Traffic Safety Analysis for Local Agencies

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Author
Tom McDonald
Safety Circuit Rider
Institute for Transportation

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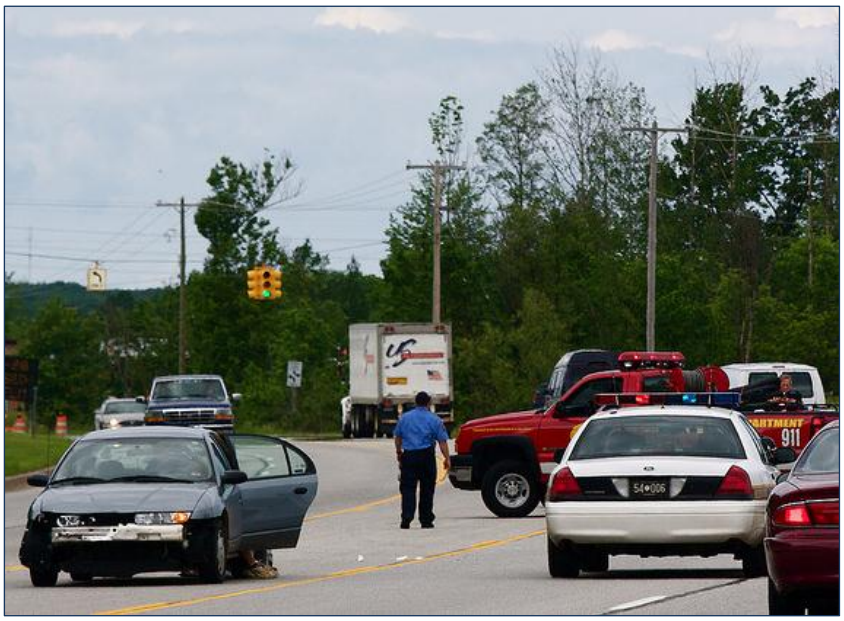

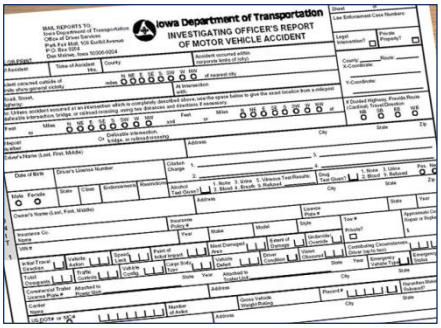

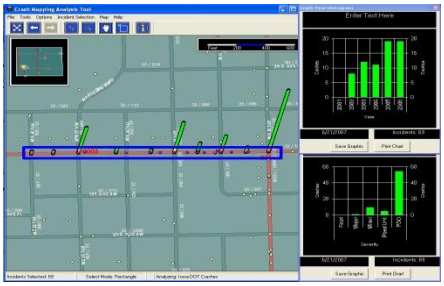

Center for Transportation Research and Education
Iowa State University
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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Iowa Department of Transportation.

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The authors also wish to acknowledge the contributions of the numerous individuals and agencies that supported and encouraged this effort from initial concept to completion. Included in that group are the 22 members of the original advisory committee, who represented a wide array of agencies and disciplines, including engineering, law enforcement, emergency response, and educators in several state and local agencies. Staffs with the Federal Highway Administration (FHWA) and the Iowa DOT were very helpful in providing reference materials, draft chapter reviews, and advice for creating a useful product. Consultants Schultz and John Latterell also provided valuable guidance and resources.

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16. Abstract

Although many larger Iowa cities have staff traffic engineers who have a dedicated interest in safety, smaller jurisdictions do not. Rural agencies and small communities must rely on consultants, if available, or local staff to identify locations with a high number of crashes and to devise mitigating measures. However, smaller agencies in Iowa have other available options to receive assistance in obtaining and interpreting crash data. These options are addressed in this manual.

Many proposed road improvements or alternatives can be evaluated using methods that do not require in-depth engineering analysis. The Iowa Department of Transportation (DOT) supported developing this manual to provide a tool that assists communities and rural agencies in identifying and analyzing local roadway-related traffic safety concerns.

In the past, a limited number of traffic safety professionals had access to adequate tools and training to evaluate potential safety problems quickly and efficiently and select possible solutions. Present-day programs and information are much more conducive to the widespread dissemination of crash data, mapping, data comparison, and alternative selections and comparisons. Information is available and in formats that do not require specialized training to understand and use.

This manual describes several methods for reviewing crash data at a given location, identifying possible contributing causes, selecting countermeasures, and conducting economic analyses for the proposed mitigation. The Federal Highway Administration (FHWA) has also developed other analysis tools, which are described in the manual.

This manual can also serve as a reference for traffic engineers and other analysts.

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Chapter 1: Introduction to this Manual

National and Local Epidemic

Traffic crashes are a national epidemic, claiming nearly 34,000 lives in 2009, despite a significant decrease in fatalities from previous years (*1*). While fatality numbers in Iowa showed a general decline in 2008 and 2009, about 400 lives are lost annually in traffic crashes, which is more than one per day (*2*). Traffic crashes are the leading cause of death in the nation and in Iowa for persons under age 35 (*3*).

Costs

In Iowa, the total cost of traffic crashes has been estimated at over $1 billion per year (*3*). Impacts from crashes have been felt either directly or indirectly by almost every citizen. In addition to the physical, financial, and emotional impacts on victims and families, significant burdens are placed on law enforcement, medical professionals, and other institutions.

Recent Success

A proactive highway safety program addressing the impacts of traffic crashes in Iowa has been invaluable for keeping the number of crashes steady or falling despite higher speeds, especially on the Interstate system, and more miles driven each year. A crucial element of this program is collecting and analyzing crash data that can be used to identify and reduce safety deficiencies on Iowa's streets and highways.

U.S. Department of Transportation Recommendations

While crash data are available to all Iowa local jurisdictions, many do not have ready access to engineering assistance for traffic crash analysis. The U.S. Department of Transportation (DOT) has recommended that cities with a population over 50,000 employ at least one full-time traffic engineer and that cities with populations between 25,000 and 50,000 have access to traffic engineering services through consultants or other government agencies, such as the Traffic Engineering Assistance Program (TEAP) offered by the Iowa DOT (*4*).

Although many larger Iowa cities have staff traffic engineers who have a dedicated interest in safety, smaller jurisdictions do not. Rural agencies and small communities must rely on consultants, if available, or local staff to identify locations with a high number of crashes and to devise mitigating measures. However, smaller agencies in Iowa have other available options to receive assistance in obtaining and interpreting crash data. These options are addressed in this manual.

Additional Assistance Needed

Because smaller communities and rural jurisdictions lack staff and/or adequate budget to provide engineering expertise, traffic safety duties are often assigned to law enforcement officers and/or public safety staff. Although these professionals routinely perform these additional duties well, the duties are not the primary focus of their jobs and additional training and guidance would be advantageous.

Traffic Safety Analysis for Local Agencies

The Iowa DOT has supported developing this manual to provide a tool that assists communities and rural agencies in identifying and analyzing local roadway-related traffic safety concerns. This manual should also serve as a reference for traffic engineers and other analysts.

Many proposed road improvements or alternatives can be evaluated using methods that do not require in-depth engineering analysis. For example, an engineer could estimate the cost of adding a lane to an existing intersection without an actual on-site investigation. Traffic volume/capacity ratios could also be used to evaluate congestion potential. These techniques, used separately or in conjunction with one another, are useful in preparing budgets or proposals but are not generally employed for the actual implementation process.

In the past, a limited number of traffic safety professionals had access to adequate tools and training to evaluate potential safety problems quickly and efficiently and select possible solutions. (A brief history of crash data and analysis in Iowa is provided in Chapter 2 of this manual.) Present-day programs and information are much more conducive to the widespread dissemination of crash data, mapping, data comparison, and alternative selections and comparisons. Information is available and in formats that do not require specialized training to understand and use.

