Road Safety Audit Program Guidelines

Maryland Department of Transportation
State Highway Administration
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Abbreviations / Acronyms

PM	-	Program Manager
RSA	-	Road Safety Audit
RSAPC	-	Road Safety Audit Program Coordinator
DEC	-	District Engineering Coordinator
FRAT	-	Fast Response Action Team
OHD	-	Office of Highway Development
OPPE	-	Office of Planning and Preliminary Engineering
OOTS	-	Office of Traffic and Safety
OOC	-	Office of Construction
MDOT	-	Maryland Department of Transportation
SHA	-	State Highway Administration
EMS	-	Emergency Medical Service

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
ROAD SAFETY AUDIT PROGRAM GUIDELINES

I. INTRODUCTION

The purpose of the guidelines is to provide guidance on the Road Safety Audit Process, roles and responsibilities, team selection process, performing a road safety audit, and audit documentation procedures.

Road safety audit is a formal procedure for assessing accident potential and safety performance for an existing and/or future roadways. However, its systematic application can also ensure that a growing awareness of good road safety principles is achieved throughout planning, design, construction and operations of the roadway. Road safety audit (RSA) is different from the typical reviews for project planning and highway design projects. The RSA review process consists of a multidisciplinary team of senior professionals representing offices from highway planning, highway and bridge design, traffic engineering, operations and construction, human factors, law enforcement, risk assessment, community traffic safety coordinators and others. This team is independent of anyone who is part of the planning and design team. The team's focus is on safety enhancements and not on compliance to highway design standards, alignments and/ or value engineering. Therefore, there is a distinct difference between the typical design reviews and the safety audit reviews. Road safety audit reviews focus on means to make roadways safer, even if standards are to be exceeded. The process takes into consideration the experience of a multi-disciplinary team of experts to address issues that aren't always emphasized in design. These issues include, but not limited to, accessibility by multi-modes of transportation, enforcement, human factors, construction and maintenance, work zone safety, risk assessment, traffic safety, etc.

The primary objective of a road safety audit is to ensure that all new and existing roads operate as safely as practical. This means that safety should be considered throughout the whole preparation and construction of any project. Road safety audit objectives are:

- To minimize the risk of accidents occurring on roadways, and to minimize their severity.
- To minimize the risk of accidents occurring on adjacent roads, i.e., to avoid creating accidents elsewhere on the road network.
- To recognize the importance of safety in highway planning and design; to meet the needs and perceptions of all types of road users; and to achieve a balance between needs where they may be in conflict.
- To reduce the long term costs of roadway design and improvements, bearing in mind that unsafe designs may be expensive or impossible to correct at a later stage.
- To improve the awareness of safe design practices by all involved in the planning, design, construction and operations of roads.

The basis for road safety audit is the application of safety principles to existing and new road design, to prevent accident occurrence or to reduce their severity. The principles are established through experience of effective accident remedial programs, planned studies of the influence of design and traffic management on safety, and of the factors contributing to the occurrence of crashes. The outcome of the audit is the identification of any potential problems, together with recommendations on how to rectify the problems.

The potential benefits from safety audit are difficult to quantify, due to both the uncertainty of estimating the numbers of accidents which would have occurred had there been no audit, and the lack of control data to make comparison with unaudited projects. Nevertheless, evidence suggests that the benefits can be substantial.

Why is roadway safety important? Obviously, everyone who uses our road system is concerned about safety. However, not everyone necessarily knows the contribution to the overall health and safety of your community made by roadway safety. The three major components of highway safety are driver behavior, vehicle safety, and roadway safety. Roadway Safety refers to that portion of overall highway safety that is determined by the roadway physical features such as road design, roadway signs, pavement markings, operating conditions, roadside objects (such as utility poles, signs, trees, guardrails), bridges, and intersections. The personal and economic costs of highway crashes to our citizens and communities are enormous. Here are a few points, about the national safety statistics, to put things in perspective: ***(Source: Roadway Safety Guide, Roadway Safety Foundation, 2004*)**

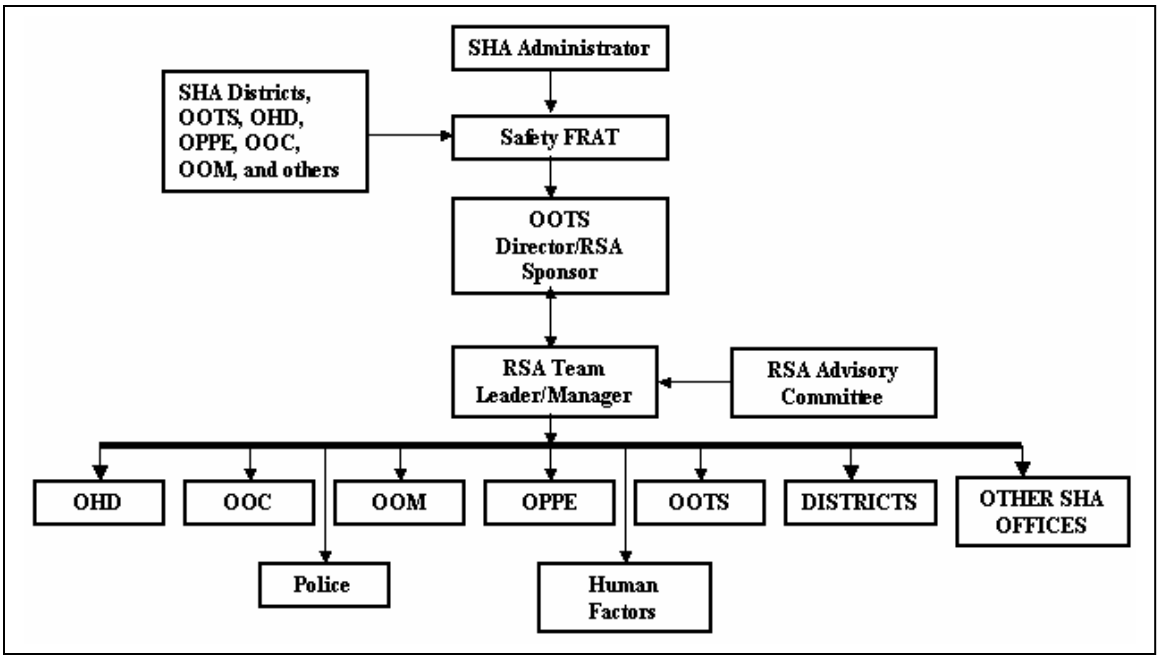
- Unlike driver behavior and vehicle design, where significant gains have been made, the percentage of deaths related to crashes with roadside hazards has increased over the past two decades.
- Roadside crashes account for one-third of all U.S. highway fatalities each year. More than 15,000 people are killed and nearly one million people are injured when vehicles run off the road and crash. According to the Transportation Research Board (TRB), many of these casualties result from crashes into roadside objects, such as trees or poles located dangerously close to the side of the road.
- Roadside crashes cost society $80 billion per year. The economic costs to society in medical expenses, worker losses, property damage, and emergency service compound the personal tragedies resulting from highway crashes.
- Local governments' costs from negligence lawsuits are rising. Tort litigation (arising out of highway crashes) against local and state government transportation agencies and officials is common today. Sovereign immunity, which once protected local governments from liability, is often waived today. Citizens can now sue, successfully, under conditions set by law.
- Removing roadside obstacles and realigning roadways can reduce fatalities by 66%.
- Constructing dedicated turning lanes and traffic channelization at high-risk intersections can reduce fatalities by 47%.
- Improving motorist information through improved signage and pavement markings can reduce fatalities by up to 39%.

Some of the potential outcomes from an RSA are listed bellows:

- Installation of rumble strips along the roadside has reduced run-off-the road crashes by 60%.
- Restoring surface friction by timely removal of ice and snow reduces injury crashes by 20% during winter months and by 88% right after a storm.

II. ROAD SAFETY AUDIT ROLES & RESPONSIBILITIES

The success of a road safety audit program relies on sound planning, coordination and execution. The following section identifies key players that will have an important role in planning, coordinating and executing of the road safety audit program; their functions are discussed accordingly. As shown in the ***organizational chart*** below, the RSA process is chaired by the SHA Administrator and led by the Safety Fast Response Action Team (FRAT).



The roles for each office are discussed below:

SHA Administrator: The SHA Administrator oversees the overall RSA process and will be briefed on the results at the conclusion for each project audited. He provides the financial, technical and managerial recourses to make sure the process is continuous and successful.

Safety FRAT Team: The Safety FRAT consists of Deputy Administrators and senior managers and engineers. They are responsible for the final screening and selection of RSA projects. The selection process is coordinated with other SHA divisions such as highways, bridges, planning, construction, maintenance, traffic and all Districts. Each office is required to present candidate projects to the Safety FRAT annually. FRAT reviews and studies all candidate projects and makes final selection(s). The final selection is presented to the Administrator for information and approval.

