A1 approach	
Install left-turn lane on #A1 approach	SIGN	Angle collisions	Left-turn collisions on #R1 road	Inadequate left turn channelization	
Install right-turn lane on #A1 approach	SIGN	Angle collisions	Right-turn collisions	Inadequate right turn channelization	
Install right-turn lane on #A1 approach	SIGN	Angle collisions	Right-turn collisions	High turning volume on #R1 road	
Provide offset for left turn lanes on #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Inadequate left turn channelization	
Provide offset for left turn lanes on #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Poor visibility of opposite vehicles	Opposite left turn vehicles on #R1 road obstruct each other sight distance
Provide protected left-turn phase for #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Single left-turn lane	Inadequate phase design
Provide protected left-turn phase for #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Two or more left-turn lanes	
Provide protected left-turn phase for #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Two or more left-turn lanes	Inadequate phase design
Provide protected/permitted phase for #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Single left-turn lane	Inadequate phase design
Provide split phases for #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Intersection area too small to allow simultaneous left turns	

Provide split phases for #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Intersection with unbalanced left-turn volumes on opposite approaches	
Provide split phases for #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Poor visibility of opposite vehicles	Opposite left turn vehicles on #R1 road obstruct each other sight distance
Redesign left-turning path(s) from #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Inadequate left turn channelization	
Redesign right-turning path(s) from #R1 road	SIGN	Angle collisions	Right-turn collisions	Inadequate right turn channelization	
Reduce speed limit on #A1 approach	SIGN	Angle collisions	Right-turn collisions	Inadequate sight distance toward vehicles approaching intersection on #A1 approach	
Remove or relocate median object obstructing sight on #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Poor visibility of opposite vehicles	Object located in median obstructs sight distance on #R1 road
Remove sight obstruction on #A1 approach	SIGN	Angle collisions	Right-turn collisions	Inadequate sight distance toward vehicles approaching intersection on #A1 approach	
Restrict left-turn maneuver on #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	High turning volume on #R1 road	
Restrict left-turn maneuver on #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	Poor visibility of opposite vehicles	Opposite left turn vehicles on #R1 road obstruct each other sight distance
Restrict or eliminate turning maneuver on #R1 road	SIGN	Angle collisions	Right-turn collisions	High turning volume on #R1 road	
Restrict or eliminate turning maneuver on #R1 road	SIGN	Angle collisions	Left-turn collisions on #R1 road	High turning volume on #R1 road	
Restrict parking close to intersection	SIGN	Angle collisions	Right-turn collisions	Parking cars close to intersection	
Restrict parking close to intersection	SIGN	Angle collisions	Right-turn collisions	Inadequate sight distance toward vehicles approaching intersection on #A1 approach	

Improve (add) signal coordination	SIGN	Rear-end collisions on #A1 approach	Inadequate signal coordination		
Provide adequate turning markers or pavement markings for turning vehicle on #R1 road	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Redesign left-turning path(s) from #R1 road	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Install left-turn lane on #A1 approach	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Increase length of left-turn bay on #A1 approach	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Increase length of left-turn bay on #A1 approach	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Provide offset for left turn lanes on #R1 road	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Improve visibility of the splitter-island	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Increase length of right-turn bay on #A1 approach	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Increase length of right-turn bay on #A1 approach	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Provide adequate delineation for right-turns at intersection (markers or lines)	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Install right-turn lane on #A1 approach	SIGN	Rear-end collisions on #A1 approach	Inadequate left turn channelization		
Adjust minimum green or extension time	SIGN	Rear-end collisions on #A1 approach	Inadequate traffic signal timing or type of signal		
Adjust phase time and cycle time	SIGN	Rear-end collisions on #A1 approach	Inadequate traffic signal timing or type of signal		
Adjust yellow change interval	SIGN	Rear-end collisions on #A1 approach	Inadequate traffic signal timing or type of signal		
Install multi-dial controller	SIGN	Rear-end collisions on #A1 approach	Inadequate traffic signal timing or		

			type of signal		
Provide all-red clearance interval	SIGN	Rear-end collisions on #A1 approach	Inadequate traffic signal timing or type of signal		
Improve (add) signal coordination	SIGN	Rear-end collisions on #A1 approach	Inadequate traffic signal timing or type of signal		
Remove late night/early morning flashing operation	SIGN	Rear-end collisions on #A1 approach	Inadequate traffic signal timing or type of signal		
Increase crosswalk setback on #A1 approach	SIGN	Rear-end collisions on #A1 approach	Pedestrians may block #E2 exit		
Prohibit right turn on red	SIGN	Rear-end collisions on #A1 approach	Pedestrians may block #E2 exit		
Relocate transit stop	SIGN	Rear-end collisions on #A1 approach	Inadequate location of transit stop		
Improve channelization/delineation on #A1 approach	SIGN	Head-on collisions on #A1 approach	Inadequate channelization on #A1 approach		
Create one-way streets	SIGN	Head-on collisions on #A1 approach	Roadway design NOT adequate for traffic conditions		
Improve horizontal/vertical alignment on #R1 road	SIGN	Head-on collisions on #A1 approach	Poor horizontal/vertical alignment on #R1 road		
Install/improve center line marking	SIGN	Head-on collisions on #A1 approach	Inadequate center line marking		
Restrict parking close to intersection	SIGN	Head-on collisions on #A1 approach	Parking cars close to intersection		
Optimize clearance intervals	SIGN	Right-angle collisions between #A1 and #A2 vehicles	Red-light running	Inadequate clearance interval	
Implement automated enforcement of red-light running (cameras)	SIGN	Right-angle collisions between #A1 and #A2	Red-light running		

		vehicles			
Provide targeted red-light running enforcement	SIGN	Right-angle collisions between #A1 and #A2 vehicles	Red-light running		
Improve visibility of traffic signals	SIGN	Right-angle collisions between #A1 and #A2 vehicles	Red-light running	Inadequate visibility of traffic signals	
Remove late night/early morning flashing operation	SIGN	Right-angle collisions between #A1 and #A2 vehicles	Night time collisions at intersection		
Post adequate speed limit on #R1 road	SIGN	Excessive speed on #R1 road	No posted speed limit on #R1 road		
Provide targeted speed enforcement on #A1 approach	SIGN	Excessive speed on #R1 road	Posted speed limit on #R1 road	Speed violations on #R1 road	
Post dynamic message sign to display speed of vehicles on #A1 approach	SIGN	Excessive speed on #R1 road	Posted speed limit on #R1 road	Speed violations on #R1 road	
Post adequate speed limit on #R1 road	SIGN	Excessive speed on #R1 road	Posted speed limit on #R1 road	Speed violations on #R1 road	
Coordinate railroad and traffic signals to provide preemption	SIGN	Intersection near to railroad crossing	Vehicles queues form across the railroad tracks		
Eliminate objects that obstruct sight to pedestrians entering crosswalk	SIGN	Pedestrian collisions at intersection	Fixed object obstructs view from a crosswalk at intersection		
Install bicycle signals	SIGN	Bicycle collisions at intersection	Inadequate bicycles access design		
Install curb-ramps	SIGN	Pedestrian collisions at intersection	Inadequate design for handicapped at intersection		

Install flashing beacons on #A1 approach	SIGN	Pedestrian collisions at intersection	School zone present	Insufficient school zone warning on #R1 road	
Install pedestrian actuated signals	SIGN	Pedestrian collisions at intersection	Significant number of pedestrian crossing intersection		
Install pedestrian overpass or underpass	SIGN	Pedestrian collisions at intersection	Inadequate protection for pedestrians at intersection		
Install physical barriers to restrict pedestrian crossing maneuvers at higher-risk locations	SIGN	Pedestrian collisions at intersection	Inadequate protection for pedestrians at intersection		
Install raised crosswalks	SIGN	Pedestrian collisions at intersection	Inadequate visibility of crosswalk(s) at intersection		
Install school crossing sign on #R1 road	SIGN	Pedestrian collisions at intersection	School zone present	Insufficient school zone warning on #R1 road	
Increase sidewalk setback on #R1 road	SIGN	Pedestrian collisions at intersection	Inadequate protection of pedestrians on #R1 road		
Install sidewalks	SIGN	Pedestrian collisions at intersection	No sidewalk present		
Install street lighting	SIGN	Pedestrian collisions at intersection	Inadequate lighting of crosswalk at intersection		
Install street lighting	SIGN	Pedestrian collisions at intersection	School zone present	Inadequate lighting of crosswalk at intersection	
Install/improve signing or marking of bicycles at intersection	SIGN	Bicycle collisions at intersection	Inadequate design for high turning traffic on #A1 approach		
Install/improve signing or marking of pedestrian crosswalks at intersection	SIGN	Pedestrian collisions at intersection	Inadequate visibility of crosswalk(s) at intersection		
Optimize clearance intervals	SIGN	Pedestrian collisions at intersection	Inadequate clearance interval		
Prohibit right turn on red	SIGN	Pedestrian collisions at intersection	Significant number of pedestrian crossing intersection		
Provide adequate drainage on #R1 road	SIGN	Bicycle collisions at intersection	Inadequate gates visibility		
Provide adequate drainage on #R1 road	SIGN	Pedestrian collisions at intersection	Poor drainage on #R1 road		
Provide adequate signals for handicapped	SIGN	Pedestrian collisions at intersection	Inadequate design for handicapped at intersection		

Provide appropriate signal intervals for pedestrians crossing and minimize wait time	SIGN	Pedestrian collisions at intersection	Too short pedestrian walk signal		
Provide bicycle box	SIGN	Bicycle collisions at intersection	Inadequate bicycles access design		
Provide separate bicycle path on #R1 road	SIGN	Bicycle collisions at intersection	Inadequate bicycles access design		
Provide median refuges at intersection	SIGN	Bicycle collisions at intersection	Multiple lanes on #R1 road make difficult for bicycles to cross #R1 road		
Provide median refuges at intersection	SIGN	Pedestrian collisions at intersection	Multiple lanes on #R1 road make difficult for pedestrian to cross #R1 road		
Provide pedestrian-only phase or pedestrian-lead phase	SIGN	Pedestrian collisions at intersection	Inadequate phase design		
Provide smooth paved shoulders on #A1 approach	SIGN	Bicycle collisions at intersection	Inadequate bicycles access design		
Relocate transit stop	SIGN	Pedestrian collisions at intersection	Inadequate location of transit stop		
Replace poorly designed drain grates on #R1 road with bicycle-safe types	SIGN	Bicycle collisions at intersection	Inadequate bicycles access design		
Restrict parking close to intersection	SIGN	Bicycle collisions at intersection	Inadequate bicycles access design		
Use school crossing guards at intersection	SIGN	Pedestrian collisions at intersection	School zone present	Insufficient school zone warning on #R1 road	
Widen outside through lanes or add bike lanes on #R1 road	SIGN	Bicycle collisions at intersection	Inadequate bicycles access design		
Apply chip seal or slurry seal on #A1 approach	SIGN	Adverse-weather collisions	Slippery pavement (no winter) on #A1		

			approach		
Apply ship seal or slurry seal on #E1 exit	SIGN	Adverse-weather collisions	Slippery pavement (no winter) on #E1 exit		
Groove pavement surface on #A1 approach	SIGN	Adverse-weather collisions	Slippery pavement (winter) on #R1 road		
Improve timeliness of winter maintenance	SIGN	Adverse-weather collisions	Inadequate snow/slush/ice maintenance		
Improve winter maintenance	SIGN	Adverse-weather collisions	Inadequate snow/slush/ice maintenance		
Install fog-warning signs	SIGN	Adverse-weather collisions	Insufficient fog warning		
Install static or variable message signs displaying weather information on #A1 approach	SIGN	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #A1 approach		
Install snow screens in areas exposed to snowdrifts on #R1 road	SIGN	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Overlay pavement on #A1 approach	SIGN	Adverse-weather collisions	Slippery pavement (no winter) on #A1 approach		
Overlay pavement on #E1 exit	SIGN	Adverse-weather collisions	Slippery pavement (no winter) on #E1 exit		
Provide "Slippery when wet" signs on #A1 approach	SIGN	Adverse-weather collisions	Slippery pavement (winter) on #A1 approach		
Reduce speed limit on #A1 approach	SIGN	Adverse-weather collisions	Slippery pavement (winter) on #A1 approach		
Use adequate methods to increase pavement friction on #R1 road	SIGN	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Use deicing/antiicing methods to #R1 road surface	SIGN	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		

Provide adequate delineation and channelization at intersection for left/right-turning trucks	SIGN	Collisions involving large vehicles	Inadequate left turn channelization/delineation for turning trucks		
Increase clearance intervals	SIGN	Collisions involving large vehicles	Inadequate clearance interval		
Provide additional pavement to accommodate turning trucks	SIGN	Collisions involving large vehicles	Pavement width inadequate for turning trucks		
Improve intersection skew angle	SIGN	Collisions involving large vehicles	Inadequate intersection skew angle		
Improve street lighting	SIGN	Night time collisions at intersection	Inadequate street lights at intersection		
Improve/install reflective signs on #R1 road	SIGN	Night time collisions at intersection	Poor signs reflectivity on #R1 road		
Improve/install reflectorized pavement markers on #R1 approach	SIGN	Night time collisions at intersection	Inadequate street lights on #R1 road		
Install street lights at intersection	SIGN	Night time collisions at intersection	Inadequate street lights at intersection		
Remove distracting commercial lighting or other source of glare at intersection	SIGN	Night time collisions at intersection	Inadequate street lights at intersection		
Upgrade signing on #R1 road	SIGN	Night time collisions at intersection	Poor signs visibility on #R1 road		
Employ emergency vehicle preemption	SIGN	Inadequate emergency vehicle preemption			
Convert a four-leg intersection into two T-intersections	SIGN	Very high crash frequency			

Convert two T-intersections into one four-leg intersection	SIGN	Very high crash frequency			
Remove deflection in through-vehicle travel path	SIGN	Very high crash frequency			
Close intersection leg or convert to one-way street	SIGN	Very high crash frequency			
Convert intersection into roundabout	SIGN	Very high crash frequency			
Convert two two-way streets into a pair of one-way streets	SIGN	Very high crash frequency			
Construct interchange	SIGN	Very high crash frequency			

Road Segment

Close or relocate driveway(s) on #R1 road	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	Driveway(s) design inadequate for high traffic on #R1 road
Channelize driveway(s) on #R1 road	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	Driveway(s) design inadequate for high traffic on #R1 road
Install curbing to define driveway(s) location on #R1 road	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	Driveway(s) design inadequate for high traffic on #R1 road
Install median divider on #R1 road to prevent left-turns from/to driveway(s)	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	Driveway(s) design inadequate for high traffic on #R1 road
Provide acceleration/deceleration lanes on #R1 road	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	Driveway(s) design inadequate for high traffic on #R1 road
Relocate driveway(s) from #R1 road	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	Driveway(s) design inadequate for high traffic on #R1 road
Remove sight obstruction on #R1 road	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	
Restrict left-turning at access point on #R1 road	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	Driveway(s) design inadequate for high traffic on #R1 road
Restrict parking near driveway(s) on #R1 road	RS	Driveway(s) collisions on #R1 road	Inadequate visibility of driveway(s) on #R1 road	
Improve street lighting	RS	Night time collisions on #R1 road	Inadequate street lights on #R1 road	
Improve/install reflective signs on #R1 road	RS	Night time collisions on #R1 road	Poor signs reflectivity on #R1 road	