This manual describes several methods for reviewing crash data at a given location, identifying possible contributing causes, selecting countermeasures, and conducting economic analyses for the proposed mitigation. A benefit-cost calculation provides one type of economic assessment and evaluation of possible mitigation alternatives. While not necessarily the determinative factor for a countermeasure, comparing the expected benefit to anticipated cost can be quite useful. The Federal Highway Administration (FHWA) is also developing other analysis tools, which are described later in the manual.

Safety management can adopt a reactive or proactive approach and each approach has merit in given circumstances. When crash experience indicates a need for immediate action, a reactive response is justified. For efficient and effective long-term, safety planning, proactive procedures may be more appropriate as budgetary considerations allow. This manual addresses both management approaches.

For low-volume roads and streets, attempting to identify and address "high-crash" locations can often yield unsatisfactory results due to the relatively low crash numbers and the random nature of crash occurrences. In low-volume situations (less than 400 vehicles per day), addressing safety concerns using a systemic approach can be more effective. Systemic, which could be favorably compared to a proactive approach, countermeasures might include initiatives such as upgrading horizontal curve delineation, even if few crashes have been recorded at a given location. A similar approach might be adopted for potential hazards, such as unshielded narrow structures or T-configuration intersections. This topic is addressed in more detail later in this manual.

Safety Attitude/Culture

Safety attitude or culture emphasizes the importance of a safety-conscious attitude. An important element of this philosophy is understanding key safety principles as they apply to roadway design and operation. Common sense, experience, and good judgment are required to supplement knowledge because information currently available about safety rarely is such that a given analysis has only one possible explanation or one plausible solution.

Nominal (Minimal) versus Substantive (Additional) Safety

Design standards have been developed over the years to govern minimum acceptable criteria for physical roadway features. However, simply meeting minimum design standards does not assure operating safety, and crashes will still occur. Compliance with standards, warrants, and established guidelines result in a nominal safety environment, but more may be needed for desired safety levels or to compensate for local conditions not accounted for in the standards.

For example, the *Manual on Uniform Traffic Control Devices* (*MUTCD*) may recommend a 30 inch Stop sign for a conventional road intersection; but crash and operational history might indicate that a larger sign, possibly supplemented by a flashing light, would be beneficial and have significant potential to reduce crashes. These added features are elements of what is termed substantive safety.

Nominal safety is useful for defining legal behavior, protecting agencies from tort liability, and possibly providing for the needs of special road users. Substantive safety, based on actual crash history and roadway conditions, goes beyond minimum standards to address particular safety concerns when identified. Resources describing substantive safety options are listed in the References at the end of each chapter and include several National Cooperative Highway Research Project (NCHRP) reports.

Purpose of this Manual

This manual has been developed to assist local communities and others in evaluating traffic safety performance and to provide several user-friendly analysis methods for addressing deficiencies. The manual describes common countermeasures and potential funding sources.

Some of the information provided in this manual is listed below:

- Useful advice for safety and crash history analysis
- Procedures for evaluating potential problem locations
- Methods to determine crash patterns and related causes and to make comparisons with average or expected values
- Established criteria for mitigation service life, costs, and countermeasure effectiveness
- Suggestions for economic analyses to use in budgeting and planning

In addition, many jurisdictions are justifiably concerned about liability and the potential resultant effects on limited budgets. Litigation resulting from crashes can have serious impacts on programs in many agencies. A systematic use of this manual to develop and prioritize traffic safety improvements within budgetary limitations should prove beneficial in defending against or avoiding crash litigation.

Using this Manual

NCHRP Report 440, *Accident Mitigation Guide for Congested Rural Two-Lane Highways*, describes a six-step process that agencies can adopt to locate and mitigate safety deficient locations (*5):*

1. Identify potential and/or actual safety problem locations
2. Evaluate crash history
3. Examine field conditions
4. Analyze contributing factors and possible countermeasures
5. Assess and select appropriate mitigation
6. Implement improvements and evaluate the effectiveness

This manual describes a similar comprehensive approach to traffic safety analysis, from collecting potentially valuable data and analyzing data to evaluating countermeasures, ranking possible solutions, and obtaining funding for traffic safety features or improvements.

Chapter 2: Early Traffic Crash History in Iowa

This chapter briefly describes the development of crash records and the evolution of various analysis methods. The information is intended to provide an appreciation for the dedicated work that was necessary to achieve the level of crash analysis capabilities that are available today in Iowa.

Chapter 3: Addressing Traffic Safety Concerns in Iowa

This chapter introduces and describes tools and activities for addressing identified and anticipated traffic safety concerns in Iowa—from data collection, to multi-disciplinary approaches, to formal statewide enforcement initiatives. These tools and activities can be utilized in both reactive and proactive approaches.

The chapter describes the many types of data necessary for complete and accurate crash analysis. Crash data are described in detail, emphasizing not only the necessary quality and the importance of law enforcement contributions but also the limitations of the database.

In addition to crash data, other necessary information is addressed, including traffic volumes and types, traffic control devices and pavement markings, roadway and roadside features, litigation experience, citation history, maintenance records, citizen and staff input, and the importance of data maintenance.

The chapter emphasizes how each type of data contributes to the analysis process and presents suggestions for gathering that information. Numerous illustrations are included for reference and the needs of special road users are addressed briefly.

This chapter also describes cooperative efforts that multi-disciplinary traffic safety teams can undertake, providing several situational examples to demonstrate the value brought to traffic safety by these teams. Finally, this chapter introduces statewide traffic safety improvement initiatives by both the Iowa DOT and the Iowa Governor's Traffic Safety Bureau (GTSB).

Chapter 4: Identifying Potential Problem Locations

The problem location chapter offers suggestions to identify potential and actual safety problem areas. Advice is given in three areas, primarily relying on information in various NCHRP reports. The following topics are addressed:

- Evaluating crash history
- Examining field conditions
- Analyzing possible contributing factors

In addition, current and future tools for augmenting these efforts are presented, including the American Association of State Highway and Transportation Officials (AASHTO) *Highway Safety Manual* (HSM) and the AASHTOWARE SafetyAnalyst software package.

Analysis techniques for determining potential crash propensity are described. Most of the material for this chapter is drawn from FHWA publications, research reports, and the Southeast Michigan Council of Governments (SEMCOG) handbook.

Chapter 5: Analyzing Crash Data

This chapter offers suggestions for procedures and techniques that can be employed to evaluate available data, including selecting years for analysis; mapping; determining frequencies, rates, and densities; identifying major contributing factors; and preparing reports.

Chapter 6: Countermeasures

Once safety issues are identified, it is necessary to select appropriate countermeasures. This chapter describes available mitigation options that have been used successfully. A cooperative approach is emphasized, including the 4 Es (engineering, enforcement, education, and emergency response) plus any others. Suggested countermeasures include initiatives in all these areas, and mitigations for specific problems are identified.

The expected life of various improvements and crash reduction factors are also included, along with several illustrations. Reference information for this chapter was from various sources, including the SEMCOG handbook and the Iowa DOT.

Although reconstruction or other major improvements may be desirable and ultimately sought, significant safety improvements can often be achieved at a relatively low cost. Improvements such as upgraded signing and markings, as well as focused law enforcement and educational efforts can be very beneficial. These and other low-cost mitigation options are presented in this chapter.

Chapter 7: Economic Analysis Procedures

Methods are presented for evaluating the economic value of alternative countermeasures. Benefit-cost computations and other evaluation comparisons are explained.

Chapter 8: Funding for Safety Improvement Projects

Topics included in this chapter are funding sources and traffic safety improvements with Resurfacing, Restoration, Rehabilitation or 3R projects.

Chapter 9: Crash Analysis Software in Iowa

Examples of several types of crash analysis are presented in this final chapter, from simple applications to more detailed analyses. Use of available software, such as CMAT, IMAT, and SAVER, are described and illustrated.