OOTS Director: The Director of OOTS is responsible for the oversight and management of the RSA program, liaison with all SHA Offices and Districts, manages all RSA training, and sponsors all RSA projects. The Director coordinates directly with the Safety FRAT for upcoming RSA projects and on-going audits.

RSA Program Coordinator (RSAPC): The Director of OOTS assigns a Team Leader to serve as the RSA Program Coordinator for a project. Assignment of team leaders could occur on a per project basis. The RSAPC responsibilities include, but are not limited to, the following:

- Develop, monitor and update policies and procedures for the RSA Program.
- Coordinate the annual list of proposed projects for consideration for audit.
- Assemble RSA personnel.
- Prepare a final annual list of projects selected for audit.
- Schedule and coordinate RSA Program Advisory Committee meetings.
- Coordinate RSA personnel training through seminars and workshops.
- Obtain project information from selective SHA Divisions and Districts.
- Make RSA team assignments based on project specifics.
- Coordinate team meetings for each stage of the project, and prepare meeting minutes.
- Oversee and monitor the implementation of RSA stages for all audits conducted.
- Coordinate with all Offices and Districts for availability of RSA personnel.
- Serve as a mediator for conflict resolution.
- Provide the RSA team with response to audit from the various SHA Divisions.
- Brief the SHA Safety FRAT on the progress of audits.
- Brief the RSA Program Advisory Committee on the annual progress of audits.
- Maintain all original correspondence, audit reports, budget and logistics associated with all audits.
- Monitor funding allocated to RSA projects and develop RSA Program annual budget.
- Compile evaluation data as appropriate for roads/projects for which audits were conducted.
- Prepare and present the RSA annual report to the Director of OOTS and the Safety FRAT.

Road Safety Audit Advisory Committee: A RSA Advisory Committee provides guidance and advice in the implementation of the RSA Program. The RSA Advisory Committee's role in the program is as follows:

- Participate in quarterly or semi-annual (as appropriate) meetings.
- Review program procedures and make recommendations to enhance operations.
- Review annual projects selected for audit.
- Review and approve an annual report to be submitted to the Director of OOTS and Deputy Administrators detailing progress, cost savings, and benefits realized by the program.

The RSA Program Advisory Committee is chaired by the RSA Program Coordinator selected by the Director of the Office of Traffic & Safety, and represented by members from the following SHA offices:

- Traffic and Safety
- Highway Development

- Construction
- Maintenance
- Planning and Preliminary Engineering
- District Engineering Special Team

RSA Team and Responsibilities: A RSA Team will be established for each project selected for audit. Different team members, from various SHA offices, could be established for the various phases of the audit, depending upon the amount of time between phases and the availability of team members. The RSAPC will submit a memorandum to the Division Chiefs and the District Engineering Coordinator (DEC) requesting members to serve on the RSA Team. Once approval is granted, the RSAPC will contact the individuals selected. The RSAPC will schedule a meeting with each team independently and perform an orientation meeting.

Each RSA Team is responsible for the following:

- Completing RSA training prior to participating in an audit.
- Electing a RSA Team Leader at the beginning of each audit.
- Using their expertise to identify concerns relative to proposed project.
- Preparing audit reports for each audit Stage completed.
- Providing documentation to the RSAPC regarding expenditures and time allocated to a specific audit.

District Engineering Coordinator (DEC): The DEC serves as the central point of contact for projects selected for audit within their districts. The District Engineer selects the DEC. The DEC's role in the RSA Program is as follows:

- Provide necessary information on the project as requested by the RSAPC.
- Coordinate with RSAPC and District Engineering Special Team members
- Present the project to the audit team.
- Be available for questions during an audit.
- Review RSA report recommendations.
- Determine action(s) to be taken.
- Investigate alternate solutions to address the identified concerns.
- Respond to concerns outlined in the RSA report.
- Respond to the RSA report and forward a written response to the RSAPC.
- Seek funding and implement solutions.

In fulfilling these responsibilities, the DEC will appoint/assign staff as appropriate to assemble the information needed.

III. ROAD SAFETY AUDIT TEAM SELECTION PROCESS

The RSAPC will assemble RSA teams based on assigned projects, required expertise and direction given from the Safety FRAT Team and Director of OOTS. RSA Teams will include a minimum of four members and a maximum of six members from the following areas:

- Highway Design
- Construction
- Planning
- Traffic Engineering
- Traffic Safety
- Maintenance
- District Offices
- Non MDOT personnel (Police/Fire/EMS/Community Organizations-Pedestrian, Bicyclist, Transit, etc./Local Traffic Engineers)
- Safety
- Risk Management

The RSAPC will submit a memorandum to the Division Chiefs and the District Engineering Coordinator (DEC) requesting members to serve on the RSA Team. Once approval is granted, the RSAPC will contact the individuals selected. The RSAPC will schedule a meeting with each team independently and perform an orientation meeting.

The RSAPC will open the meeting, introduce the team members and present the project for audit. Following the introductions and project presentation, the team will be required to accomplish the following:

- Select a Team Leader

- Establish a Project Completion Schedule

    - Schedule a meeting with project Program Manager.
    - Conduct the audit and draft a report.
    - Establish final submittal date of report.

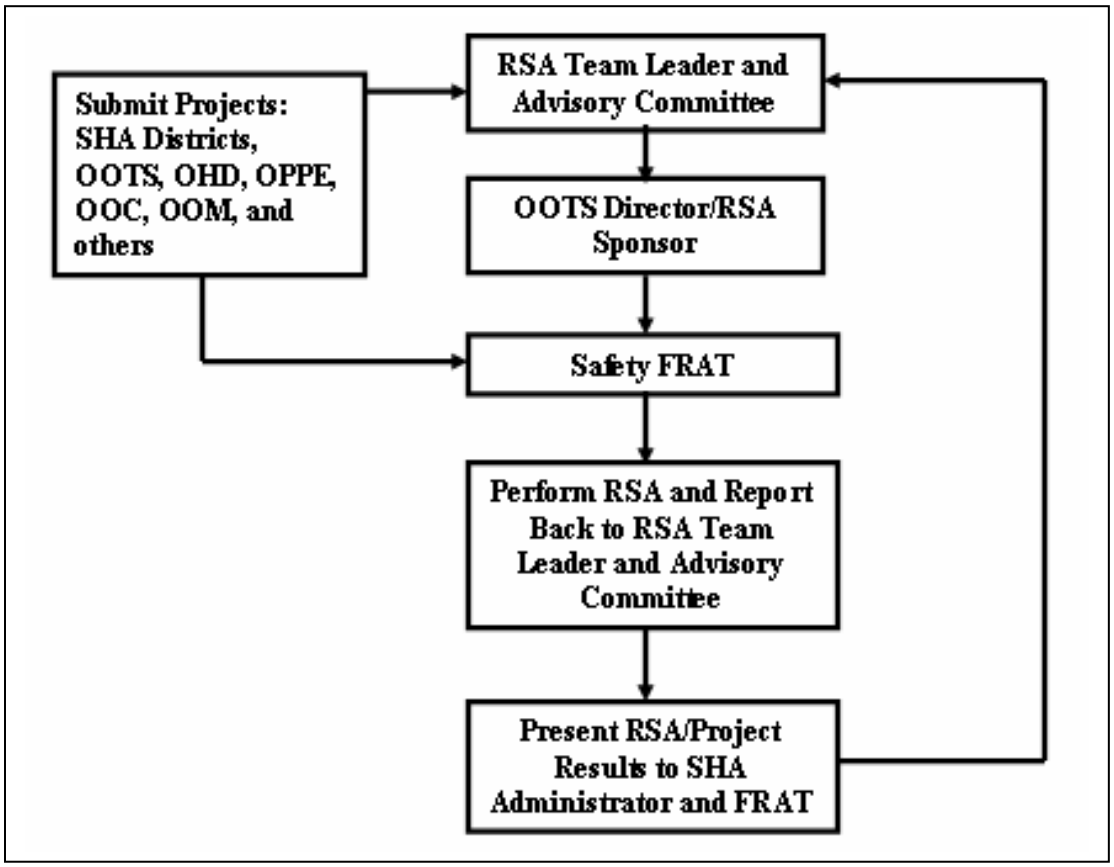
- Assign audit responsibilities

RSA team members will serve a two-year term. It is expected at first that DEC and Division Chiefs will have the opportunity to assign individuals to assist in the RSA Program on an annual basis. RSA Training will be conducted, as needed, for new team members. Independent experts will conduct the training workshops.