Improve/install reflectorized pavement markers on #R1 approach	RS	Night time collisions on #R1 road	Inadequate street lights on #R1 road		
Install street lights on #R1 road	RS	Night time collisions on #R1 road	Inadequate street lights on #R1 road		
Remove distracting commercial lighting or other source of glare on #R1 road	RS	Night time collisions on #R1 road	Inadequate street lights on #R1 road		
Construct pedestrian refuge islands and/or raised medians	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Eliminate objects that obstruct sight distance on #R1 road	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Eliminate objects that obstruct sight distance on #R1 road	RS	Pedestrian collisions on #R1 road	Inadequate visibility of pedestrians		
Implement lighting and/or illumination measures on #R1 road	RS	Pedestrian collisions on #R1 road	Inadequate visibility of pedestrians		
Consider traffic calming on #R1 road	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Improve signage and/or marking of crosswalk(s)	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Install "Cross only at Crosswalk" signs	RS	Pedestrian collisions on #R1 road	Pedestrians walking along road		
Install pedestrian overpass or underpass	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Install curb-ramps	RS	Pedestrian collisions on	Crossing point	Inadequate design of existing crosswalk	

		#R1 road			
Install street lighting	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Install pedestrian overpass or underpass	RS	Pedestrian collisions on #R1 road	Pedestrians walking along road		
Install pedestrian actuated signals	RS	Pedestrian collisions on #R1 road	Crossing point	Long distance between crosswalks on #R1 road	
Install pedestrian barriers	RS	Pedestrian collisions on #R1 road	Pedestrians walking along road		
Install pedestrian crosswalks	RS	Pedestrian collisions on #R1 road	Crossing point	Long distance between crosswalks on #R1 road	
Install pedestrian crosswalks	RS	Pedestrian collisions on #R1 road	Long distance between crosswalks on #R1 road		
Install raised crosswalks	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Install school crossing sign on #R1 road	RS	Pedestrian collisions on #R1 road	Crossing point	School zone present	Insufficient school zone warning on #R1 road
Install school zone markings on #R1 road	RS	Pedestrian collisions on #R1 road	Crossing point	School zone present	Insufficient school zone warning on #R1 road
Increase sidewalk setback on #R1 road	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Install sidewalks	RS	Pedestrian collisions on #R1 road	Pedestrians walking along road		
Post adequate speed limit on #R1 road	RS	Pedestrian collisions on	Crossing point	School zone present	Insufficient school zone warning on

		#R1 road			#R1 road
Provide separate bicycle path on #R1 road	RS	Bicycle collisions on #R1 road	Inadequate bicycles access design		
Provide median refuges on #R1 road	RS	Bicycle collisions on #R1 road	Inadequate bicycles access design		
Provide smooth paved shoulders on #R1 road	RS	Bicycle collisions on #R1 road	Inadequate bicycles access design		
Replace poorly designed drain grates on #R1 road with bicycle-safe types	RS	Bicycle collisions on #R1 road	Inadequate bicycles access design		
Install signals to alert motorists that pedestrians are crossing at crossing point	RS	Pedestrian collisions on #R1 road	Crossing point	Inadequate design of existing crosswalk	
Use school crossing guards at crossing point	RS	Pedestrian collisions on #R1 road	Crossing point	School zone present	Insufficient school zone warning on #R1 road
Widen outside through lanes or add bike lanes on #R1 road	RS	Bicycle collisions on #R1 road	Inadequate bicycles access design		
Apply chip seal or slurry seal on #R1 road	RS	Adverse-weather collisions	Slippery pavement (winter) on #R1 road		
Groove pavement surface on #R1 road	RS	Adverse-weather collisions	Slippery pavement (winter) on #R1 road		
Improve winter maintenance	RS	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Improve timeliness of winter maintenance	RS	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Install fog-warning signs	RS	Adverse-	Insufficient fog		

		weather collisions	warning		
Install static or variable message signs displaying weather information on #R1 road	RS	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Install snow screens in areas exposed to snowdrifts on #R1 road	RS	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Overlay pavement on #R1 road	RS	Adverse-weather collisions	Slippery pavement (winter) on #R1 road		
Provide warning pavement marking on #A1 approach	RS	Adverse-weather collisions	Slippery pavement (winter) on #R1 road		
Reduce speed limit on #R1 road	RS	Adverse-weather collisions	Slippery pavement (winter) on #R1 road		
Use adequate methods to increase pavement friction on #R1 road	RS	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Use deicing/antiicing methods to #R1 road surface	RS	Adverse-weather collisions	Inadequate snow/slush/ice maintenance on #R1 road		
Post adequate speed limit on #R1 road	RS	Excessive speed on #R1 road	No posted speed limit on #R1 road		
Post adequate speed limit on #R1 road	RS	Excessive speed on #R1 road	Posted speed limit on #R1 road	Frequently speed violations on #R1 road	
Post dynamic message sign to display speed of vehicles on #R1 road	RS	Excessive speed on #R1 road	Posted speed limit on #R1 road	Frequently speed violations on #R1 road	
Provide targeted speed enforcement on #R1 road	RS	Posted speed limit on #R1	Frequently speed violations on #R1 road		

		road			
Add special signing	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Install barrier curb or guardrail on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Increase clear zone on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Add special signing	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Install barrier curb or guardrail on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Increase clear zone on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Provide breakaway and crashworthy mail boxes	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Mail boxes close to traveled way
Remove or relocate mail box on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Mail boxes close to traveled way
Provide breakaway and crashworthy mail boxes	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Mail boxes close to traveled way
Remove or relocate mail box on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Mail boxes close to traveled way
Provide breakaway and crashworthy sign supports	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Sign supports close to traveled way
Remove or relocate sign	RS	Off-road	Horizontal curve	Fixed object close to	Sign supports close

		collisions on #R1 road		traveled way on #R1 road	to traveled way
Provide breakaway and crashworthy sign supports	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Sign supports close to traveled way
Remove or relocate sign	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Sign supports close to traveled way
Add special signing	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Install barrier curb or guardrail on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Install tree marker	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Increase clear zone on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Remove or relocate trees along #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Add special signing	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Install barrier curb or guardrail on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Install tree marker	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Increase clear zone on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Remove or relocate trees along #R1 road	RS	Off-road	Vertical curve	Fixed object close to	Trees close to

		collisions on #R1 road		traveled way on #R1 road	traveled way
Add special signing	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Install barrier curb or guardrail on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Install utility polet marker	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Place utilities underground	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Remove or relocate utility pole along #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Use breakaway devices on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Add special signing	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Install barrier curb or guardrail on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Install utility polet marker	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Place utilities underground	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Remove or relocate utility pole along #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Use breakaway devices on #R1 road	RS	Off-road	Vertical curve	Fixed object close to	Utility poles close to

		collisions on #R1 road		traveled way on #R1 road	traveled way
Change horizontal/vertical alignment on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Inadequate design of vertical curve	
Eliminate compound curves	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate design of horizontal curve	
Improve or restore superelevation	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate design of horizontal curve	
Improve horizontal/vertical alignment on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate design of horizontal curve	
Provide spiral transition curves	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate design of horizontal curve	
Widen lanes on #R1 road to adequate width	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate lane width on #R1 road	
Install centerline rumble strips	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate lane width on #R1 road	
Install shoulder rumble strips on #A1 approach	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate lane width on #R1 road	
Widen lanes on #R1 road to adequate width	RS	Off-road collisions on #R1 road	Vertical curve	Inadequate lane width on #R1 road	
Install centerline rumble strips	RS	Off-road collisions on #R1 road	Vertical curve	Inadequate lane width on #R1 road	
Install shoulder rumble strips on #A1 approach	RS	Off-road collisions on #R1 road	Vertical curve	Inadequate lane width on #R1 road	
Cut or trim trees and other roadside	RS	Off-road	Horizontal curve	Inadequate sight distance on horizontal curve	

vegetation that obstruct sight distance		collisions on #R1 road		
Remove sight obstruction on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate sight distance on horizontal curve
Restrict parking	RS	Off-road collisions on #R1 road	Horizontal curve	Inadequate sight distance on horizontal curve
Add special signing	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Install barrier curb or guardrail on #R1 road	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Increase clear zone on #R1 road	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Insufficient bridge visibility
Improve pavement marking along the curve on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve
Install in-pavement luminaires	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve
Install LED barrier-mounted guidance tubes	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve
Install light-emitting diode (LED)	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve
Delineate guardrail located outside the roadway curve	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve
Provide pavement marking (stop sign/chevron/etc.) on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve
Install post-mounted delineators	RS	Off-road	Horizontal curve	Insufficient delineation along the curve

		collisions on #R1 road			
Improve pavement marking along the curve on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve	
Install advisor speed sign	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Install centerline rumble strips	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Install flashing beacons on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Install advance warning signs of horizontal/vertical curve on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Install street lighting	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Install shoulder rumble strips on #A1 approach	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Install advance warning signs on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Provide curve dynamic warning system on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Install rumble strips on #A1 approach	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Install advisor speed sign	RS	Off-road collisions on #R1 road	Vertical curve	Insufficient warning	
Install flashing beacons on #R1 road	RS	Off-road	Vertical curve	Insufficient warning	

		collisions on #R1 road			
Install street lighting	RS	Off-road collisions on #R1 road	Vertical curve	Insufficient warning	
Install advance warning signs on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Insufficient warning	
Install advance warning signs of horizontal/vertical curve on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Insufficient warning	
Install rumble strips on #A1 approach	RS	Off-road collisions on #R1 road	Vertical curve	Insufficient warning	
Provide advance warning of unexpected changes in horizontal alignment	RS	Off-road collisions on #R1 road	Horizontal curve	Insufficient warning	
Provide breakaway and crashworthy mail boxes	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Mail boxes close to traveled way	
Remove or relocate mail box on #R1 road	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Mail boxes close to traveled way	
Provide/Improve pavement surface (improve transitions/drop offs/fixed potholes/rutting/etc) on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Pavement defects on #R1 road	
Provide/Improve pavement surface (improve transitions/drop offs/fixed potholes/rutting/etc) on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Pavement defects on #R1 road	
Provide adequate drainage on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Poorly designed drain grates on #R1 road	
Provide adequate drainage on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Poorly designed drain grates on #R1 road	
Increase skid resistance on #R1 road	RS	Off-road	Horizontal curve	Poor skid resistance on #R1 road	

		collisions on #R1 road		
Groove pavement surface on #R1 road	RS	Off-road collisions on #R1 road	Horizontal curve	Poor skid resistance on #R1 road
Increase skid resistance on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Poor skid resistance on #R1 road
Groove pavement surface on #R1 road	RS	Off-road collisions on #R1 road	Vertical curve	Poor skid resistance on #R1 road
Provide breakaway and crashworthy sign supports	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Sign supports close to traveled way
Remove or relocate sign	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Sign supports close to traveled way
Add special signing	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Install barrier curb or guardrail on #R1 road	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Install tree marker	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Increase clear zone on #R1 road	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Remove or relocate trees along #R1 road	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Trees close to traveled way
Add special signing	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way
Install barrier curb or guardrail on #R1 road	RS	Off-road	Fixed object close to	Utility poles close to traveled way

		collisions on #R1 road	traveled way on #R1 road		
Install utility polet marker	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way	
Place utilities underground	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way	
Remove or relocate utility pole along #R1 road	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way	
Shield drivers from poles in hazardous locations	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way	
Use breakaway devices on #R1 road	RS	Off-road collisions on #R1 road	Fixed object close to traveled way on #R1 road	Utility poles close to traveled way	
Widen lanes on #R1 road to adequate width	RS	Off-road collisions on #R1 road	Inadequate lane width on #R1 road		
Install centerline rumble strips	RS	Off-road collisions on #R1 road	Inadequate lane width on #R1 road		
Install shoulder rumble strips on #A1 approach	RS	Off-road collisions on #R1 road	Inadequate lane width on #R1 road		
Install pavement marking	RS	Off-road collisions on #R1 road	Inadequate pavement marking on #R1 road		
Improve pavement marking and texturing	RS	Off-road collisions on #R1 road	Inadequate pavement marking on #R1 road		
Provide safer slopes and ditches to prevent rollovers	RS	Off-road collisions on #R1 road	Inadequate road alignment on #R1 road		
Enhance delineation of sharp curves	RS	Off-road	Inadequate road		

		collisions on #R1 road	alignment on #R1 road		
Improve horizontal/vertical alignment on #R1 road	RS	Off-road collisions on #R1 road	Inadequate road alignment on #R1 road		
Eliminate shoulder drop-off on #R1 road	RS	Off-road collisions on #R1 road	Inadequate shoulders width on #R1 road		
Increase width of shoulders on #R1 road	RS	Off-road collisions on #R1 road	Inadequate shoulders width on #R1 road		
Provide smooth paved shoulders on #R1 road	RS	Off-road collisions on #R1 road	Inadequate shoulders width on #R1 road		
Increase width of shoulders on #R1 road	RS	Off-road collisions on #R1 road	Inadequate shoulders width on #R1 road		
Install advisor speed sign	RS	Off-road collisions on #R1 road	Insufficient warning		
Install flashing beacons on #R1 road	RS	Off-road collisions on #R1 road	Insufficient warning		
Install advance warning signs on #R1 road	RS	Off-road collisions on #R1 road	Insufficient warning		
Install advance warning signs of horizontal/vertical curve on #R1 road	RS	Off-road collisions on #R1 road	Insufficient warning		
Install rumble strips on #A1 approach	RS	Off-road collisions on #R1 road	Insufficient warning		
Increase clear zone on #R1 road	RS	Off-road collisions on #R1 road	Narrow clear zone on #R1 road		
Provide/Improve pavement surface (improve	RS	Off-road	Pavement defects on		

transitions/drop offs/fixed potholes/rutting/etc) on #R1 road		collisions on #R1 road	#R1 road		
Provide adequate drainage on #R1 road	RS	Off-road collisions on #R1 road	Poor drainage on #R1 road		
Increase skid resistance on #R1 road	RS	Off-road collisions on #R1 road	Poor skid resistance on #R1 road		
Groove pavement surface on #R1 road	RS	Off-road collisions on #R1 road	Poor skid resistance on #R1 road		
Create additional parking spaces	RS	Off-road collisions on #R1 road	Truck collisions		
Provide adequate truck signing	RS	Off-road collisions on #R1 road	Truck collisions		
Install rumble strips on #A1 approach	RS	Off-road collisions on #R1 road	Truck collisions		
Increase efficiency of use of existing parking spaces	RS	Off-road collisions on #R1 road	Truck collisions		
Install interactive truck rollover signing	RS	Off-road collisions on #R1 road	Truck collisions		
Post adequate speed limit on #R1 road	RS	Off-road collisions on #R1 road	Truck collisions		
Provide targeted speed enforcement on #R1 road	RS	Off-road collisions on #R1 road	Truck collisions		
Change horizontal/vertical alignment on #R1 road	RS	Head-on collisions on #R1 road	Vertical curve	Inadequate design of vertical curve	

Widen lanes on #R1 road to adequate width	RS	Head-on collisions on #R1 road	Horizontal curve	Inadequate lane width on #R1 road
Install centerline rumble strips	RS	Head-on collisions on #R1 road	Horizontal curve	Inadequate lane width on #R1 road
Widen lanes on #R1 road to adequate width	RS	Head-on collisions on #R1 road	Vertical curve	Inadequate lane width on #R1 road
Install rumble strips on #A1 approach	RS	Head-on collisions on #R1 road	Vertical curve	Inadequate lane width on #R1 road
Install interactive truck rollover signing	RS	Head-on collisions on #R1 road	Horizontal curve	Inadequate road design for trucks
Prohibit long semitrailers if horizontal curve(s) cannot accommodate truck offtracking	RS	Head-on collisions on #R1 road	Horizontal curve	Inadequate road design for trucks
Post adequate truck speed limit on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Inadequate road design for trucks
Cut or trim trees and other roadside vegetation that obstruct sight distance	RS	Head-on collisions on #R1 road	Horizontal curve	Inadequate sight distance on horizontal curve
Remove other obstructions	RS	Head-on collisions on #R1 road	Horizontal curve	Inadequate sight distance on horizontal curve
Restrict parking near horizontal/vertical curves on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Inadequate sight distance on horizontal curve
Improve pavement marking and texturing	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve
Install in-pavement luminaires	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve

Install LED barrier-mounted guidance tubes	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve	
Install light-emitting diode (LED)	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve	
Delineate guardrail located outside the roadway curve	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve	
Provide pavement marking (stop sign/chevron/etc.) on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve	
Install post-mounted delineators	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve	
Improve pavement marking along the curve on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient delineation along the curve	
Install advisor speed sign	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient warning	
Install flashing beacons on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient warning	
Install advance warning signs of horizontal/vertical curve on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient warning	
Install rumble strips on #A1 approach	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient warning	
Install advance warning signs on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient warning	
Provide curve dynamic warning system on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient warning	

Install rumble strips on #A1 approach	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient warning	
Install advisor speed sign	RS	Head-on collisions on #R1 road	Vertical curve	Insufficient warning	
Install flashing beacons on #R1 road	RS	Head-on collisions on #R1 road	Vertical curve	Insufficient warning	
Install street lighting	RS	Head-on collisions on #R1 road	Vertical curve	Insufficient warning	
Install advance warning signs on #R1 road	RS	Head-on collisions on #R1 road	Vertical curve	Insufficient warning	
Install rumble strips on #A1 approach	RS	Head-on collisions on #R1 road	Vertical curve	Insufficient warning	
Install advance warning signs of horizontal/vertical curve on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Insufficient warning	
Install advance warning signs of horizontal/vertical curve on #R1 road	RS	Head-on collisions on #R1 road	Vertical curve	Insufficient warning	
Provide/Improve pavement surface (improve transitions/drop offs/fixed potholes/rutting/etc) on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Pavement defects on #R1 road	
Provide/Improve pavement surface (improve transitions/drop offs/fixed potholes/rutting/etc) on #R1 road	RS	Head-on collisions on #R1 road	Vertical curve	Pavement defects on #R1 road	
Provide adequate drainage on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Poor drainage on #R1 road	
Provide adequate drainage on #R1 road	RS	Head-on collisions on #R1 road	Vertical curve	Poor drainage on #R1 road	

Increase skid resistance on #R1 road	RS	Head-on collisions on #R1 road	Horizontal curve	Poor skid resistance on #R1 road
Increase skid resistance on #R1 road	RS	Head-on collisions on #R1 road	Vertical curve	Poor skid resistance on #R1 road
Groove pavement surface on #R1 road	RS	Head-on collisions on #R1 road	Vertical curve	Poor skid resistance on #R1 road
Install centerline rumble strips	RS	Head-on collisions on #R1 road	Frequent encroachments into opposing lane	
Install median barriers	RS	Head-on collisions on #R1 road	Frequent encroachments into opposing lane	
Install centerline rumble strips	RS	Head-on collisions on #R1 road	Frequent encroachments into opposing lane	
Provide wider cross sections on two-lane roads	RS	Head-on collisions on #R1 road	Frequent encroachments into opposing lane	
Reallocate total two-lane roadway width (lane and shoulder) to include a narrow "buffer median"	RS	Head-on collisions on #R1 road	Frequent encroachments into opposing lane	
Install median barriers	RS	Head-on collisions on #R1 road	Inadequate design for high traffic volume	
Use alternating passing lanes or four-lane sections at key locations	RS	Head-on collisions on #R1 road	Inadequate design for high traffic volume	
Widen lanes on #R1 road to adequate width	RS	Head-on collisions on #R1 road	Inadequate lane width on #R1 road	
Install centerline rumble strips	RS	Head-on collisions on #R1 road	Inadequate lane width on #R1 road	

Install rumble strips on #A1 approach	RS	Head-on collisions on #R1 road	Inadequate lane width on #R1 road		
Install reflectorized pavement marking	RS	Head-on collisions on #R1 road	Inadequate pavement marking on #R1 road		
Provide pavement marking (stop sign/chevron/etc.) on #R1 road	RS	Head-on collisions on #R1 road	Inadequate pavement marking on #R1 road		
Enhance delineation of sharp curves	RS	Head-on collisions on #R1 road	Inadequate road alignment on #R1 road		
Improve horizontal/vertical alignment on #R1 road	RS	Head-on collisions on #R1 road	Inadequate road alignment on #R1 road		
Increase skid resistance on #R1 road	RS	Head-on collisions on #R1 road	Inadequate road alignment on #R1 road		
Eliminate shoulder drop-off on #R1 road	RS	Head-on collisions on #R1 road	Inadequate shoulders width on #R1 road		
Increase width of shoulders on #R1 road	RS	Head-on collisions on #R1 road	Inadequate shoulders width on #R1 road		
Provide smooth paved shoulders on #R1 road	RS	Head-on collisions on #R1 road	Inadequate shoulders width on #R1 road		
Provide smooth paved shoulders on #R1 road	RS	Head-on collisions on #R1 road	Inadequate shoulders width on #R1 road		
Provide/Improve pavement surface (improve transitions/drop offs/fixed potholes/rutting/etc) on #R1 road	RS	Head-on collisions on #R1 road	Pavement defects on #R1 road		
Provide adequate drainage on #R1 road	RS	Head-on collisions on #R1 road	Poor drainage on #R1 road		

Increase skid resistance on #R1 road	RS	Head-on collisions on #R1 road	Poor skid resistance on #R1 road		
Groove pavement surface on #R1 road	RS	Head-on collisions on #R1 road	Poor skid resistance on #R1 road		
Create additional parking spaces	RS	Head-on collisions on #R1 road	Truck collisions		
Provide adequate truck signing	RS	Head-on collisions on #R1 road	Truck collisions		
Install rumble strips on #A1 approach	RS	Head-on collisions on #R1 road	Truck collisions		
Increase efficiency of use of existing parking spaces	RS	Head-on collisions on #R1 road	Truck collisions		
Install interactive truck rollover signing	RS	Head-on collisions on #R1 road	Truck collisions		
Post adequate speed limit on #R1 road	RS	Head-on collisions on #R1 road	Truck collisions		
Provide targeted speed enforcement on #R1 road	RS	Head-on collisions on #R1 road	Truck collisions		
Install advance warning signs on #R1 road	RS	Roadway inconspicuous	No advance warning sign on #R1 road		
Install advance warning signs of horizontal/vertical curve on #R1 road	RS	Roadway inconspicuous	Advance warning sign posted on #R1 road	Warning sign poorly visible/recognizable on #R1 road	Visual distractions on #R1 road
Install overhead flashing beacon lights on #R1 road	RS	Roadway inconspicuous	Advance warning sign posted on #R1 road	Warning sign poorly visible/recognizable on #R1 road	Visual distractions on #R1 road

Install larger regulatory signs on both sides of road on #R1 road	RS	Roadway inconspicuous	Advance warning sign posted on #R1 road	Warning sign poorly visible/recognizable on #R1 road	Visual distractions on #R1 road
Provide warning pavement marking on #A1 approach	RS	Roadway inconspicuous	Advance warning sign posted on #R1 road	Warning sign poorly visible/recognizable on #R1 road	Visual distractions on #R1 road
Relocate sign on #R1 road to make it visible	RS	Roadway inconspicuous	Advance warning sign posted on #R1 road	Warning sign poorly visible/recognizable on #R1 road	Warning sign obstructed on #R1 road
Remove object obstructing sight of warning sign on #R1 road	RS	Roadway inconspicuous	Advance warning sign posted on #R1 road	Warning sign poorly visible/recognizable on #R1 road	Warning sign obstructed on #R1 road
Remove object obstructing sight of warning sign on #R1 road	RS	Roadway inconspicuous	Advance warning sign posted on #R1 road	Warning sign poorly visible/recognizable on #R1 road	

Appendix E

CRF study

Two-Way Stop-Controlled Intersection

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Install raised crosswalk			25	25					25	25							46			
Installing snow screens in areas exposed to snowdrifts					53	53														
Properly maintain the striping																				
Use school crossing guards																				
Add overhead stop-signs if the percent of tall vehicles is considerable																				
Add special signing																				
Add stop-lines in the median opening																				
Adjust signal offsets at the upstream signalized intersections to create more gaps																				
Change horizontal/vertical alignment			58	58							50	50	50	50					10	10

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Chip and seal or slurry seal approaches																				
Close curb lanes																				
Close or relocate the driveways			50	50																
Consider indirect left turns			34	34			35	35	25	25	41	41	32 (1)	32 (1)			48 (2)	47 (2)	24 (3)	
Consider intersection type "J" (no directly left turn)																				
Consider moving the right-turn lanes on the major road laterally																				
Consider traffic signals with protected left-turn phase																				
Construct Pedestrian Refuge Islands and Raised Medians		46	60 (4)	60 (4)	32	23									46					
Convert the intersection into a roundabout	58 (5)	72 (5)					40	40	40	40					58 (6)	72 (6)	58	72	38	38
Eliminate screening by physical objects													50 (7)	50 (7)					76 (8)	76 (8)
Eliminate shoulder drop-off											25	25							30 (9)	30 (9)
Enforce stop sign compliance																				
Extend "no parking" zone.					22	22					35 (1 0)	35 (1 0)							10	10
Groove pavement			21	21			14	14											46	46

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
surface																				
Implement Road Narrowing Measures																				
Improve alignment/grade																				
Improve channelization/delineation											30 (1 1)	30 (1 1)	40	40					15	
Improve clear zone					25 (1 2)	25 (1 2)														
Improve existing street lights	30	30			50	50														
Improve lanes width	8 (1 3)														8					
Improve pavement marking			21	21																
Improve pavement marking in the median opening			21	21																
Improve signage and/or marking of the crosswalk											25	25								
Improve skid resistance			9	9																
Improve visibility from median toward major approach																			10	10
Improve visibility of intersections by providing enhanced signing and delineation											30 (1 1)	30 (1 1)								
Improve visibility of the	30	30	33	33	50	50					30	30	37	37					37	37

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
intersection by providing lighting					(1 4)	(1 4)														
Improve winter maintenance methods																				
Improve winter maintenance preparedness (shorter response time)																				
Improve/install reflective signs			15	15																
Improve/install reflectorized pavement markers																				
Increase length of the right turn lanes			28	28			15 (1 5)	15 (1 5)			28	28								
Increase radius of the corner curve			13	13							15	15								
Increase the crosswalk setback																				
Increase the length of the left turn lanes			28	28			15	15			28	28								
Increase the turning path radius			13	13							15	15								
Increase width of the shoulders	9 (1 6)		14	14							20	20			9				14	
Install a barrier curb or a guardrail	45 (1 7)	45 (1 7)	11	11			47 (1 8)	47 (1 8)						4			44 (7)	44 (7)		
Install a pedestrian overpass or underpass			86	86															91	91
Install a stop sign			35	35							39	39								
Install a triangular																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
island to relocate the right-turning movement away from other movements																				
Install acceleration lanes sufficiently long for trucks			26	26																
Install advance warning sign	20	20	25	25			25 (1 9)	25 (1 9)					30	40						
Install an acceleration lane			26	26							10	10	10	10						
Install an object marker							16	16												
Install channelization of the driveways									50 (2 0)	50 (2 0)										
Install corner mirrors																				
Install curbing to define driveway location																				
Install curb-ramps																				
Install flashing beacons	30	30			50	50	30 (2 1)	30 (2 1)			30	30	24	24						
Install flashing beacons at stop-controlled intersections					50	50	30 (2 1)	30 (2 1)					24	24						
Install fog - warning signs							25 (1 9)	25 (1 9)												
Install guardrails					20	20	47	47			65 (4)	65 (4)		4			44 (4)	44 (4)		
Install indirect left-turn lanes			34 (2 2)	34 (2 2)				35	35											

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Install larger regulatory and warning signs at and in advance of intersections											15 (2 3)	15 (2 3)	40	30						
Install larger regulatory and warning signs at intersections											15 (2 3)	15 (2 3)								
Install left turn acceleration lane			26	26							10	10								
Install left turn bays	28	27			20	20									28 (2 4)	27 (2 4)				
Install lighting	30	30	33	33	50 (2 5)	50 (2 5)					30	30	37	37					37 (2 6)	37 (2 6)
Install median divider	15 (2 7)	15 (2 7)																		
Install overhead flashing beacon lights	30	30			50	50	30 (2 1)	30 (2 1)			30	30	24	24						
Install pavement markings	10	10	21	21					21	21									10	10
Install pedestrian actuated signals																				
Install pedestrian barriers																				
Install pedestrian crosswalk			25	25					25	25										
Install reflectorized pavement marking																				
Install regulatory signs on the both side of the road																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Install right turn bays if the number of vehicle turning right is considerable																				
Install right turn lane		14	25 (2 8)	25 (2 8)			25	25			24	24			14		26		10	
Install rumble strips			32	32	28	28					25 (2 3)	25 (2 3)			21				50	50
Install school crossing sign			18	18							14	14								
Install school zone markings																				
Install sidewalk set-backs																				
Install speed limit sign																				
Install static or variable message signs displaying weather information			15	15							15 (2 3)	15 (2 3)								
Install street lights	30	30			50 (2 5)	50 (2 5)														
Install streets name signs											25	25								
Install traffic signals		14	30 (2 9)	30 (2 9)							28	28	28	28		23	23 (3 0)	23 (3 0)		
Install/Improve lighting at the access points			33 (3 1)	33 (3 1)							30	30	37	37					37 (2 6)	37 (2 6)
Install/improve signing or marking of											15	15					16	16		

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
pedestrian crosswalks																				
Install/improve warning signs			25	25	20	20	25 (2 3)	25 (2 3)			25	25								
Move driveway to side street			50 (3 2)	50 (3 2)	15	15														
Overlay pavement			17	17	18	18	27	27												
Post an adequate speed limit					28	28							20	20						
Post dynamic message sign to display the speed of approaching vehicles.																	74 (3 3)	74 (3 3)		
Provide "Slippery when wet" signs																				
Provide a bypass lane on the approach with left-turn traffic																				
Provide a double yellow centerline on the median opening of a divided highway at intersections																				
Provide acceleration and deceleration lanes			26	26							10 (1 1)	10 (1 1)	10	10						
Provide adequate delineation for left-turns at the intersection (markers or lines)											30	30								
Provide adequate drainage			20	20																
Provide adequate					21	21														

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
lanes signing or marking					(3 4)	(3 4)														
Provide adequate turning markers or pavement markings	10	10	21	21															10	10
Provide dashed markings (extended left edgelines) for major-road continuity across the median opening at divided highway intersections					24 (3 5)	24 (3 5)					30	30	11 (3 6)	11 (3 6)						
Provide independent bicycle path where necessary																				
Provide median refuges		46																		
Provide offset for left turn lanes on the opposite approaches							10	10												
Provide on-pavement horizontal signing																				
Provide pavement marking (stop sign, chevron, etc.)			21	21	35 (3 7)	35 (3 7)							35	35			25 (3 7)			
Provide roadside markers or pavement markings to assist drivers in judging the suitability of available gaps for making turning and crossing maneuvers																				
Provide smooth paved			15	15										53					14	

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
shoulders														(3 8)						
Provide splitter islands																				
Provide stop signs			35	35							39	39								
Provide targeted speed enforcement																				
Provide traffic calming on intersection approaches through a combination of geometric and traffic control devices																				
Provide traffic signal if warranted											28	28				23 (3 9)	23 (4 0)	23 (4 0)		
Provide visible stop bars																				
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting, etc)																				
Reconstruct the radius			13	13							15	15								
Reduce speed on the major road											20	20	20 (4 1)	20 (4 1)						
Reduce speed limit													20	20						
Reduce the number of lanes on the minor approach if allowed by capacity																				
Relocate crosswalk																				
Relocate islands																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Relocate or split the stopping line																				
Relocate stop bar																				
Relocate stop sign																				
Relocate the sign to make it visible																				
Remove distracting commercial lighting or other source of glare											15	15								
Remove or re-locate the median object obstructing sight of opposite traffic	12 (4 2)														13 (4 3)				10	10
Remove or relocate the object					60	60	29 (4 4)	29 (4 4)			30	30	50 (7)	50 (7)						
Remove sight obstructions	12 (4 2)														13 (4 3)					
Remove the object obstructing sight of the warning sign																				
Remove the object obstructing the sight of the stop sign																				
Remove the object obstructing the sight triangle	12 (4 2)						25	25							13 (4 3)				10	10
Replace poorly designed drain grates with bicycle-safe types																				
Replace, repair, or clean the sign					5 (4 5)	5 (4 5)														