Glossary of Traffic Safety Analysis Terms and Acronyms and Abbreviations

The back of this manual includes an informative glossary of traffic safety analysis terms and a list of the acronyms and abbreviations used in this manual with their definitions.

An Example of Using this Manual

While this manual presents a comprehensive process for evaluating safety, opportunities will arise for applying only selected parts of the process.

For example, a mayor or council member may perceive a safety deficiency at a particular location based primarily on citizen input. It may be immediately concluded that a traffic signal would be the best solution to the problem. When staff is asked for a response, the first step would be to review data to determine if the site is a "high-crash" location warranting such a high-cost investment.

By applying the techniques described in Chapter 3: Addressing Traffic Safety Concerns in Iowa, it might be demonstrated that the site in question has a better safety record than several others already waiting for funding. If a proposal for the traffic signal is still supported, Chapter 4: Identifying Potential Problem Locations and Chapter 5: Analyzing Crash Data could be employed to show, perhaps, that a signal might not be as effective as improved signing and marking (while the importance of meeting predetermined signal warrants as described in the *MUTCD* should also be noted).

The value of an established local safety management system has been demonstrated in several areas of Iowa. Key elements of successful programs are cooperation between agencies (and between departments within agencies), a common purpose, and appropriate use of available data to guide decisions. This manual provides illustrations and guidance for interpreting and analyzing crash and other data when considering transportation safety improvements.

Chapter 1 References

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Chapter 2: Early Traffic Crash History in Iowa

In Iowa, records of traffic crashes have been compiled and maintained for many decades. One of the earliest reports is dated 1934 (and apparently published in 1935). It was compiled as a booklet under the direction of the Secretary of State. The title of the report, *The Four Horsemen of the Highway*, indicates road hog, drunken driver, excessive speed, and unsafe cars as the major causes of crashes (*1)*.

Statistics for 1934 revealed more than 11,000 crashes involving nearly 17,000 vehicles and resulting in 544 deaths and 11,423 injuries. Male drivers were overwhelmingly represented in these crashes. Pedestrians accounted for 154 fatalities, and 112 school-age children were killed.

Several interesting articles from the National Safety Council (NSC) are included in the report, with an emphasis on the human element in safety, dangers of drinking and driving, and concern for the nationwide death toll from traffic crashes. One article notes that Public Enemy No. 1 is the reckless automobile driver (*1*). Beginning in 1917 (with 10,196 fatalities), the article notes nearly 405,000 killed in automobile accidents over the ensuing 18 year period.

Also, of particular interest, was a comparison from Iowa's Motor Vehicle Department of fatal crashes in Iowa before and after the Iowa Highway Patrol was established in mid-1934. Statistics showed a demonstrable decrease from 1933 (*1*).

A 1941 report from the Safety and Traffic Department of the Iowa Highway Commission summarizes traffic crashes from 1934 through 1940 with the most emphasis on the primary road system (*2)*. The report notes a general decrease in the fatality rate over that period from 12.3 fatalities per one hundred million miles in 1934 to 9.4 in 1940. Counting traffic numbers was apparently initiated in 1936, resulting in improvements from previous volume estimates.

It is interesting to note that the NSC was using a miles per gallon consumption of 13.5 to make rate estimates at that time. The Council noted that Iowa had one of the lowest fatality rates in the nation for the period 1937 to 1940 (*2)*.

The 1941 report concludes that the major causes of fatal accidents were angles of movement, velocity differentials, and obstructions to movement. Interference to moving traffic along the outer edge, designated marginal friction in the report, accounted for the most fatalities in 1939 to 1940. Today, this designation would be referred to as "clear zone" interference.

The report also notes that safety programs should concentrate maximum attention during the months of September through February because fatalities were higher during that period.

Reviewing these historic records reveals many similarities in safety problems and concerns to those that traffic safety professionals face today. These reports and more recent summaries prepared by the Iowa DOT Office of Driver Services are maintained in the Iowa DOT library. Valuable information dating back to 1925 can also be obtained from the Iowa DOT Motor Vehicle Division (MVD) website at www.iowadot.gov/mvd/FactsandStats.html and www.iowadot.gov/mvd/ods/crashhistory.xls.

In contrast to the very high crash fatalities and rates noted in the historical data above, the most recent nine years (from 2001 through 2009) of Iowa data indicate a fatal crash rate of 1.53 per 100 million vehicle miles traveled (HM VMT) on rural primary roads and a fatal crash rate of 3.18 per HM VMT on rural secondary roads (*3*).

The total number of fatal crashes is also much less—about 108 per year for primary roads and approximately 162 per year for secondary roads. These reduced statistics are due to improved roadways, safer vehicles, and, in no small part, much more emphasis on traffic safety in current times.

Chapter 2 References

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Chapter 3: Addressing Traffic Safety Concerns in Iowa

This chapter introduces and describes tools and activities for addressing identified and anticipated traffic safety concerns in Iowa—from data collection to multi-disciplinary approaches to formal statewide enforcement initiatives. These tools and activities are organized into the following broad categories in this chapter:

- Iowa's Crash Data
- Additional Non-Crash Data
- Multi-Disciplinary Approaches to Roadway Safety
- Governor's Traffic Safety Bureau Safety Enforcement Initiatives
- Additional Information

The tools and activities covered in this chapter can be utilized in both reactive and proactive approaches. Information sources for this chapter include Iowa programs and resources, FHWA information, and NCHRP publications.

Iowa's Crash Data

Reviewing crash data is an effective way to identify and address traffic safety problems. However, to analyze the data effectively, the information must be collected, managed, and stored in a manner that will facilitate analysis. This section provides background information regarding Iowa's crash-data collection requirements, impediments, and analysis resources. In addition, non-crash data (e.g., road, traffic, road user demographics) are briefly discussed.

Minimum Criteria for Crash Reporting

Crashes meeting all of these criteria should have a crash report completed by an investigating officer:

1. Occurs on a public roadway

and

2. Involves at least one motor vehicle in transit, including four wheelers, mopeds, golf carts, and snowmobiles; motor vehicles not in transit would include parked cars, electric scooters, bicycles, and trains

and

3. Involves at least one fatality or one personal injury or $1,500 of property damage (Iowa Code 321.266–321.37, effective July 2010)

Local agencies may have listings of additional crashes.

Law Enforcement Responsibilities

At a crash scene, an officer has many responsibilities in addition to completing the crash report:

- Safe and prompt arrival
- Observe conditions contributing to the crash
- Be alert for physical evidence at the scene
- Position the patrol unit to protect the scene
- Watch for potential dangers—hazardous materials
- Traffic control to prevent additional collisions
- Provide emergency treatment for injured persons
- Notify fire department/ambulance if necessary
- Notify next of kin in fatalities
- Investigate hit-and-run crashes
- Identify and interview witnesses
- Collect physical evidence/photos
- Exchange information with drivers
- Clear the roadway—towing the vehicles
- Investigate the crash—accurately complete the crash form, recording details such as a description of the scene, roadway conditions, driver and vehicle information, type of crash, injuries, and approximate property damage

Depending on the severity of the crash, crash investigation is only one aspect of the enforcement officer's responsibility. While not exonerating incomplete or inaccurate reporting, these additional duties require a prioritization of the officer's time. However, officers should typically have sufficient opportunity to complete the form properly after the immediate crash issues have been addressed.

Driver/Witness/Citizen Responsibilities

Drivers also have responsibilities following a crash. For any crash occurring in Iowa resulting in death, personal injury, or property damage of $1,500 or more, an Iowa Accident Report/Report of Motor Vehicle Accident must be completed and filed unless the crash is investigated by a law enforcement officer. Insurance information must also be completed on this form. Failure to do so may result in suspension of driving privileges.

While perhaps not specifically required by Iowa Code, witnesses to crashes may be compelled by civic duty to provide information about any crash they observe.

Crash Report Forms

Quality data starts with quality reporting. Because complete, accurate crash form data are crucial for analytical purposes, the contribution of investigating law enforcement officers is significant.