IV. ROAD SAFETY AUDIT PROJECT SELECTION PROCESS

During each year, the Safety FRAT will request from various SHA District Engineering Administrators and Division Chiefs (highway, planning, traffic, maintenance) a list of five candidate projects to be evaluated through the RSA program for the upcoming year. Proposed projects will be submitted within four weeks of the request to the RSA Team Leader and Advisory Committee. The selection and presentation process will follow the work flowchart as shown on the following page.

- RSA Team Leader and Advisory Committee will compile a summary of the potential projects by category: 1) new roadway projects; 2) traffic design projects; 3) projects under construction; and 4) existing roadways and intersections with high crash frequencies.
- RSA Team Leader will schedule a follow-up meeting with the Director of OOTS to discuss and select the projects that will be presented to FRAT
- Various SHA Offices will present selected candidate projects to FRAT. FRAT will select projects for RSA.
- RSA team will perform audit, prepare an audit report, and present results to the Director of OOTS and the RSA Advisory Committee.
- Final presentation will be made to FRAT.
- RSA Team Leader will complete the final documentation of the project.



V. ROAD SAFETY AUDIT PROJECT PROCEDURES

New projects will be evaluated using the established Road Safety Audits (RSA) Stages.

- **RSA Stage 1 – Feasibility**
  The RSA team will complete at a minimum the following:

  - Review basic project scope
  - Review proposed layouts for alternative routes

- Evaluate intersection access and surrounding topography
- Examine project impact to surrounding roadway system
- Evaluate type of access/access management
- A narrative summary to address items outlined in the Feasibility Checklist in **Attachment A**

- **RSA Stage 2 – Preliminary Design**
  The RSA team will evaluate at a minimum the following categories:

  - Alignment alternatives
  - Interchange type and layout
  - Intersection design
  - Sight distances
  - Lane and shoulder widths
  - Provisions for non-motorized vehicles
  - Super-elevation and turning radii
  - A narrative summary to address items outlined in the Preliminary Design Checklist in **Attachment B**

- **RSA Stage 3 – Final Design**
  The RSA Team will evaluate, at a minimum, the following:

  - Final geometric design
  - Signing and pavement marking plan
  - Lighting
  - Landscaping
  - Provisions for special users
  - Drainage, guardrail, and other roadside obstacles
  - A narrative summary to address items outlined in the Final Design Checklist in **Attachment C.**

- **RSA Stage 4 – Pre Opening**
  The RSA team will review the road after most construction is complete. The main focus is to find overlooked physical obstructions and weather-related concerns missed in prior audit stages.

  - Complete a narrative summary to address items outlined in The Pre-opening Checklist in **Attachment D.**

- Once the project is complete, the Team will follow the sample checklist for auditing an existing facility as shown in **Attachment E.** A project specific checklist should be developed with contribution from all RSA team members.

- **RSA Stage 5 – Operations Review**
  This stage allows the audit team a final look at how well the road operates and to identify safety concerns while observing actual traffic and traveling the route.

Supplemental checklists also are shown in **Attachment I**.

Field visitation and onsite review are an important part of the RSA. Audit team members accompanied by members of the design team should visit the project site for a field review so that questions and options can be discussed onsite. At the site, the team would travel the project route in both directions following along and extending beyond the project boundaries. Each run should be videotaped to provide a visual record and to record verbal comments from members of the team. Also, the team should walk the project route to be able to more fully consider whether items such as drainage structures, utility poles, or other features could constitute matters of concern. Discussion with local businesses, residents and motorists regarding perceived safety problems are encouraged. It is not required to reach a consensus on any issues noted during the field view. Rather, as issues are raised, they should be noted and discussed when the team returns to the office.

VI. ROAD SAFETY AUDIT REPORTING PROCEDURES

The following steps will be completed for each Road Safety Audit stage:

- The RSA team meets with the District Engineering Coordinator (or other staff person to whom he has assigned the project) to discuss the project and receive background materials.

- The RSA team conducts a safety audit based on established RSA Procedures.

- Upon completion of each RSA Stage, the team will discuss their observations, develop recommendations, prioritize recommendations and establish a consensus on which concerns and recommendations should be included in the RSA report. The Team Leader will prepare a concise report, no more than 2-3 pages, outlining the Stage's findings and recommendations. The report will be submitted to the DEC in charge of the project, RSA Team members and the RSA Program Coordinator.

- The DEC has up to 30 days to reply to the RSA Report. Nevertheless, the RSA team will determine the amount of time for reply, based on the complexity of the recommendations made. The time for response may vary from 15-45 days. Extensions may be requested as needed. The reply should address each of the issues listed. The DEC has the option of incorporating the recommendations; however, the recommendations are not binding. If the DEC does not use a recommendation, an acceptable reason must be stated.

- In assembling information for response to the audit recommendations, the DEC (or the staff person assigned) should contact at the minimum the Traffic Engineering, Environmental, Right-of-way, and other units, which may have pertinent information or be impacted by the recommendation. Information from these groups will assist the DEC in making a determination as to whether the recommendations can be implemented.

- The DEC forwards the response to the RSAPC.

- The RSAPC will forward to the RSA Team the DEC's response.

- The RSAPC is responsible for maintaining all original correspondence, reports, etc.

- Team members will provide copies of their time sheets and expense reports to the RSAPC to be used at documentation of total expenditures. This documentation will be filed by a project's audit, and a summary of the audit costs should be documented. See **Attachment H** for an example.

- The RSAPC will be required to review the expenditure/time documents and verify validity. If there are any discrepancies, the RSAPC will request an explanation (via email or written memorandum) from the team members.

- The RSAPC will prepare the annual RSA summary report and present it to the Director of OOTS and the Safety FRAT.

The RSA report should be very concise and to the point. The report should begin with a description of the project location and limits, governing District, audit date, traffic data, perceived problems and a list of the RSA team members and disciplines. The report should include a brief history of safety problems, trends and patterns of crashes and issues relating to trucks, pedestrians, and bicycles, if any, and a list of specific recommendations. The report should also document the total number of hours spent on the audit. A sample report is shown in **Attachment F**. Furthermore, safety problems, potential causes and recommendations for improvements should be very concise and preferably tabulated for simplicity. The report should discuss adequacy of traffic control devices, traffic volumes and level of service of facility if this information is available, lighting, sight distances, traffic operations, drainage, alignment, and human factors elements such as driver expectancy and location of traffic control devices. The audit team may use the information in **Attachment J** (General Countermeasures for Crash Patterns and Their Probable Causes) to guide the thought process of identifying and evaluating corrective measures for particular safety concerns.

VII. FOLLOW UP ON RESULTS OF AUDIT

Three years after the implementation of all or some of the final audit recommendations on a project, the RSAPC will conduct a follow-up study to determine the impact on traffic safety. Traffic collision data as well as data on pedestrian and bicycle accidents for the three-year period before and after the audit, as appropriate (i.e., a new road would not have prior year's data) should be examined. The RSAPC may elect to have a RSA Team assist in the evaluation, as needed. Even when the audit recommendations are not implemented, it is still suggested to re-examine the project area and safety concerns to determine if the same or new recommendations may be appropriate for further considerations. To ensure the proper handling of any reports related to safety audit procedures or results, audit documents should be kept in a separate file within the project files. This includes all SHA, Federal Highway Administration, and consultant project files. The safety audit documents file and all items within the file should be labeled with the Road Safety Audit wording.

A follow-up Team Survey form should be completed at the conclusion of each project audit (see form in **Attachment G**). Information gathered from the Team Survey forms will be used to enhance the RSA process

ATTACHMENTS

ATTACHMENT "A"

Road Safety Audit
Feasibility Checklist

General
Consistency of standards with adjacent road network, especially at tie-ins.

Secondary effects on surrounding road network.

Routes
Impact of standard of route, related to design flows and speed, on safety.

Overtaking opportunities.

Consistency of junction arrangements (intersections, interchanges, driveways) and access control.

Frequency of junctions (public and private) related to safe access.

Horizontal and vertical alignments consistent with visibility requirements, both along the road and at junctions.

Facilities for pedestrians, cyclists and transit.

Provision for unusual aspects of traffic composition (heavy concentrations of particular types of road user), or environment (eg, sunrise/sunset glare, fog, or wind).

ATTACHMENT "B"

Road Safety Audit
Preliminary Design Checklist

General
Review any previous audit in order to allow for subsequent design changes.

For major projects, determine need for right-of-way acquisition for safety requirements.

Alignments and Sight Distances
Any elements of horizontal and vertical alignments, which may produce hazards due to, reduced sight distance, especially where these are combined and/or there are departures from standards.

Sightlines obstructed by bridge abutments, parapets, landscaping, structures or street furniture.

Junctions
Minimizing potential conflict points at junctions (including numbers of private accesses).