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Replace, repair, or clean the warning signs					20	20	25	25												
Reroute pedestrian paths																				
Restrict left-turn maneuver					40 (4 6)															
Restrict left-turning at the access points																		10 0 (4 7)		
Restrict parking near the driveway					22 (4 8)	22 (4 8)					35	35	8	8					10	10
Restrict parking on the approach																			10	10
Signals to alert motorists that pedestrians are crossing																	16	16		
Trim vegetation																				
Upgrade signing					5 (4 5)	5 (4 5)					24	24								
Use "Slippery when wet" signs																				
Use break-away devices					30	30														
Use salt to prevent snow or ice from forming or from sticking to the road surface																				
Use sand to increase																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
pavement friction																				
Vehicles in the right-turn lane on the major road block the minor-road drivers' view of traffic approaching on the major road																				
Widen lanes to adequate width			40	40	38		22 (4 9)	22 (4 9)	30 (5 0)	30 (5 0)	25	25	23 (5 1)	23 (5 1)	8 (5 2)				13	13
Widen the median to provide sufficient protection to crossing vehicles																				
Widen the median width													13	13						
Widen the outside through lanes or add bike lanes																				

COMMENTS

- (1) - added painted lane
- (2) - rural both approaches, 4 legs
- (3) - four legs intersection
- (4) – reduction in pedestrians fatal only
- (5) - for single lane approach; multiple lane approach CRF=5% only urban
- (6) – single lane
- (7) – fatal only
- (8) – conflict elimination
- (9) – shoulder treatment
- (10) – eliminate parking
- (11) – post delineation
- (12) - widen by 5,8,10,15,20 [ft] CRF is respectively: 13%,21%,25%,35%,44%
- (13) – widen lanes: 9ft-12ft CRF=12%; 10ft -12ft CRF=8%; 11ft-12ft CRF=2%
- (14) - provide illumination for intersection
- (15) – general any turn lane
- (16) - for width: 2ft-8ft: 12%, 4ft-8ft: 9%, 6ft-8ft:5% (only for paved shoulder)
- (17) – fatal CRF=44%; injury CRF=47%
- (18)- total injury crashes (incl. fatal)
- (19) – warning general
- (20) - channelization – CRF=50% for Rear End, Head On, Sideswipe Same Direction, Sideswipe Opposite Direction, Left Turn, and Run-off-the-Road crashes.
- (21) - for intersection only
- (22) - provide left turn lane without signal
- (23) – general warning and large sign
- (24) - 4 leg intersection
- (25) - provide illumination for intersection
- (26) – CRF between 25%-50%
- (27) - add mountable median
- (28) - turning, angle, rear-end, sideswipe - over

- (29) - 3 leg: all types CRF=14%; angle CRF=34%, rear-end CRF= (-50%), 4 leg: all types CRF=23%; angle CRF=67%, rear-end CRF= (-38%)
- (30) - 4 leg all crashes
- (31) - treat as intersection
- (32) - relocate driveway entrance: left, right, angle=10%; rear, head=20%
- (33) - speed reduction (not crashes)
- (34) - pavement markings
- (35) - edge line markings
- (36) – edge lines
- (37) – chevron
- (38) - urban multilane
- (39) - 4 leg intersection
- (40)- 4 leg both approaches
- (41) - modify speed limit
- (42) - the following reduction applies: in 1 quadrant - 5%, in 2 quadrant - 9%, in 3 quadrant 13%, in 4 quadrant -17%
- (43) - 3 quadrant
- (44) - removed fixed object (relocate=35%)
- (45) - general upgrade signing
- (46) - prohibit turning
- (47) - only turning crashes
- (48) - prohibit on street parking
- (49) - pavement widening
- (50) - widening and resurfacing or widening alone
- (51) - average from 1ft and 2 ft
- (52) – 10ft -12 ft
- (53) - average from width: 4ft, 10ft, 20 ft

Rail Road Crossing

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S22	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Add overhead stop-signs if the percent of tall vehicles is considerable																						
Change horizontal/vertical alignment (skewed-angle crossing)																					45 (1)	45 (1)
Chip and seal or slurry seal approaches																						
Close or install overpass																						
Close rail-road crossing point																						
Eliminate screening by physical objects																						
Extend "no parking" zone.																						
Groove pavement surface																						
Improve channelization/delineation											30 (2)	30 (2)	40	40			75	75	15			
Improve existing street lights at the rail-road crossing points	30	30			50	50																
Improve gates visibility/reflectivity (flashing lights along			75 (3)	75 (3)																		

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S22	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
the gate)																						
Improve maintenance of rail infrastructure (Motion Sensitive Devices, Constant Warning Time)																					50 (4)	50 (4)
Improve maintenance of train detective devices																						
Improve maintenance of visual/audio signals																						
Improve maintenance/work of existing gates																						
Improve pavement markings and texturing																						
Improve signage of the crosswalk											25	25										
Improve skid resistance			9	9																		
Improve winter maintenance methods																						
Improve winter maintenance preparedness (shorter response time)																						
Improve/install reflective signs			15	15																		
Improve/install reflectorized pavement markers																						
Install a bicycles overpass or underpass																						
Install a fence or																						

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S22	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
chicane to prevent bicycles running across the track																						
Install a fence or chicane to prevent pedestrians running across the track																						
Install a pedestrian overpass or underpass			86	86																		
Install active control devices	50	50																				
Install adequate control device																						
Install advance warning sign	20	20	25	25			30 (5)	30 (5)	40	40			30	40							50	50
Install audible signals (warning bell)									50	50												
Install automated bicycles/pedestrians gates																					50	50
Install automated pedestrian gates																						
Install automatic gates			75	75																		
Install bicycles signals																						
Install cantilever flashing-light signal																						
Install corner mirrors																						
Install crossbuck									60	60												
Install DO NOT STOP ON TRACKS signal																						
Install fixed message signs																						
Install flashers			75	75																		

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S22	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Install flashing beacons	30	30	65	65	50	50	30 (5)	30 (5)	60	60	58	58	24	24								
Install flashing light activated by queuing traffic in the exit lane(s) from the crossing																						
Install fog - warning signs							25	25														
Install four-quadrant gate arms																					55	55
Install gates			65 (6)	65 (6)																	46 (7)	46 (7)
Install gates with self deploying extension sections																						
Install lighting	30	30	33	33	50 (8)	50 (8)					30	30	37	37					37 (9)	37 (9)	45	45
Install median barriers																						
Install median retroreflective post delineators on the approach																						
Install non-mountable curb islands																						
Install overhead signs																						
Install pavement markings	10	10	21	21					21	21					10	10			10	10		
Install pedestrian barriers																						
Install pedestrian signals																						
Install pre-signals																					50	50
Install rumble strips			32	32	28	28					25 (1)	25 (1)			21				50	50		

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S22	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
											0)	0)										
Install signs on both sides of highway																						
Install speed humps																					40	40
Install static or variable message signs displaying weather information			15 (1 1)	15 (1 1)							15	15										
Install stop sign			35	35							39	39									46	46
Install street lights	30	30			50 (8)	50 (8)																
Install swing gates																						
Install symbol storage space sign																						
Install variable message signs and blank out signs																						
Install vehicle-arresting barriers																						
Install warning signs in advance of rail-road crossing									40	40											50	50
Install yield sign																						
Installing snow screens in areas exposed to snowdrifts																						
Overlay pavement (friction course)			17	17	18	18	27	27														
Post a lower speed limit for cars and/or trains																						
Post an adequate speed limit					28	28							20	20								

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S22	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Post dynamic message sign to display the speed of approaching vehicles.																	74 (1 2)	74 (1 2)				
Provide adequate delay																					33 (1 3)	33 (1 3)
Provide adequate drainage			32	32																		
Provide adequate gate interval																					33 (1 3)	33 (1 3)
Provide adequate information to train operator (for example: location of the whistle post)																						
Provide information of the crossing type																						
Provide pavement marking					35	35					10	10	35	35								
Provide photo video enforcement																					56	56
Provide targeted speed enforcement																						
Provide traffic calming on approaches through a combination of geometric and traffic control devices																						
Provide/Improve pavement surface (improve transitions, drop offs, fixed											34	34										

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S22	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
potholes, rutting, etc)																						
Relocate control device																						
Relocate stop bar (If stop sign present)																						
Relocate stop sign																						
Relocate the crossing section																						
Remove distracting commercial lights											15 (1 4)	15 (1 4)										
Remove the object obstructing the sight of the control device																						
Remove the object obstructing the sight of the stop sign																					47	47
Remove the object obstructing the sight triangle	12 (1 5)						25 (1 6)	25 (1 6)							13 (1 7)				10	10	50	50
Remove the object obstructing view from the approach																					50	50
Replace / repair signals																						
Replace, repair, or clean the control device																						
Replace, repair, or clean the sign					5 (1 8)	5 (1 8)																
Trim vegetation																						
Upgrade signing					5 (1	5 (1					24	24										

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S22	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
					8)	8)																
Use "Slippery when wet" sign (temporary)																						
Use photo video enforcement																					56	56
Use salt to prevent snow or ice from forming or from sticking to the road surface																						
Use sand to increase pavement friction																						

COMMENTS:

- (1) Crossing angle
- (2) Post delineation
- (3) Install flasher
- (4) Constant warning
- (5) Warning general
- (6) Automated gates
- (7) 2Q gates
- (8) Provide illumination for intersection
- (9) CRF between 25%-50% (average reported)
- (10) Rumble strips general
- (11) General variable message sign
- (12) Reported speed reduction (not crashes reduction)
- (13) Gate delay
- (14) Glare screen
- (15) The following reduction applies: in 1 quadrant - 5%, in 2 quadrant - 9%, in 3 quadrant 13%, in 4 quadrant -17%
- (16) Clear sight triangle
- (17) 3 quadrant
- (18) General upgrade signing

Road Segment

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Add special signing																				
Centerline rumble strips for two-lane roads			32 (1)	32 (1)	32 (1)	32 (1)					25 (1)	25 (1)			12		22	22		
Chip and seal or slurry seal approaches																				
Close or relocate the driveways			50	50	15 (2)	15 (2)														
Construct pedestrian refuge islands and raised medians		46																		
Create additional parking spaces																				
Cut trees and other roadside vegetation obstruct the view					25	25														
Design safer slopes and ditches to prevent rollovers					35 (3)	35 (3)														
Eliminate screening by physical objects					60 (4)	60 (4)							50 (5)	50 (5)					76 (6)	76 (6)
Eliminate shoulder drop-offs											25	25							30 (7)	30 (7)
Eliminating compound curves																				
Enhance delineation of sharp curves					16	16							17	17			15		15	
Enhance delineation of sharp curves segment					16	16											15		15	
Groove pavement surface			21	21			14	14											46	46
Identify and treat truck crash roadway																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
segments—signing																				
Implement lighting / illumination measures	23	23	28	28							25	25	37	37					37 (8)	37 (8)
Implement road narrowing measures																				
Improve alignment																				
Improve channelization/delineation											30 (9)	30 (9)	40	40						
Improve clear zone					25 (10)	25 (10)														
Improve existing street lights	30	30			50 (11)	50 (11)														
Improve lanes width	9 (12)										25 (13)	25 (13)	23 (14)	23 (14)	8 (15)					
Improve or restore superelevation	11 (16)		28	28							40 (17)	40 (17)			11 (18)					
Improve pavement markings			21	21	10	10			21	21									10	10
Improve pavements resistant																				
Improve reflectorization/conspicuity of pedestrians																				
Improve signage and/or marking of the crosswalk					5	5					25 (19)	25 (19)								
Improve skid resistance			9	9															20	20
Improve skid resistance along the segment			9	9																

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Improve winter maintenance methods																				
Improve winter maintenance preparedness (shorter response time)																				
Improve/install reflective signs			15	15																
Improve/install reflectorized pavement markers																				
Incorporate rumble strips into new and existing roadways			32	32	32 (1)	32 (1)					25	25								
Increase efficiency of use of existing parking spaces																				
Increase width of the shoulders			14	14			8	8			20	20			9 (20)					
Install "Cross only at Crosswalk" signs																				
Install a barrier curb or a guardrail			11	11	20	20	47	47						4			44 (5)	44 (5)		
Install a bridge warning sign			25	25			25 (21)	25 (21)			34	34								
Install a pedestrian overpass or underpass			86	86															91	91
Install a tree marker					16 (22)	16 (22)														
Install advance warning signs			25	25	36 (23)		25 (21)	25 (21)												
Install advisor speed											26	26								

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
sign																				
Install an utility polet marker					16 (2 4)	16 (2 4)														
Install central rumble strips	12 (2 5)						14	14			25 (2 6)	25 (2 6)			12		22	22	54	54
Install channelization of the driveways									50 (2 7)	50 (2 7)										
Install curbing to define driveway location																				
Install curb-ramps																				
Install flashing beacons	30	30			50	50					30	30	54	54						
Install fog - warning signs							25 (2 1)	25 (2 1)												
Install Horizontal alignment signs (Turn, Curve, Reverse Turn, Winding Road)	30	30																		
Install in-pavement luminaires																				
Install interactive truck rollover signing																				
Install larger regulatory and warning signs at and in advance of hazardous location											32 (2 8)	32 (2 8)								
Install LED barrier-mounted guidance tubes																				
Install light-emitting diode (LED)																				
Install lighting	30	30	23	23	50 (1)	50 (1)					25	25	37	37					37 (8)	37 (8)

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
					1)	1)														
Install median barriers	60 (5)				61	61			63 (5)	63 (5)			90 (5)	90 (5)	90 (5)					
Install median divider			15	15																
Install midlane rumble strips			32 (2 6)	32 (2 6)			14	14			25 (2 6)	25 (2 6)			12		22	22	54 (3 0)	54 (3 0)
Install overhead flashing beacon lights	30	30			50 (1 1)	50 (1 1)					30	30	54 (3 1)	54 (3 1)						
Install Overpasses/Underpasses			86	86																
Install pavement markings			21	21	10	10			21	21									10	10
Install pedestrian actuated signals																				
Install pedestrian barriers																				
Install pedestrian crosswalk			25	25					25	25										
Install raised crosswalk																	46			
Install reflectorized pavement markings	10	10	10	10																
Install regulatory signs on the both side of the road																				
Install rumble strips			32	32							25 (2 6)	25 (2 6)			21					
Install school crossing sign			18	18							14	14								
Install school zone markings																				
Install shoulder rumble strips	21						29	29	30	30	25 (2	25 (2			21		25	25	35	35

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
											6)	6)								
Install sidewalk set-backs																				
Install sidewalks			74	74							65	65							70 (3 1)	70 (3 1)
Install speed limit sign																				
Install static or variable message signs displaying weather information			15 (3 2)	15 (3 2)							15	15								
Install street lights	30	30			50 (1 1)	50 (1 1)														
Install warning signs (can be install on both side of the road)			25	25	36 (3 2)		25	25												
Install/Improve lighting at the access points			33	33							25	25	37	37					37 (3 3) 37 (8)	37 (8)
Installing snow screens in areas exposed to snowdrifts					53	53														
Modify horizontal alignment			45	45	40		66 (5)	66 (5)			40	40							64	64
Modify roadside clear zone					25 (1 0)	25 (1 0)														
Modify speed limits and increase enforcement to reduce truck and other vehicle speeds											20	20								
Move driveway to side			50	50	15	15														