Law enforcement officers or drivers report crashes that meet the minimum criteria using the standard Iowa DOT Investigating Officer's Report of Motor Vehicle Accident (crash form) (Figures 3.1 and 3.2) or the Iowa Accident Report Form/Report of Motor Vehicle Accident (driver's report) (accessible from www.iowadot.gov/mvd/ods/accidents.htm).

All Iowa law enforcement officers, state and local, either use the same form when investigating a traffic crash or electronically collect the data at the scene using the Traffic and Criminal Software (TraCS). TraCS can be used with laptops, desktop computers, and/or in-car data communications to provide officers with the means to record and access both crash and incident data remotely or in the office.

TraCS has proven invaluable for improving data collection accuracy and for improving crash investigation and reporting efficiency. More detailed information about TraCS can be found at www.iowatracs.us/.

For agencies not using TraCS, paper forms may be completed and the data can be entered later electronically at the local office or it can be sent to the Iowa DOT MVD Office of Driver Services (ODS) for document scanning and entry into the state database.

Most of these data are entered using standard codes from the Iowa DOT Investigating Officer's Report of Motor Vehicle Accident Code Sheet shown in Figures 3.3 and 3.4.

The current crash reporting form has been in use since 2001 when it was revised to be in close compliance with the most recent national guidelines for crash data. Prior to 2001, crash data were in a format collected using the 1979 crash reporting form.

While the entire form was revised, the following are some of the specific changes:

- Addition of a sequence of events series of data fields
- Addition of a series of work-zone-related indications and data fields
- Reduction of the directions of travel choices from eight to four (North, South, East, and West)
- Allowance of officers to enter less information for single-vehicle, non-injury- or non-fatality-related, and wild-animal-related crashes with property damage only to the vehicle involved

All crash details can prove valuable and important, with some crashes having pertinent information from one data field and other crashes providing pertinent data from others. For example, the sequence of events and crash diagram might be valuable in one instance, while vehicle action, driver contributing circumstances, point of initial impact, or other fields might be valuable in others.

Form 433003
01-01

MAIL REPORTS TO:
Iowa Department of Transportation
Office of Driver Services
Park Fair Mall, 100 Euclid Avenue
P.O. Box 9204
Des Moines, Iowa 50306-9204

Iowa Department of Transportation

INVESTIGATING OFFICER'S REPORT OF MOTOR VEHICLE ACCIDENT

Sheet of
Law Enforcement Case Numbers:
Legal Intervention? ☐ Private Property? ☐

PLEASE TYPE OR PRINT

LOCATION

Date of Accident | Time of Accident Hrs. | County | Accident occurred within corporate limits of (city)

If accident occurred outside of city limits show general vicinity — miles N NE E SE S SW W NW of nearest city

On Road, Street, or Highway: | At Intersection with:

Note: Unless accident occurred at an intersection which is completely described above, use the space below to give the exact location from a milepost or definable intersection, bridge, or railroad crossing, using two distances and directions if necessary.

Feet Miles or N NE E SE S SW W NW and Feet Miles or N NE E SE S SW W NW of

Milepost Number Or Definable intersection, bridge, or railroad crossing

County: _____ Route: _____
X-Coordinate: _____
Y-Coordinate: _____

If Divided Highway, Provide Route (Cardinal) Travel Direction
NB SB EB WB

UNIT 1

Driver's Name (Last, First, Middle) | Address | City | State | Zip

Date of Birth | Driver's License Number | Citation Charge 1. 2. 3. 4.

Male Female | State | Class | Endorsements | Restrictions

Alcohol Test Given? ☐ 1. None 2. Blood 3. Urine 4. Breath 5. Vitreous Test Results: 9. Refused

Drug Test Given? ☐ 1. None 2. Blood 3. Urine 9. Refused Pos. Neg.

Owner's Name (Last, First, Middle) | Address | City | State | Zip

Insurance Co. Name | Insurance Policy # | License Plate # | State | Year

VIN # | Year | Make | Model | Style | Tow # | Approximate Cost to Repair or Replace

Private? ☐ $

Initial Travel Direction | Vehicle Action | Speed Limit | Point of Initial Impact | Most Damaged Area | Extent of Damage | Underride/Override

Total Occupants | Traffic Controls | Vehicle Config. | Cargo Body Type | Vehicle Defect | Driver Condition | Vision Obscured | Contributing Circumstances, Driver (up to two)

Commercial Trailer License Plate # | Attached to Power Unit: State Year | Attached to Trailer Unit: State Year | Emergency Vehicle Type | Emergency Status

Carrier Name | Address | City | State | Zip

US DOT# or MC# | Number of Axles | Gross Vehicle Weight Rating | Placard # | Hazardous Materials Released?

UNIT 2

Driver's Name (Last, First, Middle) | Address | City | State | Zip

Date of Birth | Driver's License Number | Citation Charge 1. 2. 3. 4.

Male Female | State | Class | Endorsements | Restrictions

Alcohol Test Given? ☐ 1. None 2. Blood 3. Urine 4. Breath 5. Vitreous Test Results: 9. Refused

Drug Test Given? ☐ 1. None 2. Blood 3. Urine 9. Refused Pos. Neg.

Owner's Name (Last, First, Middle) | Address | City | State | Zip

Insurance Co. Name | Insurance Policy # | License Plate # | State | Year

VIN # | Year | Make | Model | Style | Tow # | Approximate Cost to Repair or Replace

Private? ☐ $

Initial Travel Direction | Vehicle Action | Speed Limit | Point of Initial Impact | Most Damaged Area | Extent of Damage | Underride/Override

Total Occupants | Traffic Controls | Vehicle Config. | Cargo Body Type | Vehicle Defect | Driver Condition | Vision Obscured | Contributing Circumstances, Driver (up to two)

Commercial Trailer License Plate # | Attached to Power Unit: State Year | Attached to Trailer Unit: State Year | Emergency Vehicle Type | Emergency Status

Carrier Name | Address | City | State | Zip

US DOT# or MC# | Number of Axles | Gross Vehicle Weight Rating | Placard # | Hazardous Materials Released?

If Property other than vehicles damaged explain | Object Damaged | Estimate of Damage $

Owner's Full Name (Last, First, Middle) | Was owner or tenant notified? ☐ 1 - Yes 9 - Unknown 2 - No