Conspicuity of junctions on approach, and sight distance from minor road approaches and private accesses.

Control of approach speed, and layout of approach roads.

Provision for turning traffic.

Other
Impact of landscaping on visibility and road user perception.

Concept of road marking/signing for road user perception.

Provision for safety aids on steep hills.

Facilities for pedestrians, cyclists and transit.

ATTACHMENT "C"

Road Safety Audit
Final Design Checklist

General
Review any previous audit in order to allow for subsequent design changes.

Note: Scope for altering alignments or junction design is less extensive at this stage, so the audit will focus mainly on details of signing, marking, lighting, etc, and issues which affect visibility and drivers' perception of the road scene, and provide aids to safety.

Junctions
Appropriateness of corner radii or curvature in relation to approach speed.

Road users' perception of road layout.

Road signs and markings
Locations of signs and markings to aid, inform, and warn of hazards, without obscuring visibility or misleading drivers.

Consistency of signing and marking information.

Positioning of signs, and markings at junctions: need for hazard perception warnings (eg chevrons, bar markings).

Lighting and signals
Consistency of lighting within the scheme and with the adjacent network.

Safe positioning of lighting poles, signals and operational equipment.

Positioning of heads for traffic and pedestrian signals to ensure clarity to appropriate road user, and avoid confusion to others to whom they do not apply.

Safe access and servicing arrangements.

Facilities for vulnerable road users
Location and type of crossing facilities; visibility.

Provision of facilities for people with mobility impairments.

Landscaping
Potential obstruction to visibility from landscaping, taking account of future growth.

Potential for trees to become collision objects: choice of appropriate species.

Ability to maintain planted areas safely.

Protective aids

Positioning of safety fences, and guard rails to protect against vehicle conflicts or roadside objects, without obscuring visibility.

Surface characteristics

Appropriate surface friction for high-speed roads or locations, which are potentially hazardous when wet.

Appropriate surface friction treatments for approaches to junctions to encourage lower vehicle speeds.

ATTACHMENT "D"

Road Safety Audit
Pre-opening Checklist

General
Review any previous audit in order to allow for subsequent design changes.

The main emphasis is to inspect the project from the viewpoint of the different road users, considering where appropriate the needs of pedestrians, cyclists, public transport operators, and drivers.

Inspection at appropriate times of day, in particular in daylight (sun blinding conditions) and darkness and during inclement weather conditions (rain, fog, snow).

ATTACHMENT "E"

Road Safety Audit Checklist – Existing Facility

General
- □ Landscaping
- □ Parking
- □ Headlight Glare

Alignment and Cross Section
- □ Visibility, Sight Distance
- □ Design Speed
- □ Overtaking
- □ Readability by Drivers
- □ Widths
- □ Shoulders
- □ Sidewalks
- □ Slope

Intersections
- □ Location
- □ Warning
- □ Controls
- □ Layout
- □ Visibility, Sight Distance

Auxiliary Lanes and Turn Lanes
- □ Tapers
- □ Shoulders
- □ Signs
- □ Turning Traffic
- □ Visibility, Sight Distance

Bike/Pedestrian/Special Needs
- □ Paths, Barriers and Fencing
- □ Bus Stops
- □ Elderly and Disabled
- □ Cyclists

Signs and Lighting
- □ Lighting
- □ Signs
- □ Marking and Delineation

Traffic Signals
- □ Operation
- □ Visibility
- □ Pedestrians
- □ Other Provision

Physical Objects
- □ Clear Zone
- □ Crash Barriers
- □ Fencing

Delineation
- □ Line Marking
- □ Guide Posts
- □ RRPM's
- □ Chevron Alignment Markers

Pavement
- □ Structural Defects
- □ Skid Resistance
- □ Ponding/Drainage
- □ PCC/HMA Distresses

ATTACHMENT "F"
Sample Road Safety Audit Reports
Road Safety Audit Review Report: MD 214

Project Description and Location: MD 214 (Central Avenue) from I-95/I-495 to Washington, D.C. Line is a 3.46 miles 6-lane urban arterial MD 214 runs parallel to the WMATA Metro Rail/Blue line and experiences a heavy volume of pedestrian traffic. This project is located in Prince George's County, SHA District 3.

Audit Team Members: Two traffic engineers, one construction engineer, highway engineer and two community traffic safety coordinators. Resources for the RSAR included crash data, aerial photographs, traffic volumes, video logs, roadway friction data and transit/rider ship data. The audit was performed in January 2006.

Crash History: Number of vehicle crashes has declined from 217 to 166 between year 2002 and 2004, respectively. The number of reported pedestrian accidents, however, has remained unchanged at five incidents per year. The great majority of all accidents are intersection related, with a substantial number of crashes occurring at night and on wet surface. The AADT varies from 23,000 vpd to 59,000 vpd.

General Issues: Lack of ADA compliance for pedestrian amenities, heavy pedestrian volumes, speeding, outdating signing, too many access driveways, near side bus stops, interchange weaves, speeding, sporadic drainage deficiencies, mountable curbs where they shouldn't be, restricted sight distances for left-turns and mid block pedestrian crossings.

Audit Findings: The audit was performed in a day time and on an average weekday. General findings are as follows:

Problem	Potential Cause	Suggestions
Pedestrian movements	Lack of ADA compliance	Install ADA amenities
In orderly maneuvers	Outdated signs and lack of it	Inventory and reevaluate
Vehicular crashes	Speeding	Reduce speed limit and install traffic calming measures
Mountable curbs as a safety hazard	Resurfacing with no milling	Install new curbs
Water/Ice accumulation	Insufficient drainage	Mill, level and resurface poor drainage areas
Damaged inlet grates	Not traffic bearing	Install traffic bearing grates
Restricted sign distances	Insufficient geometry for the prevailing speeds	Reduce speed limit
Weaving at MD 214 and I-95	Substandard weave length	Reconfigure loop ramps
Restricted sight distance for left turns	Geometry	Reevaluate left-turn signal phasing at western entrance to Addison Plaza, Addison Road, Cindy Lane and Hill Road
Pedestrian confusion at crossings	Lack of understanding WK and FDW indications	Install pedestrian countdown signals
In orderly movements for yield control conditions	Lack of pavement markings and delineation	Install Shark Teeth across MD 332 at merge point EB MD 214; larger size Yield sign and better delineation of island
Pedestrian flow at bus stops	Nearside bus stops at Intersections	Reevaluate location of bus stops from near side to far side, throughout MD 214
Unsafe maneuvers from access driveways	Too many access points	Consolidate access points

Road Safety Audit Review Report: MD 494

Project Description and Location: MD 494 (Fairview Road) from MD 57 to Fairview Church Road is a two-lane rural roadway with no shoulders. The length of this section is two miles. This project is located in Washington County, SHA District 6.

Audit Team Members: The audit team consisted of two traffic engineers, one hydraulics engineer, one highway engineer, one community traffic safety coordinator and one human factors expert. Resources for the RSAR included crash data, traffic volumes, video logs, field observations, records of citizen complaints. The audit was performed in early January 2006, in day time hours only.

Crash History: A total of 16 crashes were reported on MD 494 from January 2002 to June 2005; ten crashes occurred at MD 57 and 6 crashes at Fairview Church Road. Eleven crashes occurred at night and on wet pavement. Ten of the total crashes were fixed-object type. Twelve of the total crashes occurred on a Friday, Saturday or Sunday. The majority of crashes are perceived to be caused by speeding and substandard curves.

General Issues: This section of MD 494 has two sharp curves, one with a 30 mph advisory speed and one with a 15 mph advisory speed. It is perceived that both curves are not signed properly and the approach roadways lack adequate lighting and delineation. Furthermore, the roadway horizontal alignment appears to fail drivers' expectancy as they approach the curves.