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
street			(2)	(2)																
Overlay pavement (friction course)			17	17	18	18	27	27					13	34						
Pave shoulders			15	15							15	15		53 (3 3)						
Place utilities underground																				
Placed delineation on guardrail located outside the roadway shoulder, along the curve					16	16					30 (9)	30 (9)	17	17			15		15	
Post an adequate speed limit					28	28							20	20						
Post dynamic message sign to display the speed of approaching vehicles.																	74 (3 4)	74 (3 4)		
Profiled thermoplastic stripes for centerline																				
Prohibit/Restrict trucks with very Long semitrailers on roads with horizontal curves that cannot accommodate truck offtracking																				
Provide acceleration and deceleration lanes			26	26							10	10								
Provide adequate drainage			20	20																
Provide adequate speed limit for trucks											20 (3 5)	20 (3 5)								
Provide adequate			87	87	88		40	40	40	40	40	40	45	45						

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
vertical curve design (crest/redesign)																				
Provide advance warning of unexpected changes in horizontal alignment							25 (2 1)	25 (2 1)					30	30					18	18
Provide advance warning of unexpected changes in horizontal/vertical alignment							25 (2 1)	25 (2 1)			32 (2 8)	32 (2 8)	30	30						
Provide advance warning of unexpected changes in vertical alignment							25 (2 1)	25 (2 1)			32 (2 8)	32 (2 8)	30	30						
Provide breakaway and crashworthy mail box																				
Provide breakaway and crashworthy sign supports					30	30														
Provide chevrons					35	35					30	30	35	35			25			
Provide dynamic curve warning system																			10 0 (3 6)	
Provide enhanced pavement markings			10	10	10	10													10	10
Provide grooved pavement			21	21			14	14											46	46
Provide independent bicycle path where necessary																				
Provide median refuges		46 (3 7)																		

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Provide on-pavement horizontal signing																	10 (3 4)			
Provide post-mounted delineators					16	16					30	30	25	25			15		15	
Provide smooth paved shoulders			15	15			8 (3 8)	8 (3 8)						53 (3 9)						
Provide targeted speed enforcement																				
Provide traffic calming through a combination of geometric and traffic control devices																				
Provide wider cross sections on two-lane roads																				
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting, etc)																				
Provide/Improve pavement surface along the segment (improve transitions, drop offs, fixed potholes, rutting, etc)																				
Providing spiral transition curves																				
Raised pavement markers					9	9					10	10	4	4			9	9		
Reallocate total two-lane roadway width (lane and shoulder) to include a narrow "buffer median"																			50 (4 0)	50 (4 0)

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Relocate the sign to make it visible																				
Remove distracting commercial lights																				
Remove or relocate mail box					29 (4 1)	29 (4 1)					30 (4 2)	30 (4 2)							27 (4 3)	27 (4 3)
Remove or relocate sign					29 (4 1)	29 (4 1)														
Remove or relocate trees					25	25													66 (5)	66 (5)
Remove or relocate utility Poles					38	38													32	
Remove sight obstructions																				
Remove the object obstructing sight of the warning sign																				
Removed other obstructions					29	29														
Replace poorly designed drain grates with bicycle-safe types																				
Replace, repair, or clean the warning signs							25 (2 1)	25 (2 1)			24	24	30	40						
Restrict left-turning at the access points					45 (4 4)	45 (4 4)														
Restrict parking											35 (4 5)	35 (4 5)	8	8					10	10
Restrict parking near the driveway																				
Shield drivers from																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
poles in hazardous locations																				
Signals to alert motorists that pedestrians are crossing																				
Upgrade signing					5	5					24	24								
Use "Slippery when wet" sign (temporary)																				
Use alternating passing lanes or four-lane sections at key locations					30	30	25 (4 6)	25 (4 6)									35	35	25	25
Use break-away devices					30	30														
Use salt to prevent snow or ice from forming or from sticking to the road surface																				
Use sand to increase pavement friction																				
Use school crossing guards																				
Use transverse striping treatments																				
Widen and/or pave shoulders	9 (4 7)		14	14			8	8			20	20		53 (4 8)					19	19
Widen the outside through lanes or add bike lanes																				

COMMENTS:

- (1) - install rumble strips (general)
- (2) - relocate driveway entrance: left, right angle CRF=10%; rear, head CRF=20%
- (3) - flatted side slope
- (4) - relocate object (general) fatal only CRF= 60%
- (5) – fatal only
- (6) - conflict elimination
- (7) - shoulder treatment
- (8) – CRF for lighting between 25%-50% (average)
- (9) - post delineation
- (10) – widen by 5,8,10,15,20 [ft] CRF is respectively: 13%,21%,25%,35%,44%
- (11) - provide illumination for Intersection
- (12) - for width: 2ft-8ft: 12%, 4ft-8ft: 9%, 6ft-8ft:5% (only for paved shoulder)
- (13) - widen pavement
- (14) - average from 1 ft and 2 ft
- (15) – lane width: between 10 ft -12 ft
- (16) – CRF: 15% for 0.02-0.04; 11% for 0.04-0.06 and 5% for 0.06-0.08
- (17) - modify superelevation
- (18) – range 0.04-0.08
- (19) - mark crosswalk
- (20) – shoulder width: 4ft-8ft
- (21) - warning general
- (22) - object marker install
- (23) – CRF=36% for rural 2 lane; more than 2 lane: CRF=18%
- (24) - object marker install
- (25) – CRF=21% for head-on and sideswipe
- (26) – rumble strips general
- (27) - Channelization – CRF=50% for Rear End, Head On, Sideswipe Same Direction, Sideswipe Opposite Direction, Left Turn, and Run-off-the-Road crashes.
- (28) - curve warning sign
- (29) - install mountable median
- (30) – head-on only

- (31) – CRF between 50%-90%
- (32) – CRF=36% for rural 2 lane
- (33) - paved multilane urban
- (34) - speed reduction (not crashes)
- (35) - modify speed limit
- (36) – from 10 crashes to 0 during 3 years
- (37) – pedestrians
- (38) - improve/ widen shoulder
- (39) - paved shoulder multilane urban
- (40) - head-on collision only
- (41) - removed fixed object (relocate CRF=35%)
- (42) - remove fixed object
- (43) – CRF between 14% - 40%
- (44) - prohibit let-turn maneuver
- (45) - eliminate parking
- (46) - upgrade no passing zone
- (47) - for width: 2-8:12%, 4-8:9%, 6-8:5% (only for paved shoulder)
- (48) - paved multilane urban area

Signalized Intersection

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Add illuminated/reflectorized name signs	23	23	28	28																
Add special signing																				
Adjust minimum green or extension time																				
Adjust phase time and cycle time																				
Adjust yellow change interval															8 (1)		8			
Change horizontal/vertical alignment			58	58							50	50	50	50						
Channelize intersections									50 (2)	50 (2)			70	70						
Chip and seal or slurry seal approaches																				
Clear sight triangles	12 (3)						25	25												
Close intersection leg or convert to one-way street																				
Consider indirect left turns			28 (4)	28 (4)			25	25	25	25	22	22						37		
Construct interchanges																				
Convert a four-leg intersection to two T intersection																				
Convert intersection to roundabouts	58 (5)	72 (5)					40	40	40	40					58	72	58	72	38	38

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Convert two T intersection to one four-leg intersection																				
Convert two-way streets to a one-way pair																				
Coordinate the railroad and traffic signal to provide preemption to the traffic signal when trains are approaching the intersection							30 (6)	30 (6)											25	25
Create one way streets																				
Delineate turn path											30	30								
Eliminate screening by physical objects					60 (7)	60 (7)							50	50					76 (8)	76
Employ emergency vehicle preemption																			70 (9)	70 (9)
Encourage safe speeds through design																				
Extend "no parking" zone.					22	22					35 (10)	35 (10)	8	8					10	10
Groove pavement surface			21	21			14	14											46	46
Implement automated enforcement of red-light running (cameras)		9													9		25 (11)			
Improve (add) coordinating signals																			25	25
Improve (add)					30	30														

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
phases (length)					(12)	(12)														
Improve alignment/grade																				
Improve existing street lights	30	30			50 (13)	50 (13)														
Improve intersection angle																				
Improve intersection skew angle							40	40												
Improve left-turn lane geometry																				
Improve right-turn lane geometry																				
Improve signing and delineation											30 (14)	30 (14)	17	17					15	
Improve skid resistance			9	9																
Improve winter maintenance methods																				
Improve winter maintenance preparedness (shorter response time)																				
Improve/install reflective signs			15	15																
Improve/install reflectorized pavement markers																				
Increase the crosswalk setback																				
Install a barrier curb			11	11	20	20	47	47						4				44		

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
or a guardrail							(15)	(15)									(16)			
Install a tree marker					16 (17)	16 (17)														
Install additional signal head					50 (18)	50 (18)							31(19)	31 (19)						
Install adequate signings			30	30																
Install an utility poles marker					16 (17)	16 (17)														
Install backplates							5 (20)	5 (20)												
Install bicycles traffic lights											24	24								
Install curb-ramps																				
Install flashing beacons	30	30			50 (21)	50 (21)	30 (22)	30 (22)			30	30	24	24						
Install fog - warning signs			25 (23)	25 (23)			25 (24)	25 (24)					24	24						
Install larger signal lenses			10 (25)	10 (25)							12 (25)	12 (25)	10	10						
Install larger signs																				
Install left-turn lane			28	28					25	25										
Install median driver																				
Install multi-dialer controller																				
Install overhead street signing																				
Install painted/raised			23	23							10	10	10	10						

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
islands (provide adequate visibility of the island)																				
Install pedestrian overpasses			86	86															91	91
Install physical barriers to restrict pedestrian crossing maneuvers at higher-risk locations																				
Install queue detection system																				
Install raised crosswalk			25	25					25	25							46			
Install right-turn lane		4	17 (26)	17 (26)																
Install rumble strips on approach			32 (27)	32 (27)							25 (28)	25 (28)							50	50
Install static or variable message signs displaying weather information			15 (29)	15 (29)							15 (30)	15 (30)								
Install street lights	30	30			50 (13)	50 (13)														
Install traffic actuated signal											22	22								
Install warning sign			25	25	20	20	25	25					20	15						
Install/improve center line markings			33	33	33	33					35	35								
Install/improve Intersection lighting	30	30	33	33	50 (31)	50 (31)					30	30	37	37					37	37
Installing snow					53	53														

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
screens in areas exposed to snowdrifts																				
Lengthen left-turn lane	9 (32)		28	28			15 (33)	15 (33)												
Lengthen right-turn lane	9 (32)		28	28			15 (33)	15 (33)												
Lengthening clearance intervals		8 (34)	15	15													8			
Modify roadside clear zone					25 (35)	25 (35)													9	9
Optimize clearance interval																			9	9
Overlay pavement (friction course)			17	17	18	18	27	27					13	34						
Place utilities underground																				
Post an adequate speed limit					28	28							20	20						
Post dynamic message sign to display the speed of approaching vehicles.																	74 (36)	74 (36)		
Prohibit right turn on red			20	20	45	45														
Prohibit turning movements					40						45	45								
Provide additional pavement																				
Provide adequate channelization and dealination			22	22					50 (2)	50 (2)										
Provide adequate			20	20																

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
drainage																				
Provide adequate lane width	9 (32)										25 (37)	25 (37)				8 (38)				
Provide adequate left-turn lane width	9 (32)															8 (38)				
Provide adequate right-turn lane width	9 (32)															8 (38)				
Provide adequate signals for handicapped																				
Provide adequate signing			30	30																
Provide adequate signs and markings			30	30																
Provide all-red clearance interval			15	15																
Provide appropriate intervals for crossings and minimize wait time																				
Provide bicycle box																				
Provide breakaway and crashworthy sign supports					30	30														
Provide channelization			22	22					50 (2)	50 (2)										
Provide continuous sidewalks			74	74							65	65								
Provide crossing guards for school children																				
Provide far-side left-turn signal																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Provide grooved pavement			21	21			14	14											46	46
Provide independent bicycle path where necessary																				
Provide indirect left turn (can be for high left turn volume)			28 (4)	28 (4)			25	25	25	25	22	22								
Provide intersection lighting	30	30	33	33	50	50					30	30	37	37				37	37	37
Provide lights in crosswalks in schools zones																			43 (39)	43 (39)
Provide longer clearance intervals			15 (40)	15 (40)																
Provide louvers, visors, or special lenses so drivers are able to view signals only for their approach																				
Provide median refuges		46																		
Provide offset for left turn lanes on the opposite approaches							37 (41)	37 (41)												
Provide pavement markings			21	21	10	10			21	21									10	10
Provide pedestrian push buttons																				
Provide pedestrian-only phase or pedestrian-lead phase during signal operation			20	20							23	23							50 (42)	50 (42)

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Provide positive offset for left-turn lanes							37 (41)	37 (41)												
Provide right turn lane			25	25			25	25			24	24			4		8 (43)			
Provide roadside delineators											30	30							15	
Provide sidewalk set-backs																				
Provide smooth paved shoulders			15	15							15	15		53 (44)						
Provide target conventional enforcement of traffic laws																				
Provide target enforcement																				
Provide targeted speed enforcement																				
Provide traffic calming on intersection approaches through a combination of geometric and traffic control devices																				
Provide visors to shade signal lenses from sunlight																				
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting, etc)																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Provide/improve progression through a set of signalized intersections																				
Provide/improve signal progression																				
Reconstruct intersection																				
Redesign intersection approaches																				
Reduce speed limit on approaches											20 (45)	20 (45)	20	20						
Relocate of transit stops from the near side to the far side of the intersection																				
Relocate signal hardware out of clear zone																				
Relocate signals																				
Relocate transit stop																				
Remove constriction as parked vehicles																				
Remove deflection in through-vehicle travel path																				
Remove distracting commercial lights																				
Remove late night/early morning flash																				
Remove or relocate sign																				
Remove or re-locate the median object																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
obstructing sight of opposite traffic																				
Remove or relocate trees																			66 (16)	
Remove or relocate utility poles					38	38													32	32
Remove sight obstructions	12 (3)																			
Remove the object obstructing the sight triangle	12 (3)						25 (46)	25 (46)												
Remove unwarranted signal			75	75							53	53						24		
Removed or relocate unnecessary signs "visual clutter"																				
Replace poorly designed drain grates with bicycle-safe types																				
Restrict and prohibit turning maneuver by channelization or signing (enforcement may be required in the first stage)																				
Restrict left-turn maneuver					45	45														
Restrict or eliminate parking near corners											35 (10)	35 (10)							10	10
Restrict or eliminate turning maneuver																				
Restrict parking					22	22					35 (10)	35 (10)	8	8					10	10

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
											)	)								
Restrict parking near corners																			10	10
Re-strip shoulder to provide right turn lane (assure adequate distance to fix object)																				
Review signal timing (consider timing optimization)					10	10	15 (47)	15 (47)					10	10						
Shield drivers from poles in hazardous locations																				
Signed and marked crosswalks											25	25								
Trim vegetation																				
Upgrade signing					5 (47)	5 (47)														
Use "Slippery when wet" sign (temporary)																				
Use advance guide signs			25	25																
Use advance street name signs											25	25								
Use automated enforcement of approach speeds																				
Use break-away devices					30	30														
Use flashing lights in advance on approach					50	50														
Use other traffic calming applications to reduce vehicle speeds or traffic																				

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
volumes on intersection approaches.																				
Use post-mounted delineation													25 (48)	25 (48)						
Use protected phase		70 (49)	27	27				25								70 (49)				
Use Protected/Permitted phase			10 (50)	10 (50)			10	10												
Use salt to prevent snow or ice from forming or from sticking to the road surface																				
Use sand to increase pavement friction																				
Use split phases																				
Use two red signal sections																				
Widen the outside through lanes or add bike lanes																				