Street or RFD | City, State, & Zip Code

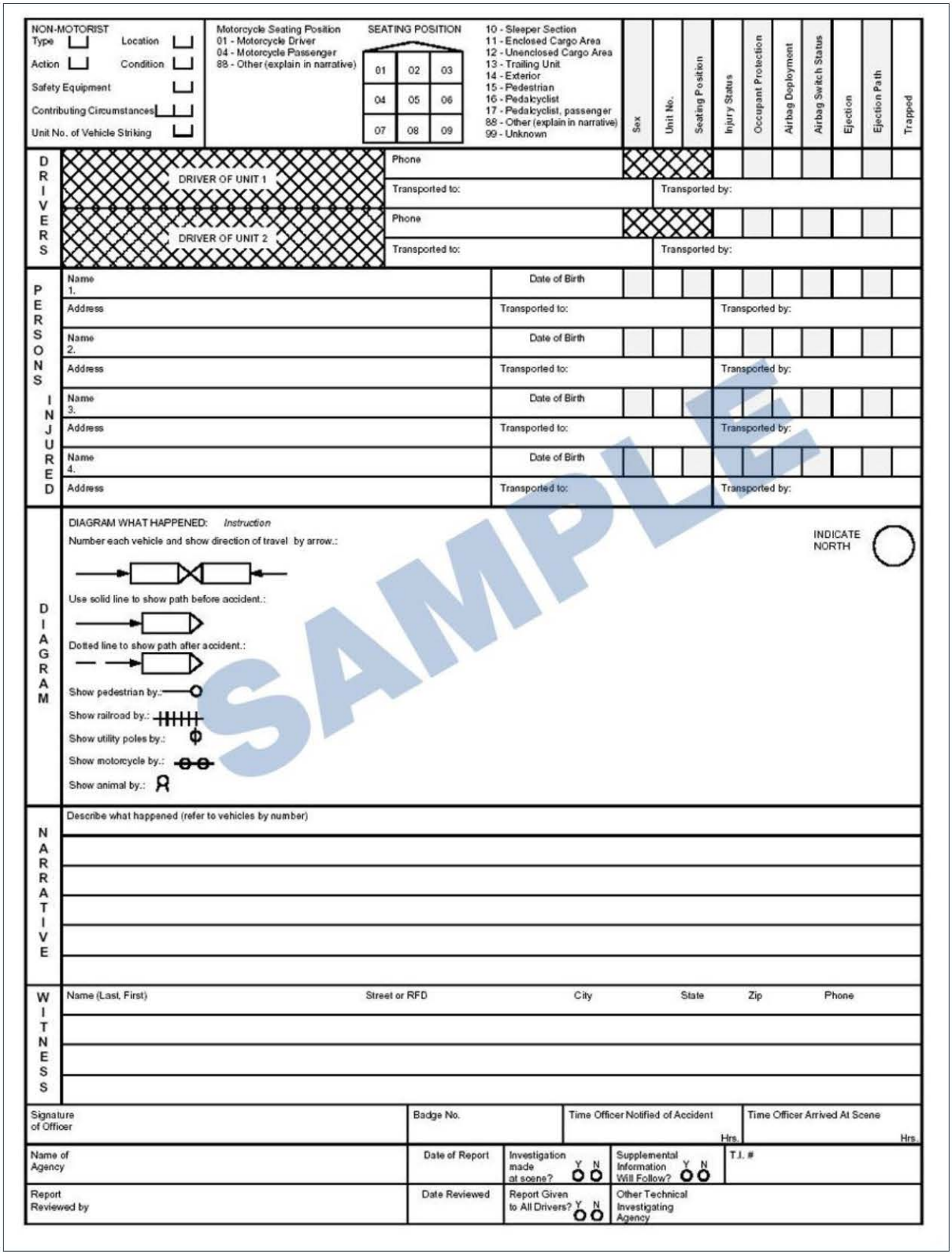
ACCIDENT ENVIRONMENT
Location of First Harmful Event ☐ Weather Conditions (up to two) ☐☐
Manner of Crash/Collision ☐ ☐☐
Light Conditions ☐ Surface Conditions ☐

ROADWAY CHARACTERISTICS
Major Contributing Circumstances: Environment ☐ Roadway ☐☐
Type of Roadway Junction/Feature ☐☐

WORK ZONE RELATED? Yes No
☐ Location
☐ Type
☐ Workers Present?

Unit 1	Unit 2	SEQUENCE OF EVENTS
☐☐	☐☐	First Event
☐☐	☐☐	Second Event
☐☐	☐☐	Third Event
☐☐	☐☐	Fourth Event
☐☐	☐☐	Most Harmful Event (by vehicle)
	☐☐	First Harmful Event of Crash (use codes 11-42 only)

Figure 3.1. Form 433003 Investigating Officer's Report of Motor Vehicle Accident (front)



NON-MOTORIST
Type ☐ Location ☐
Action ☐ Condition ☐
Safety Equipment ☐
Contributing Circumstances ☐
Unit No. of Vehicle Striking ☐

Motorcycle Seating Position
01 - Motorcycle Driver
04 - Motorcycle Passenger
88 - Other (explain in narrative)

SEATING POSITION

01	02	03
04	05	06
07	08	09

10 - Sleeper Section
11 - Enclosed Cargo Area
12 - Unenclosed Cargo Area
13 - Trailing Unit
14 - Exterior
15 - Pedestrian
16 - Pedalcyclist
17 - Pedalcyclist, passenger
88 - Other (explain in narrative)
99 - Unknown

	Sex	Unit No.	Seating Position	Injury Status	Occupant Protection	Airbag Deployment	Airbag Switch Status	Ejection	Ejection Path	Trapped
DRIVERS										
DRIVER OF UNIT 1	Phone									
	Transported to:			Transported by:						
DRIVER OF UNIT 2	Phone									
	Transported to:			Transported by:						
PERSONS INJURED	Name 1.		Date of Birth							
	Address		Transported to:		Transported by:					
	Name 2.		Date of Birth							
	Address		Transported to:		Transported by:					
	Name 3.		Date of Birth							
	Address		Transported to:		Transported by:					
	Name 4.		Date of Birth							
	Address		Transported to:		Transported by:					

DIAGRAM

DIAGRAM WHAT HAPPENED: *Instruction*
Number each vehicle and show direction of travel by arrow.:
Use solid line to show path before accident.:
Dotted line to show path after accident.:
Show pedestrian by.:
Show railroad by.:
Show utility poles by.:
Show motorcycle by.:
Show animal by.:

INDICATE NORTH

NARRATIVE

Describe what happened (refer to vehicles by number)

WITNESS

Name (Last, First)	Street or RFD	City	State	Zip	Phone

Signature of Officer	Badge No.	Time Officer Notified of Accident Hrs.	Time Officer Arrived At Scene Hrs.
Name of Agency	Date of Report	Investigation made at scene? Y N	Supplemental Information Will Follow? Y N / T.I. #
Report Reviewed by	Date Reviewed	Report Given to All Drivers? Y N	Other Technical Investigating Agency

Figure 3.2. Form 433003 Investigating Officer's Report of Motor Vehicle Accident (back)

Driver / Vehicle Characteristics

Initial Travel Direction
(prior to coded Vehicle Action)
1 - North
2 - East
3 - South
4 - West
9 - Unknown

N W E S

Vehicle Action
01 - Movement essentially straight
02 - Turning left
03 - Turning right
04 - Making U-turn
05 - Overtaking/passing
06 - Changing lanes
07 - Entering traffic lane (merging)
08 - Leaving traffic lane
09 - Backing
10 - Slowing/stopping
11 - Stopped for stop sign/signal
12 - Legally parked
13 - Illegally parked/Unattended
88 - Other (explain in narrative)
99 - Unknown

Point of Initial Impact Most Damaged Area

01 02 03 04 05 06 07 08 09
Front
10 Undercarriage 99 Unknown

Extent of Damage
1 - None
2 - Minor damage
3 - Functional damage
4 - Disabling damage
5 - Severe, vehicle totalled
9 - Unknown

Underride/Override
1 - None
2 - Underride, compartment intrusion
3 - Underride, no compartment intrusion
4 - Underride, compartment intrusion unknown
5 - Override, moving vehicle
6 - Override, parked/stationary vehicle
9 - Unknown

Traffic Controls
01 - No controls present
02 - Traffic signals
03 - Flashing traffic control signal
04 - Stop signs
05 - Yield signs
06 - No Passing Zone (marked)
07 - Warning sign
08 - School zone signs
09 - Railway crossing device
10 - Traffic director
11 - Work Zone signs
88 - Other control (explain in narrative)
99 - Unknown

Vehicle Configuration
01 - Passenger car
02 - Four-tire light truck (pick-up, panel)
03 - Van or mini-van
04 - Sport utility vehicle
05 - Single-unit truck (2-axle, 6-tire)
06 - Single-unit truck (> = 3 axles)
07 - Truck/trailer
08 - Truck tractor (bobtail)
09 - Tractor/semi-trailer
10 - Tractor/doubles
11 - Tractor/triples
12 - Other heavy truck (cannot classify)
13 - Motor home/recreational vehicle
14 - Motorcycle
15 - Moped/ All-Terrain Vehicle
16 - School bus (seats > 15)
17 - Small school bus (seats 9-15)
18 - Other bus (seats > 15)
19 - Other small bus (seats 9-15)
20 - Farm vehicle/equipment
21 - Maintenance/construction vehicle
22 - Train
88 - Other (explain in narrative)
99 - Unknown