Audit Findings: During the audit period the pavement surface was dry. Speed limits in both directions are 55 mph, with a 30 mph advisory speed and a 15 mph advisory speed at the curves. General findings are as follows:

Problem	Potential Cause	Suggestion
Chevron signs are difficult to see on eastbound approach MD 494 to left hand curve	Alignment of roadway not too conducive to drivers' expectancy	Relocate chevron signs
Alignment of Curve on eastbound approach of MD 494	Right edge line and flare of traffic barrier could be misinterpreted by unfamiliar drivers	Re-stripe dashed edge line through intersection to delineate edge of road travel path. Install intersection lighting
Reverse curve signs on MD 494 at MD 57	Signs not appropriate for the curve alignment	Replace reverse curve sign with turn or curve sign, based on results of Ball-Bank study
Fixed object crashes, striking traffic barrier on MD 494	Possible lack of super-elevation and speeding	Perform super-elevation study and wedge and level to meet minimum requirements. Consider reducing speed limit
Warning signs on MD 494	Outdated signs	Upgrade all warning signs per latest MUTCD guidelines—fluorescent yellow standard
Sight distance from MD 57 onto MD 494	Alignment of intersection	Install stop line closer to intersection. Also consider a roundabout
Crashes at both Curves	Speeding	Consider reducing the speed limit. Also consider a roundabout
Conflict at intersection of MD 494 at Fairview Church Rd.	Limited sight distance for motorists making left onto Fairview Church Rd.	Reconfigure intersection to a T or a roundabout
Pavement markings between two curves	Lack of uniformity in pavement markings and delineation	Install wide edge lines throughout the limits of this section of MD 494
Majority of crashes involved vehicles traveling eastbound, crossing the centerline and leaving the roadway	Speeding and failing to pay attention	Install centerline rumble strips

Road Safety Audit Review Report: US 50

Project Description and Location: This section of US 50 begins at Phillip Morris Drive and ends at Walston Switch Road, in Wicomico County, SHA District 1. The length of this section is three miles, and consists of US 50 Business in its western limits from Phillip Morris Drive to the US 50/US 13 interchange and US 50 from west of Hobbs Road to Walston Switch road at its eastern limits.

Audit Team Members: The audit team consisted of one traffic engineer, one highway engineer, one maintenance engineer, one transportation planner, two community traffic safety coordinators and one human factors expert. Resources for the RSAR included crash data, existing roadway plans, traffic counts, video logs and field observations. The audit was performed in early January 2006, in day time hours only.

Crash History: A total of 74 crashes occurred in 2004, in this section. Rear-end and angle crashes accounted for 33 and 22-percent of the total crashes, respectively. The majority of crashes occurred on dry pavement and in day time hours. The speed limit on US 50 is 55 mph. SHA has recently installed rumble strips on the westbound approaches to Walston Switch Road and Hobbs Road, and flashing Signal Ahead signs on the westbound approach to Walston Switch Road and the eastbound approach to Hobbs Road.

General Issues: This section of US 50 experiences unusual delay at Tilghman Road; sporadic pedestrian movements in mid-blocks along US 50, across from shopping centers and hotels; lack of lighting along US 50; weaving from westbound US 50 to northbound Salisbury Bypass; a high accident intersection at Walston Switch Road; and high traffic volumes during the summer months.

Audit Findings: During the audit period the pavement surface was dry. General findings are as follows:

Problem	Potential Cause	Suggestion
Special event traffic conditions for the East Wicomico Little League	Increase in traffic volumes and unusual surges in traffic movements	Community outreach to the local communities and drivers
Substantial number of intersection crashes at US 50 and Walston Switch Road	Young drivers and failing to pay attention and yield right of way to other drivers	Outreach to students at the Wor/Wic Community College
Signals at Walston Switch Road and Hobbs Road are not necessarily expected by motorists	Great separation between signals on US 50; drivers may not expect to see signals	Install flashing "Signal Ahead" signs on eastbound Walston Switch Road and westbound Hobbs Road
Weaving from westbound US 50 to northbound Salisbury Bypass	Road geometry	Install advance signing under the US 50/MD 13 overhead sign on westbound US 50, indicating "RIGHT LANE"
Markings and sign control for weaving section from westbound US 50 to northbound Salisbury Bypass	Auxiliary lane markings may confuse drivers. Lack of Yield sign could may contribute to crashes	Change a portion of puppy tracks between Hobbs Road and the on-ramp to regular lane markings. Install a "Yield" sign on the on-ramp from eastbound US 50 Business
Restricted sight distance in eastbound crossover to Salisbury Bypass	Overgrown vegetation	Trim vegetation in median
Right turn from southbound Hobbs Road to US 50	Uncontrolled movement	Signalize right turn movement and don't allow with westbound US 50
Confusion at the split of US 50 into the Salisbury Bypass	Roadway alignment	Geometric improvements to the existing split. Dualize the ramp to the Bypass. Redesign the interchange so that US 50 connects to US 50 rather than US 50 Business.

Road Safety Audit Review Report: MD 31

Project Description and Location: This section of MD 31 is six miles long two-lane rural minor arterial. It begins at west of MD 140 and ends immediately west of MD 852S (Old New Windsor Pike), in Carroll County, SHA District 7. This section includes 12 intersections, two of which are signalized. The speed limit varies from 40 to 55 mph. Truck traffic accounts for approximately 20-percent of all traffic volumes.

Audit Team Members: The audit team consisted of one traffic engineer, one highway engineer, two transportation planners, and one community traffic safety coordinator. Resources for the RSAR included crash data, traffic counts, record of citizen complaints, an earlier traffic safety study, video logs and field observations. The audit was performed in early January 2006, in both daytime and nighttime hours.

Crash History: A total of 80 crashes have occurred between January 2000 and September 2003. Angle collisions are the most dominant type of accidents and occurred mostly at Windsor Drive, Long Drive, Long Valley Road and Old New Windsor Pike. Rear-end crashes also accounted for 20 of the total crashes. Opposite direction crashes also occurred between the section of Medford and Byron Road.

General Issues: Primary complaints from citizens focus on traffic operations and safety; bus drivers waiting on the shoulders to start their routes in the morning, speeding throughout the arterial; and need for signals at intersections in residential developments on MD 31. Also, there has been concern regarding increased residential developments in the areas of Tahoma Farm Road and Long Valley Road, as well as high truck volumes at Byron Road and the quarry at Medford Road and Stone Chapel Road.

Audit Findings: The audit team traveled the site during the AM and PM peak hours and observed traffic conditions throughout the day. General findings are as follows:

Problem	Potential Cause	Suggestion
Buses stopping on the shoulders with oversized truck loads having to go into the oncoming traffic lane to get around busses.	Bus drivers are arriving early to start bus pick-ups and wait on shoulder	Recommend contacting bus company to ask drivers to wait in more safe locations.
Opposite direction crashes in passing zones	Passing zones may not reflect the prevailing speeds	Examine the existing passing zones and make recommendation for upgrades
Yield sign at Byron Road	Not clear if proper sign is installed	Perform a warrant study for "Yield" versus a "Stop" sign control
Sight Distance at Wakefield Valley Road and south leg of Medford Road	Intersection Geometry	Consider relocating stop bar at Wakefield Valley Road and repaint stop bar on south leg of Medford Road, lengthen deceleration lanes
Frequent bicycle activities in the corridor	No allocated space in existing travel lanes	Install bicycle lanes with future safety improvements
Failed shoulder pavement	Truck traffic	Consider full depth patching in failed shoulder pavement
Guardrail end treatments and roadside slope protection	Substandard end treatments and changes in roadside conditions	Perform a guardrail safety study and upgrade sections and end treatments accordingly
Pedestrian facilities at Uniontown Road and Windsor Drive	ADA compatibility	Upgrade pedestrian facilities for ADA compliance
Unrestricted right-turn from Uniontown Road and Main Street	Sight distance onto westbound MD 31	Evaluate restriction for right turns
Acceleration Lane at Medford Rd.	Short acceleration lane	Evaluate lengthening and widening accel. lane
TCDs on parallel section of Old New Windsor Road	Stop control into parallel road may not be the best type of control	Perform study for TCDs along the parallel roadway, specifically for stop control conditions

Road Safety Audit Review Report: MD 100/I-97

Project Description and Location: The study section of MD 100 starts at mile point 6.18 and ends at mile point 6.68. This section is within the limits of a full directional interchange for MD 100 and I-97. The interchange is located in Anne Arundel County, SHA District 5.

Audit Team Members: The audit team consisted of one traffic engineer, one highway engineer, one transportation planner, one maintenance engineer, one safety engineering representative from the FHWA Maryland Division office in Baltimore, one representative from a local Sheriff's Office, and one highway safety program coordinator. Resources for the RSAR included crash data, traffic counts, roadway plans, and discussion with the District 5 Traffic Engineering office, video logs and field observations. The audit was performed on December 12, 2005, during day time and night time hours.

Crash History: The primary section of MD 100 with the highest concentration of crashes begins at mile point 6.42 (west of the I-97 bridge deck) and ends at mile point 6.53, prior to the bridge deck over the northbound I-97 ramp to westbound MD100. This section is within the limits of a horizontal curve over I-97. Thirty-three crashes occurred in 2004 in this study section, including 82-percent of all crashes occurring within mile points 6.42 and 6.53. Single car crashes accounted for 76-percent of all incidents. Crashes occurring on wet pavement also accounted for almost 60-percent. Daytime crashes accounted for 80-percent of all reported crashes. The primary (75-percent) reported probable cause of crashes was "driving too fast" or "inattentive driving."