COMMENTS

- (1) – all type of crashes
- (2) - channelization – CRF=50% for Rear End, Head On, Sideswipe Same Direction, Sideswipe Opposite Direction, Left Turn, and Run-off-the-Road crashes.
- (3) – the following reduction applies: in 1 quadrant - 5%, in 2 quadrant - 9%, in 3 quadrant 13%, in 4 quadrant -17%
- (4) - provide left turn with signal
- (5) - for single lane approach; multiple lane approach: 5% only urban
- (6) - queue detection ramp location
- (7) - relocate object fatal only CRF=60%
- (8) - conflict elimination
- (9) - crashes with emergency vehicle
- (10) - eliminate parking
- (11) - right angle collisions
- (12) - for left turn; if new CRF=50%, existing CRF=30%, no left lane CRF=20%
- (13) - provide illumination for intersection
- (14) - provide delineation
- (15) - total injury
- (16) – fatal crashes only
- (17) - install object marker
- (18) - only for pedestrian
- (19) – fatal only: install signal heads
- (20) - install signal backplates
- (21) - provide illumination for Intersection
- (22) - for intersection only
- (23) - general warning sign
- (24) - general warning (sign/other)
- (25) – 12 inch
- (26) – crash type: turning, angle, rear-end, sideswipe - over
- (27) - general install rumble strips

- (28) - rumble strip general
- (29) - general variable message sign
- (30) – general information messages
- (31) - provide illumination for intersection
- (32) – width: from 2ft to 8ft: 12%, from 4ft to 8ft:9%, from 6ft to 8ft:5% (only for paved shoulder)
- (33) - general length turning lanes
- (34) - all: 8%, rear-end (-12%), angle - 4%, pedestrian 34%
- (35) - by 5ft, 8ft, 10ft, 15ft, 20ft CRF is respectively: 13%,21%,25%,35%,44%
- (36) - speed reduction (not crashes)
- (37) - widen pavement
- (38) – 10ft-12ft
- (39) – only crosswalk (no school zone) data for Israel
- (40) - improve clearance interval al
- (41) - provide offset
- (42) - exclusive pedestrian phase
- (43) - 4 leg both approaches
- (44) - urban multilane
- (45) - modify speed limit
- (46) - clear sight triangle
- (47) - general upgrade signing
- (48) - for horizontal curve only
- (49) - change from permitted to protected
- (50) - add protected/permissive left turn phase

All-Way Stop-Controlled Intersection

	S1		S2		S3		S4		s5		s6		s7		s8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Add overhead stop-signs if the percent of tall vehicles is considerable																				
Add special signing																				
Change horizontal/vertical alignment			58	58							50	50	50	50					10	10
Chip and seal or slurry seal approaches																				
Close curb lanes																				
Close or relocate the driveways			50	50																
Construct pedestrian refuge islands and raised medians		46	60 (4)	60 (4)	32	23									46					
Eliminate screening by physical objects													50 (7)	50 (7)					76 (8)	76 (8)
Eliminate shoulder drop-off											25	25							30 (9)	30 (9)
Enforce stop sign compliance																				
Extend "no parking" zone.					22	22					35 (10)	35 (10)							10	10
Groove pavement surface			21	21			14	14											46	46
Implement road narrowing measures																				
Improve alignment/grade																				
Improve channelization/delineatio											30 (11)	30 (11)	40	40					15	

	S1		S2		S3		S4		s5		s6		s7		s8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
n											)	)								
Improve clear zone					25 (12)	25 (12)														
Improve existing street lights	30	30			50	50														
Improve lanes width	8 (13)														8					
Improve pavement marking in the median opening			21	21																
Improve signage and/or marking of the crosswalk											25	25								
Improve skid resistance			9	9																
Improve winter maintenance methods																				
Improve winter maintenance preparedness (shorter response time)																				
Improve/install reflective signs			15	15																
Improve/install reflectorized pavement markers																				
Increase width of the shoulders	9 (16)		14	14							20	20			9				14	
Install a barrier curb or a guardrail	45 (17)	45 (17)	11	11			47 (18)	47 (18)						4			44 (7)	44 (7)		
Install a pedestrian overpass or underpass			86	86															91	91
Install a stop sign			35	35							39	39								
Install a triangular island to relocate the right-																				

	S1		S2		S3		S4		s5		s6		s7		s8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
turning movement away from other movements																				
Install adequate traffic control device for bicycles (i.e. stop sign)																				
Install advance warning sign	20	20	25	25			25 (19)	25 (19)					30	40						
Install an object marker							16	16												
Install channelization of the driveways									50 (20)	50 (20)										
Install corner mirrors																				
Install curbing to define driveway location																				
Install curb-ramps																				
Install flashing beacons	30	30			50	50	30 (21)	30 (21)			30	30	24	24						
Install fog - warning signs							25 (19)	25 (19)												
Install guardrails					20	20	47	47			65 (4)	65 (4)	4				44 (4)	44 (4)		
Install larger regulatory and warning signs at and in advance of intersections											15 (23)	15 (23)	40	30						
Install lighting	30	30	33	33	50 (25)	50 (25)					30	30	37	37					37 (26)	37 (26)
Install median divider	15 (27)	15 (27)																		

	S1		S2		S3		S4		s5		s6		s7		s8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Install overhead flashing beacon lights	30	30			50	50	30 (21)				30	30	24	24						
Install pavement markings	10	10	21	21					21	21									10	10
Install pedestrian actuated signals																				
Install pedestrian barriers																				
Install pedestrian crosswalk			25	25					25	25										
Install raised crosswalk																				
Install reflectorized pavement marking																				
Install regulatory signs on the both side of the road																				
Install rumble strips			32	32	28	28					25 (23)	25 (23)			21				50	50
Install school crossing sign			18	18							14	14								
Install school zone markings																				
Install sidewalk set-backs																				
Install speed limit sign																				
Install static or variable message signs displaying weather information			15	15							15 (23)	15 (23)								
Install street lights	30	30			50 (25)	50 (25)														

	S1		S2		S3		S4		s5		s6		s7		s8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Install streets name signs											25	25								
Install traffic signals		14	30 (29)	30 (29)							28	28	28	28		23	23 (30)	23 (30)		
Install/Improve lighting at the access points			33 (31)	33 (31)							30	30	37	37					37 (26)	37 (26)
Installing snow screens in areas exposed to snowdrifts																				
Move driveway to side street			50 (32)	50 (32)	15	15														
Overlay pavement			17	17	18	18	27	27												
Post an adequate speed limit					28	28							20	20						
Post dynamic message sign to display the speed of approaching vehicles.																	74 (33)	74 (33)		
Provide adequate median width that will not limited visibility																				
Provide "slippery when wet" signs																				
Provide a double yellow centerline on the median opening of a divided highway at intersections																				
Provide acceleration and deceleration lanes			26	26							10 (11)	10 (11)	10	10						
Provide adequate delineation for left-turns											30	30								

	S1		S2		S3		S4		s5		s6		s7		s8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
at the intersection (markers or lines)																				
Provide adequate drainage			20	20																
Provide independent bicycle path where necessary																				
Provide median refuges		46																		
Provide on-pavement horizontal signing																				
Provide pavement marking (stop sign, chevron, etc.)			21	21	35 (37)								35	35			25 (37)			
Provide smooth paved shoulders			15	15										53 (38)					14	
Provide splitter islands																				
Provide targeted speed enforcement																				
Provide traffic calming on intersection approaches through a combination of geometric and traffic control devices																				
Provide visible stop bars																				
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting, etc.)																				
Reduce speed limit													20	20						
Reduce the number of lanes if allowed by capacity																				

	S1		S2		S3		S4		s5		s6		s7		s8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Relocate islands																				
Relocate or split the stopping line																				
Relocate stop bar																				
Relocate stop sign																				
Relocate the sign to make it visible																				
Remove distracting commercial lighting or other source of glare											15	15								
Remove or relocate the object					60	60	29 (44)	29 (44)			30	30	50 (7)	50 (7)						
Remove sight obstructions	12 (42)														13 (43)					
Remove the object obstructing sight of the warning sign																				
Remove the object obstructing the sight of the stop sign																				
Remove the object obstructing the sight triangle	12 (42)						25	25							13 (43)				10	10
Remove the object obstructing visibility from the median																				
Replace poorly designed drain grates with bicycle-safe types																				
Replace, repair or clean the warning signs					20	20	25	25												
Reroute pedestrian paths																				

	S1		S2		S3		S4		s5		s6		s7		s8		S9,S10		S11-S21	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U
Restrict left-turning at the access points																			100 (47)	
Restrict parking near the driveway					22 (48)	22 (48)					35	35	8	8					10	10
Restrict parking on the approach																			10	10
Signals to alert motorists that pedestrians are crossing																				
Trim vegetation																				
Trim vegetation on the median																				
Upgrade signing					5 (45)	5 (45)					24	24								
Use "Slippery when wet" sign (temporary)																				
Use break-away devices					30	30														
Use salt to prevent snow or ice from forming or from sticking to the road surface																				
Use sand to increase pavement friction																				
Use school crossing guards																				
Widen the outside through lanes or add bike lanes																				

COMMENTS

- (1) - added painted lane
- (2) - rural both approaches, 4 legs
- (3) - four legs intersection
- (4) – reduction in pedestrians fatal only
- (5) - for single lane approach; multiple lane approach CRF=5% only urban
- (6) – single lane
- (7) – fatal only
- (8) – conflict elimination
- (9) – shoulder treatment
- (10) – eliminate parking
- (11) – post delineation
- (12) - widen by 5,8,10,15,20 [ft] CRF is respectively: 13%,21%,25%,35%,44%
- (13) – widen lanes: 9ft-12ft CRF=12%; 10ft -12ft CRF=8%; 11ft-12ft CRF=2%
- (14) - provide illumination for intersection
- (15) – general any turn lane
- (16) - for width: 2ft-8ft: 12%, 4ft-8ft: 9%, 6ft-8ft:5% (only for paved shoulder)
- (17) – fatal CRF=44%; injury CRF=47%
- (18)- total injury crashes (incl. fatal)
- (19) – warning general
- (20) - channelization – CRF=50% for Rear End, Head On, Sideswipe Same Direction, Sideswipe Opposite Direction, Left Turn, and Run-off-the-Road crashes.
- (21) - for intersection only
- (22) - provide left turn lane without signal
- (23) – general warning and large sign
- (24) - 4 leg intersection
- (25) - provide illumination for intersection
- (26) – CRF between 25%-50%
- (27) - add mountable median

- (28) - turning, angle, rear-end, sideswipe - over
- (29) - 3 leg: all types CRF=14%; angle CRF=34%, rear-end CRF= (-50%), 4 leg: all types CRF=23%; angle CRF=67%, rear-end CRF= (-38%)
- (30) - 4 leg all crashes
- (31) - treat as intersection
- (32) - relocate driveway entrance: left, right, angle=10%; rear, head=20%
- (33) - speed reduction (not crashes)
- (34) - pavement markings
- (35) - edge line markings
- (36) – edge lines
- (37) – chevron
- (38) - urban multilane
- (39) - 4 leg intersection
- (40)- 4 leg both approaches
- (41) - modify speed limit
- (42) - the following reduction applies: in 1 quadrant - 5%, in 2 quadrant - 9%, in 3 quadrant 13%, in 4 quadrant -17%
- (43) - 3 quadrant
- (44) - removed fixed object (relocate=35%)
- (45) - general upgrade signing
- (46) - prohibit turning
- (47) - only turning crashes
- (48) - prohibit on street parking
- (49) - pavement widening
- (50) - widening and resurfacing or widening alone
- (51) - average from 1ft and 2 ft
- (52) – 10ft -12 ft
- (53) - average from width: 4ft, 10ft, 20 ft

The final CRF values

TWSC

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Add overhead stop-signs if the percent of tall vehicles is considerable																					20
Add special signing																					10
Add stop-lines in the median opening																					10
Adjust signal offsets at the upstream signalized intersections to create more gaps																					20
Change horizontal/vertical alignment			58	58							50	50	50	50					10	10	42
Chip and seal or slurry seal approaches																					10
Close curb lanes																					25
Close or relocate the driveways			50	50																	50
Consider indirect left turns			34	34			35	35	25	25	41	41	32	32			48	47	24		35
Consider intersection type "J" (no directly left turn)																					20
Consider moving the right-turn lanes on the major road laterally																					20
Consider traffic signals with protected left-turn phase																					40
Construct Pedestrian Refuge Islands and		46	60	60	32	23										46					45

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Raised Medians																					
Convert the intersection into a roundabout	58	72					40	40	40	40					58	72	58	72	38	38	52
Eliminate screening by physical objects													50	50					76	76	63
Eliminate shoulder drop-off											25	25							30	30	28
Enforce stop sign compliance																					70
Extend "no parking" zone.					22	22					35	35							10	10	22
Groove pavement surface			21	21			14	14											46	46	27
Implement Road Narrowing Measures																					30
Improve alignment/grade																					35
Improve channelization/delineation											30	30	40	40					15		31
Improve clear zone					25	25															25
Improve existing street lights	30	30			50	50															40
Improve lanes width	8														8						8
Improve pavement marking			21	21																	21
Improve pavement marking in the median opening			21	21																	21
Improve signage and/or marking of the crosswalk											25	25									25
Improve skid resistance			9	9																	9
Improve visibility from median toward major approach																			10	10	10
Improve visibility of intersections by providing											30	30									30

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
enhanced signing and delineation																					
Improve visibility of the intersection by providing lighting	30	30	33	33	50	50					30	30	37	37					37	37	36
Improve winter maintenance methods																					25
Improve winter maintenance preparedness (shorter response time)																					20
Improve/install reflective signs			15	15																	15
Improve/install reflectorized pavement markers																					12
Increase length of the right turn lanes			28	28			15	15			28	28									24
Increase radius of the corner curve			13	13							15	15									14
Increase the crosswalk setback																					15
Increase the length of the left turn lanes			28	28			15	15			28	28									24
Increase the turning path radius			13	13							15	15									14
Increase width of the shoulders	9		14	14							20	20			9				14		14
Install a barrier curb or a guardrail	45	45	11	11			47	47						4			44	44			33
Install a pedestrian overpass or underpass			86	86															91	91	89
Install a stop sign			35	35							39	39									37
Install a triangular island to																					25

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
relocate the right-turning movement away from other movements																					
Install acceleration lanes sufficiently long for trucks			26	26																	26
Install advance warning sign	20	20	25	25			25	25					30	40							26
Install an acceleration lane			26	26							10	10	10	10							15
Install an object marker							16	16													16
Install channelization of the driveways									50	50											50
Install corner mirrors																					10
Install curbing to define driveway location																					20
Install curb-ramps																					15
Install flashing beacons	30	30			50	50	30	30			30	30	24	24							33
Install flashing beacons at stop-controlled intersections					50	50	30	30					24	24							35
Install fog - warning signs							25	25													25
Install guardrails					20	20	47	47			65	65		4			44	44			40
Install indirect left-turn lanes			34	34			35	35													35
Install larger regulatory and warning signs at and in advance of intersections											15	15	40	30							25
Install larger regulatory and warning signs at intersections											15	15									15
Install left turn acceleration lane			26	26							10	10									18
Install left turn bays	28	27			20	20									28	27					25
Install lighting	30	30	33	33	50	50					30	30	37	37					37	37	36

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Install median divider	15	15																			15
Install overhead flashing beacon lights	30	30			50	50	30	30			30	30	24	24							33
Install pavement markings	10	10	21	21					21	21									10	10	16
Install pedestrian actuated signals																					35
Install pedestrian barriers																					60
Install pedestrian crosswalk			25	25					25	25											25
Install raised crosswalk			25	25					25	25							46				29
Install reflectorized pavement marking																					57
Install regulatory signs on the both side of the road																					20
Install right turn bays if the number of vehicle turning right is considerable																					25
Install right turn lane		14	25	25			25	25			24	24			14		26		10		21
Install rumble strips			32	32	28	28					25	25			21				50	50	32
Install school crossing sign			18	18							14	14									16
Install school zone markings																					20
Install shoulder rumble strips	21						29	29	30	30	25	25			21		25	25	35	35	28
Install sidewalk set-backs																					20
Install speed limit sign																					15
Install static or variable message signs displaying weather information			15	15							15	15									15
Install street lights	30	30			50	50															40
Install streets name signs											25	25									25
Install traffic signals		14	30	30							28	28	28	28		23	23	23			26