Cargo Body Type
01 - Not applicable

Truck Cargo Type:
02 - Van/enclosed box
03 - Dump truck (grain, gravel)
04 - Cargo tank
05 - Flatbed
06 - Concrete mixer
07 - Auto transporter
08 - Garbage/refuse
09 - Other truck cargo type (explain in narrative)

Trailer Type:
10 - Small utility (one axle)
11 - Large utility (2+ axles)
12 - Boat
13 - Camper
14 - Large mobile home
15 - Oversize load
16 - Towed vehicle
17 - Pole
18 - Other trailer type (explain in narrative)
99 - Unknown

Vehicle Defect
01 - None
02 - Brakes
03 - Steering
04 - Blowout
05 - Other tire defect (explain in narrative)
06 - Wipers
07 - Trailer hitch
08 - Exhaust
09 - Headlights
10 - Tail lights
11 - Turn signal
12 - Suspension
88 - Other (explain in narrative)
99 - Unknown

Driver Condition
1 - Apparently normal
2 - Physical impairment
3 - Emotional (e.g. depressed, angry, disturbed)
4 - Illness
5 - Asleep, fainted, fatigued, etc.
6 - Under the influence of alcohol/drugs/medications
8 - Other (explain in narrative)
9 - Unknown

Vision Obscured
01 - Not obscured
02 - Trees/crops
03 - Buildings
04 - Embankment
05 - Sign/billboard
06 - Hillcrest
07 - Parked vehicles
08 - Moving vehicles
09 - Person/object in or on vehicle
10 - Blinded by sun or headlights
11 - Frosted windows/windshield
12 - Blowing snow
13 - Fog/smoke/dust
88 - Other (explain in narrative)
99 - Unknown

Contributing Circumstances, Driver (up to two)
01 - Ran traffic signal
02 - Ran stop sign
03 - Exceeded authorized speed
04 - Driving too fast for conditions
05 - Made improper turn
06 - Travelling wrong way or on wrong side of road
07 - Crossed centerline
08 - Lost control
09 - Followed too close
10 - Swerved to avoid: vehicle, object, non-motorist, or animal in roadway
11 - Over correcting/over steering
12 - Operating vehicle in an erratic, reckless, careless, negligent, or aggressive manner

Failed to yield right-of-way:
13 - From stop sign
14 - From yield sign
15 - Making left turn
16 - Making right turn on red signal
17 - From driveway
18 - From parked position
19 - To pedestrian
20 - At uncontrolled intersection
21 - Other (explain in narrative)

Inattentive/distracted by:
22 - Passenger
23 - Use of phone or other device
24 - Fallen object
25 - Fatigued/asleep

Other (explain in narrative):
26 - Vision obstructed
27 - Other improper action
28 - No improper action

99 - Unknown

Emergency Vehicles

Emergency Vehicle Type
1 - Not applicable
2 - Police
3 - Fire
4 - Ambulance
5 - Towing
6 - Military
7 - Maintenance
9 - Unknown

Emergency Status
1 - Yes, in emergency
2 - No, not in emergency
3 - Not applicable
9 - Unknown

Hazardous Materials Released? (Cargo Only)

1 - Yes
2 - No
3 - Not applicable
9 - Unknown

Iowa Department of Transportation

INVESTIGATING OFFICER'S REPORT OF MOTOR VEHICLE ACCIDENT CODE SHEET

Form 433014
01-01

Work Zone Related?

Location
1 - Before work zone warning sign
2 - Between advance warning sign and work area
3 - Within transition area for lane shift
4 - Within or adjacent to work activity
5 - Between end of work area and "End Work Zone" sign
8 - Other work zone area (explain in narrative)
9 - Unknown

Type
1 - Lane closure
2 - Lane shift/crossover/ head-to-head traffic
3 - Work on shoulder or median
4 - Intermittent or moving work
8 - Other type of work zone (explain in narrative)
9 - Unknown

Workers Present?
1 - Yes
2 - No
9 - Unknown

Figure 3.3. Form 433014 Investigating Officer's Report of Motor Vehicle Accident Code Sheet (front)

Accident Environment

Location of First Harmful Event
1 - On Roadway
2 - Shoulder
3 - Median
4 - Roadside
5 - Gore
6 - Outside trafficway
9 - Unknown

Manner of Crash/Collision
1 - Non-collision
2 - Head-on
3 - Rear-end
4 - Angle, oncoming left turn
5 - Broadside
6 - Sideswipe, same direction
7 - Sideswipe, opposite direction
9 - Unknown

Light Conditions
1 - Daylight
2 - Dusk
3 - Dawn
4 - Dark, roadway lighted
5 - Dark, roadway not lighted
6 - Dark, unknown roadway lighting
9 - Unknown

Weather Conditions (up to two)
01 - Clear
02 - Partly cloudy
03 - Cloudy
04 - Fog, smoke
05 - Mist
06 - Rain
07 - Sleet, hail, freezing rain
08 - Snow
09 - Severe winds
10 - Blowing sand, soil, dirt, snow
88 - Other (explain in narrative)
99 - Unknown

Surface Conditions
1 - Dry
2 - Wet
3 - Ice
4 - Snow
5 - Slush
6 - Sand, mud, dirt, oil, gravel
7 - Water (standing, moving)
8 - Other (explain in narrative)
9 - Unknown

Roadway Characteristics

Contributing Circumstances, Environment
1 - None apparent
2 - Weather conditions
3 - Physical obstruction
4 - Pedestrian action
5 - Glare
6 - Animal in roadway
7 - Previous accident
8 - Other (explain in narrative)
9 - Unknown

Contributing Circumstances, Roadway
01 - None apparent
02 - Road surface condition
03 - Debris
04 - Ruts, holes, bumps
05 - Work Zone (construction, maintenance, utility)
06 - Worn, travel-polished surface
07 - Obstruction in roadway
08 - Traffic control device inoperative, missing, obscured
09 - Shoulders (none, low, soft, high)
10 - Non-highway work
11 - Non-contact vehicle
99 - Unknown

Type of Roadway Junction/ Feature

Non-intersection:
01 - No special feature
02 - Bridge/overpass/underpass
03 - Railroad crossing
04 - Business drive
05 - Farm/residential drive
06 - Alley intersection
07 - Crossover in median
08 - Other non-intersection (explain in narrative)

Intersection:
11 - Four-way intersection
12 - T - intersection
13 - Y - intersection
14 - Five-leg or more
15 - Offset four-way intersection
16 - Intersection with ramp
17 - On-ramp merge area
18 - Off-ramp diverge area
19 - On-ramp
20 - Off-ramp
21 - With bike/pedestrian path
22 - Other intersection (explain in narrative)
99 - Unknown

Harmful Events

Sequence of Events
Most Harmful Event
First Harmful Event

Pre-crash events:
01 - Ran off road, right
02 - Ran off road, straight
03 - Ran off road, left
04 - Crossed centerline/median
05 - Animal or object in roadway
06 - Evasive action (swerve, panic braking, etc.)
07 - Downhill runaway
08 - Cargo/equipment loss or shift
09 - Equipment failure (tires, brakes, etc.)
10 - Separation of units

Non-collision events:
11 - Overturn/rollover
12 - Jackknife
13 - Other non-collision (explain in narrative)

Collision with:
20 - Non-motorist (see non-motorist type)
21 - Vehicle in traffic
22 - Vehicle in/from other roadway
23 - Parked motor vehicle
24 - Railway vehicle/train
25 - Animal
26 - Other non-fixed object (explain in narrative)

Collision with fixed object:
30 - Bridge/bridge rail/overpass
31 - Underpass/structure support
32 - Culvert
33 - Ditch/embankment
34 - Curb/island/raised median
35 - Guardrail
36 - Concrete barrier (median or right side)
37 - Tree
38 - Poles (utility, light, etc.)
39 - Sign post
40 - Mailbox
41 - Impact attenuator
42 - Other fixed object (explain in narrative)