General Issues: Field observations by the audit team revealed several concerns such as high speeds within the curved section of MD 100, substandard pavement surface friction factors and potential slipper pavement, limited sight distance between mile point 6.42 and mile point 6.53, and a lane drop on eastbound MD 100 approaching the I-97 northbound on-ramp.

Audit Findings: The audit team traveled the site during the AM and PM peak hours and observed traffic conditions throughout the day. General findings are as follows:

Problem	Potential Cause	Suggestion
Slippery pavement, low skid resistance on both directions	Pavement surface friction factors lower than 35	Mill and resurface entire section, both directions, to increase skid resistance. Install "Slippery When Wet" signs as a temporary means.
Crashes on curved section in east bound direction. Headlight light glares.	Speeds too high. East section Design Speed is 70 mph while Design Speed for west section is 60 mph. No glare screening/paddles.	Reduce posted speed limit and approach roads to the study section. Also consider grooving the pavement in the curved sections and install visual barriers.
Super-elevation on curved sections, traveling west to east	Rates of super-elevation appear to be inconsistent	Evaluate the super-elevation rates in both direction and upgrade accordingly
Speeding. Avg. speeds exceed 65 mph for a 60 mpg Design Speed	Perception of open roadways and high speed facilities in interchange	Install Reduced Speed Ahead and chevron and curve warning signs
Wet pavement on bridges	Inadequate drainage in bridge areas	Check drainage for adequacy
Driver distraction from vehicles and possible headlight glare in opposite direction	Open roadway in curved sections	Install median landscaping to obstruct views of vehicles in opposite direction
Lighting in EB approach in interchange area	Lack of adequate lighting at the I-97 bridge deck	Install high-mast lighting
Signing on eastbound MD 100	Lane drop is not announced	Install "Left lane ends ½ mile" sign on overhead sign with flashing beacons.

Problem	Potential Cause	Suggestion
Double Merge Sign , eastbound	Sign not appropriate for conditions	Replace sign
Lane drop not announced	Pavement markings not clear	Evaluate pavement markings throughout
Lane Drop/merge in eastbound	Geometric constraints	Reevaluate geometric changes to allow two lanes on EB MD 100 to continue through interchange
Interchange signing	Lateral and vertical clearance for signs	Perform a signing inventory and assess compliance
Yield control at I-97 NB ramp	Yield control not too conducive	Install advance Yield warning signs
Merge and diverge confusion at ramps	Pavement markings may need improvement	Evaluate adequacy of pavement marking striping and hatching

Road Safety Audit Review Report: MD 26

Project Description and Location: This section of MD 26 9Liberty Road) is approximately two mile long inside the Beltway. MD 26 is a four-lane urban principal arterial with a center turn lane. It begins east of the Beltway at mile point 8.27 and ends at to the City of Baltimore Line at mile point 10.31. The entire section is located in Baltimore County, SHA District 4. The ADT on this section of MD 26 ranges from 37,000 to 48,000 vehicles per day. The posted speed limit is 35mph. This section of MD 26 has a mix of residential and high turnover of retail and commercial land uses.

Audit Team Members: The audit team consisted of a traffic engineer, one engineer from the Access Permit Division, a highway engineer, a community traffic safety coordinator, a human factors expert, one maintenance engineer and one person from the SHA special programs. Resources for the RSAR included crash data, traffic counts, highway plans, Visitdata for 2004 and 2005 logs, and field observations. The audit was performed in early January 2006, in day time hours only.

Crash History: A portion of this MD 26 section is identified as a high accident location. There have been several pedestrian fatalities over the past five years and also a high concentration of rear end crashes.

General Issues: Primary issues include substandard traffic barriers and end treatments, obstacles within the clear zone, access management, ADA amenities, bus stop locations and ad hoc pedestrian movements.

Audit Findings: General findings are as follows:

Problem	Potential Cause	Suggestion
Outdated guardrails, low in height	Very old design	Remove and reset or install new guardrails
Potential for fixed object crashes at bridge piers	Bridge Piers not protected	Fill in between the piers with a flush vertical concrete wall and install crash cushions
Potential for fixed object crashes at approach to access roads	No end treatment for exposed retaining walls	Recommend standard end treatment for wall
Clear zone obstacles	Utility poles in clear zone	Evaluate possibilities for relocation, shielding and relocation of utility poles
Too many conflicts at access points	Ad hoc access control along corridor	Implement access control measures (consolidate access, install medians and refuge islands and implement one way driveways)
Substandard Pedestrian facilities	Lack of ADA amenities	Retrofit all sidewalks and ramps and bus stops
Bus stops impact traffic operations and safety on MD 26	Too many bus stop locations; 15 per mile	Coordinate with MTA to consolidate number of bus stops
Pedestrian crashes	Jaywalking	Install refuge islands; educate and enforce laws

ROAD SAFETY AUDIT

Suggested Corrective Measures for Safety Concerns

Element	Concerns	Suggested Mitigation Measures
Signing	• Outdated warning signs • Curve signs and Right Turn signs not in accordance with MUTCD application guidelines	• Update signs with new colors per MUTCD 2003 (Fluorescent) • Perform Ball Bank Speed studies to determine appropriate type of signs for prevailing condition(s)
Bicycling	• Bicycle activities but no bicycle lanes	• Consider installing bicycle lanes with safety and maintenance improvements
Pavement Markings & Delineation	• Lack of pavement markings & delineation – General • Lack of pavement markings for "Yield" control condition • Alignment/location of Chevron signs does not meet drivers expectancy • Roadside crashes	• Update pavement markings & delineation per MUTCD 2003 • Install "Shark Teeth" markings for yield control • Realign location of Chevron signs • Consider special applications for roadside delineation and wider road edge markings
Signals	• Unexpected signal(s) • Signal heads not too visible	• Install active advance signal warning signs • Install passive "flashing Signal Ahead" signs • Install signal head backplates
Roadside Objects	• Roadside object crashes • Unprotected side slopes	• Remove, relocate, protect and/or delineate fixed objects • Install guardrails
Lighting	• Nighttime crashes	Install intersection lighting
Roadway Super Elevation	• Run off the road crashes on curves	• Evaluate super-elevation rates and correct accordingly
Pavement Surface	• Crashes on wet pavement	• Mill & overlay • Groove pavement surface • Install "Slippery Pavement when Wet" sign until concern is resolved

Element	Concerns	Suggested Mitigation Measures
Pedestrian Access & Movement Circulation	• Lack of ADA compliance • Short "Flashing Do Not Walk" interval • Pedestrians standing in median area, center lane	• Inventory & audit per AASHTO requirements, especially for HC ramps & access to push buttons • Update pedestrian signal intervals per MUTCD 2003 • Install refuse islands
Geometrics: Sight Distance & Alignment	• Substandard roadway horizontal and vertical sight distance • Left-turn phasing with restricted sight distance • Unconventional intersection configuration with offset legs	• Trim vegetation in median and road sides • Reduce posted speed limit • Evaluate left-turn phasing for "Protected" only phasing and restrict tight-turn on Red • Consider alternate intersection configuration (roundabout or realign approaches to 90-degree angles)
Two-Lane Roadway	• Opposite direction crashes on two-lane roads	• Consider centerline rumble strips • Reduce posted speed limit
Speeding	• Speeds exceeding speed limits by 10 mph and more	• Reduced posted speed limit • Traffic calming/roundabouts
Bus Stops	• Near side bus stops reduce intersection capacity and compromise pedestrian safety	• Consider far side bus stops, past intersection

ATTACHMENT "G"

TEAM SURVEY

Project Audited: _____

Name: _____

Title: _____

Division: _____

	Yes	No
Did you receive sufficient notification of being selected for an RSA Project and the orientation meeting date?	☐	☐
Would you like to receive the materials prior to the orientation meeting?	☐	☐
Was the orientation meeting conducted in an efficient/timely manner?	☐	☐
Were the information and procedures presented in a clear manner?	☐	☐
Would it be advantageous to conduct the actual audit on the same day as the orientation meeting, or should this be a team-by-team option?	☐	☐
Were the checklists beneficial?	☐	☐
Was the videotape beneficial?	☐	☐

Did the RSA Team have a sufficient number of auditors?
If not, what other areas of expertise should have been included on the team?

_____
_____
_____

What information would most help you in conducting this type of audit?

_____
_____
_____

How would you improve the RSA process?

_____
_____
_____

ATTACHMENT "H"

Example cost estimate for implementing the Road Safety Audit for a new project.

5 people/audit x 8 hours/person x 4 audit stages = 160 hours.
Administration and typing time expended = 16 hours.
RSA PC additional management time = 16 hours.
RSA Presentation = 16 hours
Total Hours: 208

Rates: $30.00/hour per Auditor and RSA PC
$20.00/hour per Administrative Assistant

Total Labor Cost = $6,080.00
Overhead cost (Assume 150%) = $9,120.00
Direct Costs:
Mileage 500 miles at $0.445/mile = $225.5

Total Cost for Audit = $15,425.50

Example cost estimate for implementing the Road Safety Audit Review (RSAR) for an existing facility.