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Install/Improve lighting at the access points			33	33							30	30	37	37					37	37	34
Install/improve signing or marking of pedestrian crosswalks											15	15					16	16			16
Install/improve warning signs			25	25	20	20	25	25			25	25									24
Installing snow screens in areas exposed to snowdrifts					53	53															53
Move driveway to side street			50	50	15	15															33
Overlay pavement			17	17	18	18	27	27													21
Post an adequate speed limit					28	28							20	20							24
Post dynamic message sign to display the speed of approaching vehicles.																	74	74			74
Properly maintain the striping																					10
Provide "Slippery when wet" signs																					25
Provide a bypass lane on the approach with left-turn traffic																					10
Provide a double yellow centerline on the median opening of a divided highway at intersections																					5
Provide acceleration and deceleration lanes			26	26							10	10	10	10							15
Provide adequate delineation for left-turns at the intersection (markers											30	30									30

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
or lines)																					
Provide adequate drainage			20	20																	20
Provide adequate lanes signing or marking					21	21															21
Provide adequate turning markers or pavement markings	10	10	21	21															10	10	14
Provide dashed markings (extended left edgelines) for major-road continuity across the median opening at divided highway intersections					24	24					30	30	11	11							22
Provide independent bicycle path where necessary																					20
Provide median refuges		46																			46
Provide offset for left turn lanes on the opposite approaches							10	10													10
Provide on-pavement horizontal signing																					10
Provide pavement marking (stop sign, chevron, etc.)			21	21	35	35							35	35			25				30
Provide roadside markers or pavement markings to assist drivers in judging the suitability of available gaps for making turning and crossing maneuvers																					10
Provide smooth paved shoulders			15	15										53					14		24
Provide splitter islands																					35

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Provide stop signs			35	35							39	39									37
Provide targeted speed enforcement																					70
Provide traffic calming on intersection approaches through a combination of geometric and traffic control devices																					20
Provide traffic signal if warranted											28	28				23	23	23			25
Provide visible stop bars																					5
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting, etc)																					28
Reconstruct the radius			13	13							15	15									14
Reduce speed on the major road											20	20	20	20							20
Reduce speed limit													20	20							20
Reduce the number of lanes on the minor approach if allowed by capacity																					15
Relocate crosswalk																					15
Relocate islands																					10
Relocate or split the stopping line																					10
Relocate stop bar																					10
Relocate stop sign																					15
Relocate the sign to make it visible																					20
Remove distracting											15	15									15

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
commercial lighting or other source of glare																					
Remove or re-locate the median object obstructing sight of opposite traffic	12														13				10	10	11
Remove or relocate the object					60	60	29	29			30	30	50	50							42
Remove sight obstructions	12														13						13
Remove the object obstructing sight of the warning sign																					20
Remove the object obstructing the sight of the stop sign																					30
Remove the object obstructing the sight triangle	12						25	25							13				10	10	16
Replace poorly designed drain grates with bicycle-safe types																					10
Replace, repair, or clean the sign					5	5															5
Replace, repair, or clean the warning signs					20	20	25	25													23
Reroute pedestrian paths																					30
Restrict left-turn maneuver					40																40
Restrict left-turning at the access points																			100		100
Restrict parking near the driveway					22	22					35	35	8	8					10	10	19
Restrict parking on the approach																			10	10	10
Signals to alert motorists that pedestrians are																	16	16			16

	S1		S2		S3		S4		S5		S6		S7		S8		S9,S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
crossing																					
Trim vegetation																					35
Upgrade signing					5	5					24	24									15
Use "Slippery when wet" signs																					15
Use break-away devices					30	30															30
Use salt to prevent snow or ice from forming or from sticking to the road surface																					20
Use sand to increase pavement friction																					20
Use school crossing guards																					50
Vehicles in the right-turn lane on the major road block the minor-road drivers' view of traffic approaching on the major road																					15
Widen lanes to adequate width			40	40	38		22	22	30	30	25	25	23	23	8				13	13	25
Widen the median to provide sufficient protection to crossing vehicles																					5
Widen the median width													13	13							13
Widen the outside through lanes or add bike lanes																					15

AWSC

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Add overhead stop-signs if the percent of tall vehicles is considerable																					20
Add special signing																					10
Change horizontal/vertical alignment			58	58							50	50	50	50					10	10	42
Chip and seal or slurry seal approaches																					10
Close curb lanes																					10
Close or relocate the driveways			50	50																	50
Construct pedestrian refuge islands and raised medians		46	60	60	32	23									46						45
Eliminate screening by physical objects													50	50					76	76	63
Eliminate shoulder drop-off											25	25							30	30	28
Enforce stop sign compliance																					70
Extend "no parking" zone					22	22					35	35							10	10	22
Groove pavement surface			21	21			14	14											46	46	27
Implement road narrowing measures																					30
Improve alignment/grade																					35
Improve channelization/delineation											30	30	40	40					15		31
Improve clear zone					25	25															25
Improve existing street lights	30	30			50	50															40
Improve lanes width	8														8						8

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Improve pavement marking in the median opening			21	21																	21
Improve signage and/or marking of the crosswalk											25	25									25
Improve skid resistance			9	9																	9
Improve winter maintenance methods																					25
Improve winter maintenance preparedness (shorter response time)																					20
Improve/install reflective signs			15	15																	15
Improve/install reflectorized pavement markers																					12
Increase width of the shoulders	9		14	14							20	20			9				14		14
Install a barrier curb or a guardrail	45	45	11	11			47	47					4				44	44			33
Install a pedestrian overpass or underpass			86	86															91	91	89
Install a stop sign			35	35							39	39									37
Install a triangular island to relocate the right-turning movement away from other movements																					25
Install adequate traffic control device for bicycles (i.e. stop sign)																					10
Install advance warning sign	20	20	25	25			25	25					30	40							26
Install an object marker							16	16													16

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Install channelization of the driveways									50	50											50
Install corner mirrors																					10
Install curbing to define driveway location																					20
Install curb-ramps																					15
Install flashing beacons	30	30			50	50	30	30			30	30	24	24							33
Install fog - warning signs							25	25													25
Install guardrails					20	20	47	47			65	65		4			44	44			40
Install larger regulatory and warning signs at and in advance of intersections											15	15	40	30							25
Install lighting	30	30	33	33	50	50					30	30	37	37					37	37	36
Install median divider	15	15																			15
Install overhead flashing beacon lights	30	30			50	50	30	30			30	30	24	24							33
Install pavement markings	10	10	21	21					21	21									10	10	16
Install pedestrian actuated signals																					35
Install pedestrian barriers																					60
Install pedestrian crosswalk			25	25					25	25											25
Install raised crosswalk																					29
Install reflectorized pavement marking																					57
Install regulatory signs on the both side of the road																					20
Install rumble strips			32	32	28	28					25	25			21				50	50	32
Install school crossing sign			18	18							14	14									16
Install school zone markings																					20
Install sidewalk set-backs																					20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Install speed limit sign																					15
Install static or variable message signs displaying weather information			15	15							15	15									15
Install street lights	30	30			50	50															40
Install streets name signs											25	25									25
Install traffic signals		14	30	30							28	28	28	28		23	23	23			26
Install/Improve lighting at the access points			33	33							30	30	37	37					37	37	34
Installing snow screens in areas exposed to snowdrifts																					53
Move driveway to side street			50	50	15	15															33
Overlay pavement			17	17	18	18	27	27													21
Post an adequate speed limit					28	28							20	20							24
Post dynamic message sign to display the speed of approaching vehicles.																	74	74			74
Provide adequate median width that will not limited visibility																					15
Provide "slippery when wet" signs																					15
Provide a double yellow centerline on the median opening of a divided highway at intersections																					5
Provide acceleration and deceleration lanes			26	26							10	10	10	10							15
Provide adequate delineation for left-turns at											30	30									30

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
the intersection (markers or lines)																					
Provide adequate drainage			20	20																	20
Provide independent bicycle path where necessary																					20
Provide median refuges		46																			46
Provide on-pavement horizontal signing																					10
Provide pavement marking (stop sign, chevron, etc.)			21	21	35	35							35	35			25				30
Provide smooth paved shoulders			15	15										53					14		24
Provide splitter islands																					35
Provide targeted speed enforcement																					70
Provide traffic calming on intersection approaches through a combination of geometric and traffic control devices																					20
Provide visible stop bars																					5
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting,etc.)																					28
Reduce speed limit													20	20							20
Reduce the number of lanes if allowed by capacity																					15
Relocate islands																					10
Relocate or split the stopping line																					10

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Relocate stop bar																					10
Relocate stop sign																					15
Relocate the sign to make it visible																					20
Remove distracting commercial lighting or other source of glare											15	15									15
Remove or relocate the object					60	60	29	29			30	30	50	50							42
Remove sight obstructions	12														13						13
Remove the object obstructing sight of the warning sign																					20
Remove the object obstructing the sight of the stop sign																					30
Remove the object obstructing the sight triangle	12						25	25							13				10	10	16
Remove the object obstructing visibility from the median																					20
Replace poorly designed drain grates with bicycle-safe types																					10
Replace, repair or clean the warning signs					20	20	25	25													23
Reroute pedestrian paths																					30
Restrict left-turning at the access points																			100		90
Restrict parking near the driveway					22	22					35	35	8	8					10	10	19
Restrict parking on the approach																			10	10	10

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Signals to alert motorists that pedestrians are crossing																					16
Trim vegetation																					35
Trim vegetation on the median																					25
Upgrade signing					5	5					24	24									15
Use "Slippery when wet" sign (temporary)																					15
Use break-away devices					30	30															30
Use salt to prevent snow or ice from forming or from sticking to the road surface																					20
Use sand to increase pavement friction																					20
Use school crossing guards																					50
Widen the outside through lanes or add bike lanes																					15

RRC

	S1	S2	S3	S4	S5	S6	S7	S8	S9-S10	S11-S21	S23	FINAL
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	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Add overhead stop-signs if the percent of tall vehicles is considerable																							20
Change horizontal/vertical alignment (skewed-angle crossing)																				45	45		45
Chip and seal or slurry seal approaches																							10
Close or install overpass																							90
Close rail-road crossing point																							90
Eliminate screening by physical objects																							63
Extend "no parking" zone.																							22
Groove pavement surface																							27
Improve channelization/delineation												30	30	40	40			75	75	15			44
Improve existing street lights at the rail-road crossing points	30	30			50	50																	40
Improve gates visibility/reflectivity (flashing lights along the gate)			75	75																			75
Improve maintenance of rail infrastructure (Motion Sensitive Devices, Constant Warning Time)																					50	50	50
Improve maintenance of train detective devices																							10
Improve maintenance of visual/audio signals																							15
Improve maintenance/work of																							35

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S23		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
existing gates																							
Improve pavement markings and texturing																							16
Improve signage of the crosswalk											25	25											25
Improve skid resistance			9	9																			9
Improve winter maintenance methods																							25
Improve winter maintenance preparedness (shorter response time)																							20
Improve/install reflective signs			15	15																			15
Improve/install reflectorized pavement markers																							12
Install a bicycles overpass or underpass																							90
Install a fence or chicane to prevent bicycles running across the track																							30
Install a fence or chicane to prevent pedestrians running across the track																							30
Install a pedestrian overpass or underpass			86	86																			86
Install active control devices	50	50																					50
Install adequate control device.																							20
Install advance warning sign	20	20	25	25			25	25	40	40			30	40							50	50	33

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S23		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Install audible signals (warning bell)									50	50													50
Install automated bicycles/pedestrians gates																					50	50	50
Install automated pedestrian gates																							30
Install automatic gates			75	75																			75
Install bicycles signals																							20
Install cantilever flashing-light signal																							33
Install corner mirrors																							20
Install crossbuck									60	60													60
Install DO NOT STOP ON TRACKS signal																							10
Install fixed message signs																							10
Install flashers			75	75																			75
Install flashing beacons.	30	30	65	65	50	50	30	30	60	60	58	58	24	24									45
Install flashing light activated by queuing traffic in the exit lane(s) from the crossing																							25
Install fog - warning signs							25	25															25
Install four-quadrant gate arms																					55	55	55
Install gates			65	65																	46	46	56
Install gates with self deploying extension sections																							20
Install lighting	30	30	33	33	50	50					30	30	37	37					37	37	45	45	37
Install median barriers																							35

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S23		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Install median retroreflective post delineators on the approach																							15
Install non-mountable curb islands																							20
Install overhead signs																							10
Install pavement markings	10	10	21	21					21	21					10	10			10	10			14
Install pedestrian barriers																							25
Install pedestrian signals																							15
Install pre-signals																					50	50	50
Install rumble strips			32	32	28	28					25	25			21				50	50			32
Install signs on both sides of highway																							20
Install speed humps																					40	40	40
Install static or variable message signs displaying weather information			15	15							15	15											15
Install stop sign			35	35							39	39									46	46	40
Install street lights	30	30			50	50																	40
Install swing gates																							25
Install symbol storage space sign																							10
Install variable message signs and blank out signs																							20
Install vehicle-arresting barriers																							25
Install warning signs in advance of rail-road crossing									40	40											50	50	45
Install yield sign																							10

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S23		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Installing snow screens in areas exposed to snowdrifts																							53
Overlay pavement (friction course)			17	17	18	18	27	27															21
Post a lower speed limit for cars and/or trains																							20
Post an adequate speed limit					28	28							20	20									24
Post dynamic message sign to display the speed of approaching vehicles.																	74	74					74
Provide adequate delay																					33	33	33
Provide adequate drainage																							20
Provide adequate gate interval																					50	50	50
Provide adequate information to train operator (for example: location of the whistle post)																							15
Provide information of the crossing type																							10
Provide pavement marking					35	35					10	10	35	35									27
Provide photo video enforcement																					56	56	56
Provide targeted speed enforcement																							70
Provide traffic calming on approaches through a combination of geometric																							20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S23		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
and traffic control devices																							
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting, etc)											34	34											34
Relocate control device																							20
Relocate stop bar (If stop sign present)																							10
Relocate stop sign																							15
Relocate the crossing section																							30
Remove distracting commercial lights											15	15											15
Remove the object obstructing the sight of the control device																							20
Remove the object obstructing the sight of the stop sign																					47	47	47
Remove the object obstructing the sight triangle	12						25	25							13				10	10	50	50	24
Remove the object obstructing view from the approach																					50	50	50
Replace / repair signals																							10
Replace, repair, or clean the control device																							20
Replace, repair, or clean the sign					5	5																	5
Trim vegetation																							35

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		S23		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Upgrade signing					5	5					24	24											15
Use “Slippery when wet” sign (temporary)																							15
Use photo video enforcement																					56	56	56
Use salt to prevent snow or ice from forming or from sticking to the road surface																							20
Use sand to increase pavement friction																							20

RS

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Add special signing																					10
Centerline rumble strips for two-lane roads			32	32	32	32					25	25			12		22	22			26
Chip and seal or slurry seal approaches																					10
Close or relocate the driveways			50	50	15	15															33
Construct pedestrian refuge islands and raised medians		46																			46
Create additional parking spaces																					10

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Cut trees and other roadside vegetation obstruct the view					25	25															25
Design safer slopes and ditches to prevent rollovers					35	35															35
Eliminate screening by physical objects					60	60							50	50					76	76	62
Eliminate shoulder drop-offs											25	25							30	30	28
Eliminating compound curves																					25
Enhance delineation of sharp curves					16	16							17	17			15		15		16
Enhance delineation of sharp curves segment					16	16											15		15		16
Groove pavement surface			21	21			14	14											46	46	27
Identify and treat truck crash roadway segments—signing																					26
Implement lighting / illumination measures	23	23	28	28							25	25	37	37					37	37	30
Implement road narrowing measures																					30
Improve alignment																					35
Improve channelization/delineation											30	30	40	40							35
Improve clear zone					25	25															25
Improve existing street lights	30	30			50	50															40
Improve lanes width	9										25	25	23	23	8						19