Misc. events:
50 - Fire/explosion
51 - Immersion
52 - Hit and run
99 - Unknown

Injury/Protective Devices

Injury Status
1 - Fatal
2 - Incapacitating
3 - Non-incapacitating
4 - Possible
5 - Uninjured
9 - Unknown

Occupant Protection
1 - None used
2 - Shoulder and lap belt used
3 - Lap belt only used
4 - Shoulder belt only used
5 - Child safety seat used
6 - Helmet used
8 - Other (explain in narrative)
9 - Unknown

Airbag Deployment
1 - Deployed front of person
2 - Deployed side of person
3 - Deployed both front/side
4 - Other deployment (explain in narrative)
5 - Not deployed
6 - Not applicable
9 - Unknown

Airbag Switch Status
1 - Switch in ON position
2 - Switch in OFF position
3 - No ON/OFF switch present
9 - Unknown

Ejection
1 - Not ejected
2 - Partially ejected
3 - Totally ejected
4 - Not applicable (motorcycle, bicycle, etc.)
9 - Unknown

Ejection Path
1 - Not ejected/not applicable
2 - Through front windshield
3 - Through side window/door
4 - Through roof
5 - Through back window/tailgate
9 - Unknown

Trapped
1 - Not trapped
2 - Freed by non-mechanical means
3 - Extricated by mechanical means
9 - Unknown

Non-Motorist

Type
1 - Pedestrian
2 - Pedalcyclist (bicycle, tricycle, unicycle, pedal car)
3 - Skater
8 - Other (explain in narrative)
9 - Unknown

Location (prior to impact)
1 - Marked crosswalk at intersection
2 - At intersection, no crosswalk
3 - Non-intersection crosswalk
4 - Driveway access crosswalk
8 - Other non-intersection (explain in narrative)
9 - Unknown

Action
1 - Entering or crossing roadway
2 - Walking, running, jogging, playing, cycling
3 - Working
4 - Pushing vehicle
5 - Approaching or leaving vehicle
6 - Playing or working on vehicle
7 - Standing
8 - Other (explain in narrative)
9 - Unknown

Condition
1 - Apparently normal
2 - Physical impairment
3 - Emotional (e.g. depressed, angry, disturbed)
4 - Illness
5 - Asleep, fainted, fatigued, etc.
6 - Under the influence of alcohol/drugs/medications
8 - Other (explain in narrative)
9 - Unknown

Safety Equipment
1 - Helmet
2 - Reflective clothing
3 - Lighting
4 - None
8 - Other (explain in narrative)
9 - Unknown

Contributing Circumstances
01 - Improper crossing
02 - Darting
03 - Lying or sitting in roadway
04 - Failure to yield right of way
05 - Not visible (dark clothing)
06 - Inattentive (talking, eating, etc.)
07 - Failure to obey traffic signs, signals, or officer
08 - Wrong side of road
88 - Other (explain in narrative)
99 - Unknown

Figure 3.4. Form 433014 Investigating Officer's Report of Motor Vehicle Accident Code Sheet (back)

Another section of the crash report that can provide valuable information for analysis is the narrative and crash diagram where the investigating officer can add comments not addressed in the standard entries. However, these features are not typically distributed with data from the crash database or the crash analysis tools and must be requested from the Iowa DOT.

A jurisdiction's engineering and enforcement staff may improve the value of crash form data by meeting regularly to exchange information and opinions on the value of quality data and possible improvements for crash reporting. If desired, MVD ODS can provide specific training on the proper completion of crash forms.

Data Retention

The State of Iowa maintains a comprehensive database of 10+ years of crash history for all public roads and streets. The non-personal records are available for analysis from the Iowa DOT Office of Traffic and Safety (TAS). Public agencies can request and obtain data and training at no cost.

Data Analysis

The Iowa DOT TAS provides a variety of software, data, analyses, and services to assist in analyzing crash data. Software training and safety-related topic workshops are also provided. See Chapter 5: Analyzing Crash Data for a detailed explanation of crash analysis, regardless of the software tool(s), data, analyses, and services desired.

Iowa's crash-analysis software tools provide spot and stacked maps, charts, reports, and collision diagrams of crash history for desired time periods and locations. A spot map, for example, provides a visual display of crash locations and can be coded for severity, type, roadway feature involved, or other desired data. Examples of stacked maps, charts, collisions diagrams, and reports are included in later sections of this manual. See Chapter 9: Crash Analysis Software in Iowa to learn more about the TAS-provided crash analysis software, data, analyses, and services.

Data Quality and Timeliness

Data, to be most useful, must be current, accurate, and fully accessible to interested persons. Establishing files and systems that allow efficient and easy cross-referencing is also important. Crash data type and accessibility varies with the agency size. The data collection methods most commonly used (listed in order of occurrence) include electronic record systems (e.g., TraCS), paper files, and spot maps.

In Iowa, the large majority of crash reports (roughly 80 percent) are submitted to the state crash database via TraCS, but many are still filed as paper reports, whether by an enforcement officer, a driver, or another involved party. Electronic reporting via TraCS, with the natural resultant distribution of data entry effort, has markedly improved data

availability. In Iowa, the average availability of crash data following a crash has been estimated at less than two weeks. However, not all crashes are submitted that quickly, meaning the more recent the crash, the more likely the data are not yet available.

With fatal crashes, which are usually of the most immediate interest, this timeframe can be compounded by a lengthy, detailed investigated. Nevertheless, Iowa's crash data are recognized nationally as being of excellent quality, timely, and accessible. Despite this recognition, efforts are continually underway to improve the quality, timeliness, and accessibility of the data with updates to validations and edits, increased use of TraCS and other time-saving efforts, and upgrades to analysis tools, resources, and services.

Crash Data Mapping

All crashes using the Iowa crash report form (since 2001) should have been geolocated by either the investigating officer or the person who entered the data into the database (at the enforcement agency or at MVD) using a smart map tool dubbed the Incident Location Tool (ILT). The ILT assists the person entering the data by providing an electronic map showing Iowa's roads and by allowing for crash point placement on this map with a literal description for the point placement provided as feedback. The output of this location tool translated into the crash database is X and Y coordinates. These coordinates are collected and stored in the Universal Transverse Mercator, North American Datum 1983, Zone 15N meters projection.

Although the ILT has significantly reduced the former bottleneck of crash data processing and greatly enhanced accurate crash occurrence placement, this crash-location capture system is not perfect. A relatively small fraction of crashes may not be properly located. The following are some of the causes of location errors:

- Not enough information is available to locate the crash properly. This problem is most common for crashes that are submitted to the state via paper reports and are thus located at MVD. For these crashes, the submitting agency is contacted in an effort to locate crashes that are more severe. If no location information can be obtained reasonably, these crashes are assigned coordinates outside of the Iowa borders. These crash data need to be included in the database for statewide, countywide, or citywide statistic-generation purposes, but if the proper location is unknown and assigned coordinates within the Iowa borders, these crashes may be erroneously assigned to a particular location.
- Crashes occur on roads that have not been added to the map yet. Roads are being constructed or relocated continually, especially in rapidly growing communities, and crashes may occur on these roads before the electronic road maps are updated and provided for the crash-point location tool. These crashes may be placed in the approximate location of the new road or may be intentionally stored outside of Iowa (for the same reason described above).

- The accuracy of the underlying electronic road maps improves over time. Some crashes may appear to have occurred off the roadway because they were located using an earlier version of the map and the roads have since been more accurately represented.
- Location was estimated. The locator maps include only public roadways, rivers, lakes, borders, and railroads. Crashes at a private driveway that is open to public travel or is a long distance from a cross street, the reporting officer must either measure or estimate the distance to the nearest street or mile marker. As a result, crashes that occur at the same business driveway may be assigned different locations along the corridor.

Nationwide, Iowa's crash, roadway, traffic volume, and other safety-related data are considered excellent. However, this recognition does not mean that improvements cannot be made—which the State of Iowa is continually striving to do.