5 people/audit x 16 hours/person x 1 audit stage = 80 hours. (Includes project initiation)
Administration and typing time expended = 16 hours.
RSA PC additional management time = 16 hours.
RSA Presentation = 16 hours.
Total Hours: 128

Rates: $30.00/hour per Auditor and RSA PC
$20.00/hour per Administrative Assistant

Total Labor Cost = $3,560.00
Overhead cost (Assume 150%) = $5,340.00
Direct Costs:
Mileage 500 miles at $0.445/mile = $225.5

Total Cost for RSAR = $9,125.50

ATTACHMENT "I"

SUPPLEMENTAL CHECKLISTS FOR ROAD SAFETY AUDITS

This attachment presents an overview of checklists for road safety audits. These checklists are developed based on Australian, New Zealand, United States, and Canadian experiences.

The master checklist provides the audit team members with a general listing of the topics to be considered depending on the stage of design at the time of the audit. These lists provide exemplary issues/items to be considered – grouped by area of concern (e.g., alignment, intersections, road surface, visual aids, physical object, and others).

It is important to note that the checklists should serve only as a guide or memory-aid for the individual or team conducting the safety audit. They are not all inclusive, nor are they intended to be used as a substitute for knowledge or experience. The RSA Team is encouraged to develop a detailed checklist for each project.

The master checklist can be used to scan the key topics to be considered for the audit. The master checklist should encourage the auditor to begin thinking about the safety audit and help identify any additional topics that are not included in the manual.

During the field visit, team members may wish to carry a copy of both the master and their developed detailed checklists. It must be reemphasized that the checklists should only be used as a guide or memory aid. The topics listed are intended to remind that auditor or audit team of common elements involved in a safety audit. A comprehensive safety audit can only be achieved through the collaboration and participation of each auditor during the audit process based on individual experience and knowledge.

MASTER CHECKLIST

NEW FACILITIES / UPGRADES • DEVELOPMENT STAGES •					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
GENERAL	**GENERAL**	**GENERAL**	**GENERAL**	**GENERAL**	**GENERAL**
G1. Scope G2. Staging of Construction G12. Consistency of Design Parameters	G2. Staging of Construction G5. Changes since Previous Audit G12. Consistency of Design Parameters G13. Rest areas/Picnic sites	G2. Staging of Construction G3. New/Old Facility Interaction * G4. Impact on Adjacent Networks * G5. Changes since Previous Audit G6. Traffic Barrier Warrants G7. Landscaping G12. Consistency of Design Parameters G13. Rest areas/Picnic sites	G3. New/Old Facility Interaction * G5. Changes since Previous Audit G6. Traffic Barrier Warrants G7. Landscaping G8. Construction Clean-up G12. Consistency of Design Parameters G13. Rest areas/Picnic sites	G3. New/Old Facility Interaction* G6. Traffic Barrier Warrants G7. Landscaping G9. Temporary Works G10. Headlight Glare G12. Consistency of Design Parameters G13. Rest areas/Picnic sites	G6. Traffic Barrier Warrants G7. Landscaping G9. Temporary Works G10. Headlight Glare G11. Accident Reports G12. Consistency of Design Parameters G13. Rest areas/Picnic sites

** Denotes items unique to upgraded facilities.*

MASTER CHECKLIST

NEW FACILITIES / UPGRADES • DEVELOPMENT STAGES •					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
ALIGNMENT AND CROSS SECTIONS	**ALIGNMENT AND CROSS SECTIONS**	**ALIGNMENT AND CROSS SECTIONS**	**ALIGNMENT AND CROSS SECTIONS**	**ALIGNMENT AND CROSS SECTIONS**	**ALIGNMENT AND CROSS SECTIONS**
A1. Classification A2. Design Speed/Posted Speed* A3. Route Selection/Alignment A4. Cross Sectional Elements	A1. Classification A2. Design Speed/Posted Speed* A3. Route Selection/Alignment A4. Cross Sectional Elements A4.1 Drainage A4.2 Lane Width A4.3 Shoulders/ Sidewalks /ADA A4.4 Cross Slopes / Superelevation A4.5 Pavement Widening A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight Distances A8. Bridge Structures	A2. Design Speed/Posted Speed* A4. Cross Sectional Elements A4.1 Drainage A4.2 Lane Width A4.3 Shoulders/ Sidewalks /ADA A4.4 Cross Slopes/ Superelevation A4.5 Pavement Widening A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight Distances A8. Bridge Structures	A2. Design Speed/Posted Speed * A4. Cross Sectional Elements A4.1 Drainage A4.2 Lane Width A 4.3 Shoulders/ Sidewalks /ADA A4.4 Cross Slopes / Superelevation A4.5 Pavement Widening A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight Distances A8. Bridge Structure	A2. Design Speed / Posted Speed * A4. Cross Sectional Elements A4.1 Drainage A4.2 Lane Widths A4.3 Shoulders/ Sidewalks /ADA A4.4 Cross Slopes/ Superelevation A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight Distances A7. Readability by Drivers A8. Bridge Structure	A1. Classification A2. Design Speed / Posted Speed* A4. Cross Sectional Elements A4.1 Drainage A4.2 Lane Widths A4.3 Shoulders/ Sidewalks /ADA A4.4 Cross Slopes / Superelevations A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight Distances A7. Readability by Drivers A8. Bridge Structures

** denotes items unique to upgraded facilities.*

MASTER CHECKLIST

NEW FACILITIES / UPGRADES • DEVELOPMENT STAGES •					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
INTERSECTIONS	**INTERSECTIONS**	**INTERSECTIONS**	**INTERSECTIONS**	**INTERSECTIONS**	**INTERSECTIONS**
S1. Quantity S2. Type S3. Location/Spacing	S3. Locations/Spacing S4. Visibility/Conspicuity S5. Layout S6. Sight Distances	S3. Location/Spacing S4. Visibility / Conspicuity S5. Layout S5.1 Maneuvers S5.2 Auxiliary/ Turning Lanes S6. Sight Distances S7. Controls S7.1 Markings S7.2 Signs S7.3 Signals S7.4 Signal Phasing S8. Warnings	S3. Location/Spacing S4. Visibility/ Conspicuity S5. Layout S5.1 Maneuvers S5.2 Auxiliary/ Turning Lanes S6. Sight Distance S7. Controls S7.1 Markings S7.2 Signs S7.3 Signals S7.4 Signal Phasing S8. Warnings	S3. Location/Spacing S4. Visibility/ Conspicuity S5. Layout S5.1 Maneuvers S5.2 Auxiliary/ Turning Lanes S6. Sight Distance S7. Controls S7.1 Markings S7.2 Signs S7.3 Signals S7.4 Signal Phasing S8. Warnings	S3. Location/Spacing S4. Visibility/ Conspicuity S5. Layout S5.1 Maneuvers S5.2 Auxiliary/ Turning Lanes S6. Sight Distance S7. Controls S7.1 Markings S7.2 Signs S7.3 Signals S7.4 Signal Phasing S8. Warnings

** denotes items unique to upgraded facilities.*

MASTER CHECKLIST

NEW FACILITIES / UPGRADES • DEVELOPMENT STAGES •					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
INTERCHANGES	**INTERCHANGES**	**INTERCHANGES**	**INTERCHANGES**	**INTERCHANGES**	**INTERCHANGES**
C1. Considerations C2. Location/Spacing C6. Lane Balance/Basic Lanes/Lane Continuity	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C6. Lane Balance/Basic Lanes/Lane Continuity	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C5. Service Road Systems C6. Lane Balance/Basic Lanes/Lane Continuity C7. Auxiliary/Turning Lanes	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C5. Service Road Systems C6. Lane Balance/Basic Lanes/Lane Continuity C7. Auxiliary/Turning Lanes	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C5. Service Road Systems C6. Lane Balance/Basic Lanes/Lane Continuity C7. Auxiliary/Turning Lanes	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C5. Service Road Systems C6. Lane Balance/Basic Lanes/Lane Continuity C7. Auxiliary/Turning Lanes
			ROAD SURFACE	**ROAD SURFACE**	**ROAD SURFACE**
			R1. Skid Resistance	R1. Skid Resistance	R1. Skid Resistance R2. Pavement Defects R3. Surface Texture R4. Ponding

MASTER CHECKLIST

NEW FACILITIES / UPGRADES • DEVELOPMENT STAGES •					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
		VISUAL AIDS	**VISUAL AIDS**	**VISUAL AIDS**	**VISUAL AIDS**
		D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs
PHYSICAL OBJECTS	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**
P1. Poles and Other Obstructions P2. Medians	P1. Poles and Other Obstructions P2. Medians	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings
ENVIRONMENTAL CONSIDERATIONS	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**
E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals