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Improve or restore superelevation	11		28	28							40	40			11						26
Improve pavement markings			21	21	10	10			21	21									10	10	16
Improve pavements resistant																					9
Improve reflectorization/conspicuity of pedestrians																					20
Improve signage and/or marking of the crosswalk					5	5					25	25									15
Improve skid resistance			9	9															20	20	15
Improve skid resistance along the segment			9	9																	9
Improve winter maintenance methods																					25
Improve winter maintenance preparedness (shorter response time)																					20
Improve/install reflective signs			15	15																	15
Improve/install reflectorized pavement markers																					57
Incorporate rumble strips into new and existing roadways			32	32	32	32					25	25									30
Increase efficiency of use of existing parking spaces																					10

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Increase width of the shoulders			14	14			8	8			20	20			9						13
Install "Cross only at Crosswalk" signs																					5
Install a barrier curb or a guardrail			11	11	20	20	47	47						4			44	44			28
Install a bridge warning sign			25	25			25	25			34	34									28
Install a pedestrian overpass or underpass			86	86															91	91	89
Install a tree marker					16	16															16
Install advance warning signs			25	25	36		25	25													27
Install advisor speed sign											26	26									26
Install a utility pole marker					16	16															16
Install central rumble strips	12						14	14			25	25			12		22	22	54	54	25
Install channelization of the driveways									50	50											50
Install curbing to define driveway location																					10
Install curb-ramps																					15
Install flashing beacons	30	30			50	50					30	30	54	54							41
Install fog - warning signs							25	25													25
Install Horizontal alignment signs (Turn, Curve, Reverse Turn, Winding Road)	30	30																			30
Install in-pavement luminaires																					20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Install interactive truck rollover signing																					10
Install larger regulatory and warning signs at and in advance of hazardous location											32	32									32
Install LED barrier-mounted guidance tubes																					20
Install light-emitting diode (LED)																					20
Install lighting	30	30	23	23	50	50					25	25	37	37					37	37	34
Install median barriers	60				61	61			63	63			90	90	60						69
Install median divider			15	15																	15
Install midlane rumble strips			32	32			14	14			25	25			12		22	22	54	54	28
Install overhead flashing beacon lights	30	30			50	50					30	30	54	54							41
Install Overpasses/Underpasses			86	86																	86
Install pavement markings			21	21	10	10			21	21									10	10	16
Install pedestrian actuated signals																					22
Install pedestrian barriers																					60
Install pedestrian crosswalk			25	25					25	25											25
Install raised crosswalk																	46				46
Install reflectorized pavement markings	10	10	10	10																	10
Install regulatory signs																					20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
on the both side of the road																					
Install rumble strips			32	32							25	25			21						27
Install school crossing sign			18	18							14	14									16
Install school zone markings																					20
Install shoulder rumble strips	21						29	29	30	30	25	25			21		25	25	35	35	28
Install sidewalk set-backs																					20
Install sidewalks			74	74							65	65							70	70	70
Install speed limit sign																					25
Install static or variable message signs displaying weather information			15	15							15	15									15
Install street lights	30	30			50	50															40
Install warning signs (can be install on both side of the road)			25	25	36		25	25													27
Install/Improve lighting at the access points			33	33							25	25	37	37					37	37	33
Installing snow screens in areas exposed to snowdrifts					53	53															53
Modify horizontal alignment			45	45	40		66	66			40	40							64	64	52
Modify roadside clear zone					25	25															25
Modify speed limits and increase enforcement to reduce truck and other vehicle											20	20									20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
speeds																					
Move driveway to side street			50	50	15	15															33
Overlay pavement (friction course)			17	17	18	18	27	27					13	34							21
Pave shoulders			15	15							15	15		53							23
Place utilities underground																					60
Placed delineation on guardrail located outside the roadway shoulder, along the curve					16	16					30	30	17	17			15		15		20
Post an adequate speed limit					28	28							20	20							24
Post dynamic message sign to display the speed of approaching vehicles.																	74	74			74
Profiled thermoplastic stripes for centerline																					10
Prohibit/Restrict trucks with very Long semitrailers on roads with horizontal curves that cannot accommodate truck offtracking																					60
Provide acceleration and deceleration lanes			26	26							10	10									18
Provide adequate drainage			20	20																	20
Provide adequate speed limit for trucks											20	20									20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Provide adequate vertical curve design (crest/redesign)			87	87	88		40	40	40	40	40	40	45	45							54
Provide advance warning of unexpected changes in horizontal alignment							25	25					30	30					18	18	24
Provide advance warning of unexpected changes in horizontal/vertical alignment							25	25			32	32	30	30							29
Provide advance warning of unexpected changes in vertical alignment							25	25			32	32	30	30							29
Provide breakaway and crashworthy mail box																					15
Provide breakaway and crashworthy sign supports					30	30															30
Provide chevrons					35	35					30	30	35	35			25				32
Provide dynamic curve warning system																			100		100
Provide enhanced pavement markings			10	10	10	10													10	10	10
Provide grooved pavement			21	21			14	14											46	46	27
Provide independent bicycle path where necessary																					40
Provide median refuges		46																			46

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Provide on-pavement horizontal signing																	10				10
Provide post-mounted delineators					16	16					30	30	25	25			15		15		22
Provide smooth paved shoulders			15	15			8	8						53							20
Provide targeted speed enforcement																					70
Provide traffic calming through a combination of geometric and traffic control devices																					20
Provide wider cross sections on two-lane roads																					20
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting, etc)																					28
Provide/Improve pavement surface along the segment (improve transitions, drop offs, fixed potholes, rutting, etc)																					28
Providing spiral transition curves																					20
Raised pavement markers					9	9					10	10	4	4			9	9			8
Reallocate total two-lane roadway width (lane and shoulder) to include a narrow																			50	50	50

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
"buffer median"																					
Relocate the sign to make it visible																					20
Remove distracting commercial lights																					15
Remove or relocate mail box					29	29					30	30							27	27	29
Remove or relocate sign					29	29															29
Remove or relocate trees					25	25													66	66	46
Remove or relocate utility Poles					38	38													32		36
Remove sight obstructions																					20
Remove the object obstructing sight of the warning sign																					20
Removed other obstructions					29	29															29
Replace poorly designed drain grates with bicycle-safe types																					10
Replace, repair, or clean the warning signs							25	25			24	24	30	40							28
Restrict left-turning at the access points					45	45															45
Restrict parking											35	35	8	8					10	10	18
Restrict parking near the driveway																					19
Shield drivers from poles in hazardous locations																					20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Signals to alert motorists that pedestrians are crossing																					10
Upgrade signing					5	5					24	24									15
Use "Slippery when wet" sign (temporary)																					15
Use alternating passing lanes or four-lane sections at key locations					30	30	25	25									35	35	25	25	29
Use break-away devices					30	30															30
Use salt to prevent snow or ice from forming or from sticking to the road surface																					20
Use sand to increase pavement friction																					20
Use school crossing guards																					50
Use transverse striping treatments																					10
Widen and/or pave shoulders	9		14	14			8	8			20	20		53					19	19	18
Widen the outside through lanes or add bike lanes																					15

SIGN

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Add illuminated/reflectorized name signs	23	23	28	28																	26
Add special signing																					10
Adjust minimum green or extension time																					10
Adjust phase time and cycle time																					15
Adjust yellow change interval															8		8				8
Change horizontal/vertical alignment			58	58							50	50	50	50							53

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Channelize intersections									50	50			70	70							60
Chip and seal or slurry seal approaches																					10
Clear sight triangles	12						25	25													21
Close intersection leg or convert to one-way street																					40
Consider indirect left turns			28	28			25	25	25	25	22	22						37			26
Construct interchanges																					50
Convert a four-leg intersection to two T intersection																					57
Convert intersection to roundabouts	58	72					40	40	40	40					58	72	58	72	38	38	52
Convert two T intersection to one four-leg intersection																					15
Convert two-way streets to a one-way pair																					35
Coordinate the railroad and traffic signal to provide preemption to the traffic signal when trains are approaching the intersection							30	30											25	25	28
Create one way streets																					45
Delineate turn path											30	30									30
Eliminate screening by physical objects					60	60							50	50					76	76	62
Employ emergency vehicle preemption																			70	70	70
Encourage safe speeds																					20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
through design																					
Extend "no parking" zone.					22	22					35	35	8	8					10	10	19
Groove pavement surface			21	21			14	14											46	46	27
Implement automated enforcement of red-light running (cameras)		9													9		25				14
Improve (add) coordinating signals																			25	25	25
Improve (add) phases (length)					30	30															30
Improve alignment/grade																					35
Improve existing street lights	30	30			50	50															40
Improve intersection angle																					30
Improve intersection skew angle							40	40													40
Improve left-turn lane geometry																					10
Improve right-turn lane geometry																					10
Improve signing and delineation											30	30	17	17					15		22
Improve skid resistance			9	9																	9
Improve winter maintenance methods																					25
Improve winter maintenance preparedness (shorter response time)																					20
Improve/install reflective			15	15																	15

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
signs																					
Improve/install reflectorized pavement markers																					12
Increase the crosswalk setback																					15
Install a barrier curb or a guardrail			11	11	20	20	47	47						4				44			26
Install a tree marker					16	16															16
Install additional signal head					50	50							31	31							41
Install adequate signings			30	30																	30
Install an utility poles marker					16	16															16
Install backplates							5	5			24	24									15
Install bicycles traffic lights																					20
Install curb-ramps																					15
Install flashing beacons	30	30			50	50	30	30			30	30	24	24							33
Install fog - warning signs			25	25			25	25					24	24							25
Install larger signal lenses			10	10							12	12	10	10							11
Install larger signs																					25
Install left-turn lane			28	28					25	25											27
Install median driver																					30
Install multi-dialer controller																					10
Install overhead street signing																					78
Install painted/raised islands (provide			23	23							10	10	10	10							14

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
adequate visibility of the island)																					
Install pedestrian overpasses			86	86															91	91	89
Install physical barriers to restrict pedestrian crossing maneuvers at higher-risk locations																					60
Install queue detection system																					22
Install raised crosswalk			25	25					25	25								46			29
Install right-turn lane		4	17	17																	13
Install rumble strips on approach			32	32							25	25							50	50	36
Install static or variable message signs displaying weather information			15	15							15	15									15
Install street lights	30	30			50	50															40
Install traffic actuated signal											22	22									22
Install warning sign			25	25	20	20	25	25					20	15							22
Install/improve center line markings			33	33	33	33					35	35									34
Install/improve Intersection lighting	30	30	33	33	50	50					30	30	37	37					37	37	36
Installing snow screens in areas exposed to snowdrifts					53	53															53
Lengthen left-turn lane	9		28	28			15	15													19
Lengthen right-turn lane	9		28	28			15	15													19
Lengthening clearance intervals		8	15	15														8			12

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Modify roadside clear zone					25	25													9	9	17
Optimize clearance interval																			9	9	9
Overlay pavement (friction course)			17	17	18	18	27	27					13	34							21
Place utilities underground																					60
Post an adequate speed limit					28	28							20	20							24
Post dynamic message sign to display the speed of approaching vehicles.																	74	74			74
Prohibit right turn on red			20	20	45	45															33
Prohibit turning movements					40						45	45									43
Provide additional pavement																					45
Provide adequate channelization and dealination			22	22					50	50											36
Provide adequate drainage			20	20																	20
Provide adequate lane width	9										25	25				8					17
Provide adequate left-turn lane width	9															8					9
Provide adequate right-turn lane width	9															8					9
Provide adequate signals for handicapped																					20
Provide adequate signing			30	30																	30

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Provide adequate signs and markings			30	30																	30
Provide all-red clearance interval			15	15																	15
Provide appropriate intervals for crossings and minimize wait time																					35
Provide bicycle box																					10
Provide breakaway and crashworthy sign supports					30	30															30
Provide channelization			22	22					50	50											36
Provide continuous sidewalks			74	74							65	65									70
Provide crossing guards for school children																					50
Provide far-side left-turn signal																					28
Provide grooved pavement			21	21			14	14											46	46	27
Provide independent bicycle path where necessary																					40
Provide indirect left turn (can be for high left turn volume)			28	28			25	25	25	25	22	22									25
Provide intersection lighting	30	30	33	33	50	50					30	30	37	37				37	37	37	36
Provide lights in crosswalks in schools zones																			43	43	43
Provide longer clearance intervals			15	15																	15
Provide louvers, visors,																					10

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
or special lenses so drivers are able to view signals only for their approach																					
Provide median refuges		46																			46
Provide offset for left turn lanes on the opposite approaches							37	37													37
Provide pavement markings			21	21	10	10			21	21									10	10	16
Provide pedestrian push buttons																					15
Provide pedestrian-only phase or pedestrian-lead phase during signal operation			20	20							23	23							50	50	31
Provide positive offset for left-turn lanes							37	37													37
Provide right turn lane			25	25			25	25			24	24				4		8			20
Provide roadside delineators											30	30							15		25
Provide sidewalk set-backs																					20
Provide smooth paved shoulders			15	15							15	15		53							23
Provide target conventional enforcement of traffic laws																					70
Provide target enforcement																					70
Provide targeted speed enforcement																					70
Provide traffic calming																					20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
on intersection approaches through a combination of geometric and traffic control devices																					
Provide visors to shade signal lenses from sunlight																					20
Provide/Improve pavement surface (improve transitions, drop offs, fixed potholes, rutting, etc)																					28
Provide/improve progression through a set of signalized intersections																					25
Reconstruct intersection																					45
Redesign intersection approaches																					35
Reduce speed limit on approaches											20	20	20	20							20
Relocate signal hardware out of clear zone																					62
Relocate signals																					20
Relocate transit stop																					15
Remove constriction as parked vehicles																					19
Remove deflection in through-vehicle travel path																					20
Remove distracting commercial lights																					45

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Remove late night/early morning flash																					20
Remove or relocate sign																					15
Remove or re-locate the median object obstructing sight of opposite traffic																					45
Remove or relocate trees																			66		66
Remove or relocate utility poles					38	38													32	32	35
Remove sight obstructions	12																				12
Remove the object obstructing the sight triangle	12						25	25													21
Remove unwarranted signal			75	75							53	53						24			56
Removed or relocate unnecessary signs "visual clutter"																					30
Replace poorly designed drain grates with bicycle-safe types																					25
Restrict and prohibit turning maneuver by channelization or signing (enforcement may be required in the first stage)																					60
Restrict left-turn maneuver					45	45															45
Restrict or eliminate parking near corners											35	35							10	10	23

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
Restrict or eliminate turning maneuver																					60
Restrict parking					22	22					35	35	8	8					10	10	19
Restrict parking near corners																			10	10	10
Re-strip shoulder to provide right turn lane (assure adequate distance to fix object)																					40
Review signal timing (consider timing optimization)					10	10	15	15					10	10							12
Shield drivers from poles in hazardous locations																					30
Signed and marked crosswalks											25	25									25
Trim vegetation																					40
Upgrade signing					5	5															5
Use "Slippery when wet" sign (temporary)																					15
Use advance guide signs			25	25																	25
Use advance street name signs											25	25									25
Use automated enforcement of approach speeds																					25
Use break-away devices					30	30															30
Use flashing lights in advance on approach					50	50															50
Use other traffic calming applications to reduce vehicle speeds or traffic																					20

	S1		S2		S3		S4		S5		S6		S7		S8		S9-S10		S11-S21		FINAL
	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	
volumes on intersection approaches.																					
Use post-mounted delineation													25	25							25
Use protected phase		70	27	27				25								70					44
Use Protected/Permitted phase			10	10			10	10													10
Use salt to prevent snow or ice from forming or from sticking to the road surface																					20
Use sand to increase pavement friction																					20
Use split phases																					25
Use two red signal sections																					36
Widen the outside through lanes add bike l.																					15