MASTER CHECKLIST

NEW FACILITIES / UPGRADES • DEVELOPMENT STAGES •					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
		VISUAL AIDS	**VISUAL AIDS**	**VISUAL AIDS**	**VISUAL AIDS**
		D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs
PHYSICAL OBJECTS	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**
P1. Poles and Other Obstructions P2. Medians	P1. Poles and Other Obstructions P2. Medians	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings
ENVIRONMENTAL CONSIDERATIONS	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**
E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals

MASTER CHECKLIST

NEW FACILITIES / UPGRADES • DEVELOPMENT STAGES •					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
ROAD USERS	**ROAD USERS**	**ROAD USERS**	**ROAD USERS**	**ROAD USERS**	**ROAD USERS**
U1. Motorized Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorized Traffic U2.1 Cyclists U2.2. Pedestrians	U1. Motorized Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorized Traffic U2.1 Cyclists U2.2. Pedestrians	U1. Motorized Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorized Traffic U2.1 Cyclists U2.2. Pedestrians	U1. Motorized Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorized Traffic U2.1 Cyclists U2.2. Pedestrians	U1. Motorized Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorized Traffic U2.1 Cyclists U2.2. Pedestrians	U1. Motorized Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorized Traffic U2.1 Cyclists U2.2. Pedestrians

MASTER CHECKLIST

NEW FACILITIES / UPGRADES • DEVELOPMENT STAGES •					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
ACCESS AND ADJACENT DEVELOPMENT	**ACCESS AND ADJACENT DEVELOPMENT**	**ACCESS AND ADJACENT DEVELOPMENT**	**ACCESS AND ADJACENT DEVELOPMENT**	**ACCESS AND ADJACENT DEVELOPMENT**	**ACCESS AND ADJACENT DEVELOPMENT**
AA1. Right-of-Way	AA1. Right-of-Way	AA1. Right-of-Way	AA2. Proposed Development AA3. Driveways	AA2. Proposed Development AA3. Driveways	AA1. Right-of-Way AA2. Proposed Development AA3. Driveways AA4. Roadside Development AA5. Building Setbacks

ATTACHMENT "J"

General Countermeasures for Crash Patterns and their Probable Causes

Crash Pattern	Probable Cause	General Countermeasure
Right-angle collisions at unsignalized intersections	Restricted sight distance	Remove sight obstructions Restrict parking near corners Install stop signs (see MUTCD) Install warning signs (see MUTCD) Install/improve street lighting Reduce speed limit on approaches* Install signals (see MUTCD) Channelize intersection
	Large total intersection volume	Install signals (see MUTCD)
	High approach speed	Reduce speed limit on approaches* Install rumble strips
Right-angle collisions at signalized intersections	Poor visibility of signals	Install advanced warning devices (see MUTCD Install 12-in. signal lenses (see MUTCD) Install overhead signals Install visors Install back plates Improve location of signal heads Add additional signal heads Reduce speed limit on approaches*
	Inadequate signal timing	Adjust Change interval Provide all-red clearance interval Install signal actuation Retime signals Provide progression through a set of signalized intersections
Rear-end collisions at unsignalized intersections	Pedestrian crossing	Install/improve signing or marking of pedestrian crosswalks Relocate crosswalk
	Driver not aware of intersection	Install/improve warning signs
	Slippery surface	Overlay pavement Provide adequate drainage Groove pavement Reduce speed limit on approaches* Provide "SLIPPERY WHEN WET" signs
	Large numbers of turning vehicles	Create left-or right-turn lanes Prohibit turns Increase curb radii
* Spot speed study should be conducted to justify speed limit reduction.		

Crash Pattern	Probable Cause	General Countermeasure
Rear-end collisions at signalized intersections	Poor visibility of signals	Install/improve advance warning devices Install overhead signals Install 12 in. signal lenses (see MUTCD) Install visors Install back plates Relocate signals Add additional signal heads Remove obstacles Reduce speed limits on approaches*
	Inadequate signal timing	Adjust change interval Provide progression through a set of signalized intersections
	Pedestrian crossings	Install/improve signing or marking of pedestrian crosswalks Provide pedestrian "WALK" signal indication
	Slippery surface	Overlay pavement Provide adequate drainage Groove pavement Reduce speed limit on approaches* Provide "SLIPPERY WHEN WET" signs
	Unwarranted signals	Remove signals (see MUTCD)
	Large turning volumes	Create left or right-turn lanes Prohibit turns Increase curb radii
Pedestrian accidents at intersections	Restricted sight distance	Remove sight obstructions Install pedestrian crossings Improve/install pedestrian crossing signs Reroute pedestrian paths
	Inadequate protection for pedestrians	Add pedestrian refuge islands
	Inadequate signals	Install pedestrian signals (see MUTCD)
	Inadequate signal phasing	Add pedestrian "WALK" signal indication Change timing of pedestrian phase
	School crossing area	Use school crossing guards
Pedestrian accidents between intersections	Driver has inadequate warning of frequent mid-block crossings	Prohibit parking Install warning signs Lower speed limit* Install pedestrian barriers
	Pedestrians walking on roadway	Install sidewalks
	Long distance to nearest crosswalk	Install pedestrian crosswalk Install pedestrian actuated signals (see MUTCD)
* Spot speed study should be conducted to justify speed limit reduction.		

Crash Pattern	Probable Cause	General Countermeasure
Pedestrian accidents at driveway crossings	Sidewalk too close to traveled way	Move sidewalk laterally away from highway
Left-turn collisions at intersections	Large volume of left turns	Provide left-turn signal phases Prohibit left turns Reroute left-turn traffic Channelize intersection Install STOP signs (see MUTCD) Create one-way streets
	Restricted sight distance	Remove obstacles Install warning signs Reduce speed limit on approaches*
Right-turn collisions at intersections	Short turning radii	Increase curb radii
Fixed-object collisions	Objects near traveled way	Remove obstacles near roadway Install barrier curbing Install breakaway feature to light poles, signposts, etc. Protect objects with guardrail
Fixed-object collisions and/or vehicles running off roadway	Slippery pavement	Overlay existing pavement Provide adequate drainage Groove existing pavement Reduce speed limit* Provide "SLIPPERY WHEN WET" signs
	Roadway design inadequate for traffic conditions	Widen lanes Relocate islands Close curb lane
	Poor delineation	Improve/install pavement markings Install roadside delineators Install advance warning signs (e.g., curves)
Sideswipe collisions between vehicles traveling in opposite directions or head-on collisions	Roadway design inadequate for traffic conditions	Install/improve pavement markings Channelize intersections Create one-way streets Install median divider Widen lanes
Collisions between vehicles traveling in same direction such as sideswipe, turning or lane changing	Roadway design inadequate for traffic conditions	Widen lanes Channelize intersections Provide turning bays Install advance route or street signs Install/improve pavement lane lines Remove parking Reduce speed limit*
* Spot speed study should be conducted to justify speed limit reduction.		

Crash Pattern	Probable Cause	General Countermeasure
Collisions with parked cars or cars being parked	Large parking turnovers	Prohibit parking Change from angle to parallel parking Reroute through traffic Create off-street parking Reduce speed limit*
	Roadway design inadequate for present conditions	Widen lanes Change from angle to parallel parking Prohibit parking Reroute through traffic
Collisions at driveways	Left-turning vehicles	Install median divider Install two-way left-turn lanes
	Improperly located driveway	Regulate minimum spacing of driveways Regulate minimum corner clearance Move driveway to side street Install curbing to define driveway location Consolidate adjacent driveways
	Right-turning vehicles	Provide right-turn lanes Restrict parking near driveways Increase the width of the driveway Widen through lanes Increase curb radii
	Large volume of through traffic	Move driveway to side street Construct a local service road Reroute through traffic
	Large volume of driveway traffic	Signalize driveway Provide acceleration and deceleration lanes Channelize driveway
	Restricted sight distance	Remove sight obstructions Restrict parking near driveway Install/improve street lighting Reduce speed limit*
Night accidents	Poor visibility	Install/improve street lighting Install/improve delineation markings Install/improve warning signs
Wet pavement accidents	Slippery pavement	Overlay existing pavement Provide adequate drainage Groove existing pavement Reduce speed limit* Provide “SLIPPERY WHEN WET” signs
Collisions at railroad crossings	Restricted sight distance	Remove sight obstructions Reduce grades Install train actuated signals (see MUTCD) Install stop signs (see MUTCD) Install gates (see MUTCD) Install advance warning signs (see MUTCD)
* Spot speed study should be conducted to justify speed limit reduction.		