Additional Non-Crash Data

Identifying and addressing traffic safety problems in an efficient and effective manner depends on data, primarily crash history. However, crash data must be supplemented by other information to scrutinize causes thoroughly when identifying potentially successful mitigation for safety concerns. This manual has been developed to provide guidance for crash analysis, but the primary interest is in improving safety, which requires considering non-crash data and driver, roadway, and vehicle countermeasures.

Crash data provides the core information for analyzing safety history, and these data describe instances where drivers, vehicles, and roadway conditions failed to function properly. Near misses and potential for crashes are not shown in these records. For that insight, other non-crash information sources must be consulted.

Agencies may need to examine some or all of these items during a detailed crash analysis. This examination is particularly valuable for low-volume roadways where crashes are infrequent and random in occurrence. Safety mitigation on these roads might be applied more effectively on a systemic basis instead of attempting to identify "high-crash" locations.

Potentially valuable supplemental information for comprehensive crash analysis includes but is not limited to the following:

- Roadway design and roadside features
- Traffic volumes and speeds
- Vehicle types and categories
- Pedestrian volumes and ages
- Traffic control devices and pavement markings
- Litigation history
- Traffic citation history
- Maintenance records
- Law enforcement, citizen, and staff input

- Analysis of reported incidents
- As-built plans
- Field visits

Considering these data as part of the safety analysis process will result in a more complete picture of all potential contributing elements.

Roadway and Roadside Features

Information describing physical conditions of the roadway can provide insight into contributing crash factors and possible mitigation steps. Useful information may include geometric features, such as the degree of curvature, curve superelevation, grades, and details of intersection design. Also, consider the number of lanes, traffic control, speed limits, road surface width and type, and shoulder conditions. On roadsides, natural and constructed obstacles, the available clear zone width, and side slopes can be important features for analyzing and predicting potential problem locations.

Condition diagrams can be useful for identifying and visually presenting locations and features of possible concern. These drawings are made roughly to scale to illustrate curve locations, traffic control devices, guardrails, fixed objects on the roadside, and other potentially hazardous safety items. To prepare a condition diagram, an analyst needs a measuring wheel or tape, clipboard, and paper. Any roadway feature of interest could be recorded for future reference, but appropriate accuracy is necessary. A condition diagram could be a simplified substitute for as-built plans if these are not available.

The Iowa DOT Office of Transportation Data (TransData) maintains an extensive database of many of these roadway features for state-owned roads in the entire state.

Local agencies should supplement state records with other specific information. Field visits may also be necessary to evaluate possible crash contributory factors sufficiently.

Traffic Volumes and Speeds

The Iowa DOT collects and maintains an extensive database of actual and estimated traffic volumes, both total and listed by various vehicle types (e.g., automobiles, motorcycles, buses, trucks). These data can be accessed at www.iowadotmaps.com. TransData manages and maintains this information in the Geographic Information Management System (GIMS). In addition, the TAS crash analysis software includes distribution of roadway and traffic data.

The Iowa DOT collects traffic volume and speed data in a variety of ways. Some of this data collection is undertaken at permanent count stations placed throughout the state on a statistical sampling of road classes and types. In addition, a portion of roads in the state is counted “manually” every year across a variety of road classes, population distributions,

and so forth. Special count requests (e.g., a particular intersection requested by a local agency) are covered as well. As counting every road within the state is unrealistic, only a representative roadway sample is used and these two methods (permanent and cyclical) are combined to estimate volumes across the various roadway classes and types.

In addition, local agencies may desire to generate location-specific volume data by performing counts themselves. These local counts can be accomplished as needed and often prove more timely. Advice on traffic volume counting can be obtained from sources such as the *Handbook of Simplified Practice for Traffic Studies*, which is available from the Institute for Transportation (InTrans) at www.ctre.iastate.edu/pubs/traffichandbook/index.htm.

Traffic volumes are particularly important data to consider during crash analysis, especially when comparing sites with widely ranging volumes. By developing a ratio of crash frequency to traffic volume (and accounting for differences in segment lengths), a more accurate comparison and assessment of potential hazards may be possible. For example, using crash rates, a higher-volume intersection with a similar crash frequency to a lower-volume intersection should appear a less significant issue. Conversely, the lower-volume intersection from this example should appear more significant.

Crash rates are often expressed as crashes per million entering vehicles (MEV) for intersections and as crashes per 100 million vehicle miles traveled (HM VMT) for road segments. For non-site-specific analyses, rates can be developed and expressed in terms unrelated to volumes, such as crash rates per 1,000 population or per 1,000 licensed drivers. (However, for the purposes of this manual, these ad hoc rates aren't likely to be relevant.)

Note that using crash rates for low-volume roads can be misleading and should be utilized with caution. For intersections, turning movement volumes are often necessary for safety and operational analysis, especially in urban areas. TransData maintains turning movement data for many intersections, performs special counts by request, and provides advice for gathering the information locally.

Assessing operating speeds along a corridor or through an intersection may be instructive for determining whether a regulatory speed modification might be justified and/or if differential vehicle speeds (i.e., wide disparities between the slowest and fastest vehicles) might be contributing to the crash history. This information may also help identify areas for focused enforcement efforts. The *Handbook of Simplified Practice for Traffic Studies* contains advice for obtaining these data (www.ctre.iastate.edu/pubs/traffichandbook/index.htm).

Vehicle Types and Categories

A high number of large trucks or recreational vehicles in normal traffic flow may indirectly contribute to higher crash frequency due to slower travel speeds, increased congestion, and hampered visibility. Reviewing the percentage of large commercial vehicles might be instructive in some situations. The presence of larger vehicles in the traffic mix may invite a selection of different responses to mitigate crashes. An example might be installing additional signing, including overhead and/or left-side mounting to compensate for reduced visibility.

Slow-moving agricultural equipment on rural roads may also pose safety concerns, especially at certain times of the year. And, in many areas of Iowa, Amish vehicles are often encountered. Special warning signing or even improved roadway shoulders may be justified where traffic of these types are significant.

Pedestrian and Bicyclist Involvement

When crash analysis reveals incidents involving pedestrians and/or bicyclists or if a high number of these road users are included in the traffic mix, special and unique mitigation may be warranted. This issue can be particularly sensitive as children are often involved. Considering special road user frequency may be important for comparing exposure rates at similar locations. The *MUTCD* and many other excellent resources can be used for mitigation references.

Traffic Control Devices and Pavement Markings

Traffic control devices include all signs, signals, and other devices used to regulate, warn, and guide traffic. The existence and condition of traffic control devices and pavement markings can be critical in traffic safety. Analyze the location and condition of these devices and markings, not only at the study location, but also for a significant distance in advance of the devices and marking. Improving and upgrading traffic control devices is a proven low-cost method to reduce crashes.

Many Iowa agencies have established and maintain an inventory of traffic control devices, particularly signs. A current and complete database of traffic control devices, whether electronic or paper, coupled with a regular, documented condition assessment is a valuable asset in any safety management program. Assuring compliance with minimum retro-reflectivity standards will improve nighttime driving visibility.

For example, signalized intersections can exhibit a high number of crashes, particularly rear end, broadside, and left turn. Local agencies should periodically review traffic signal conditions and warrants to see if improving or removing unjustified signals may be beneficial to overall traffic safety. Where red light running occurs with high frequency or where crash history indicates a need for mitigation, automated enforcement might be a logical consideration.

Litigation History

Prioritizing safety improvements might include reviewing past litigation issues both within the agency jurisdiction and throughout the state. While tort claims and lawsuits are not necessarily a reliable indicator of hazardous conditions, these records can provide information about potential areas for concern, such as deficient guardrail, signing, and pavement edge drop-offs. Frequent damage claims for specific alleged deficiencies may indicate a need for corrective action.

Traffic Citation History

Traffic citations for certain violations are another source of knowledge related to potential safety problems. Reviewing traffic citation history may reveal behavior patterns that could contribute to higher crash numbers. Comparing crash history and citation records at a given location may also identify immediate improvements that are needed. For example, a high number of red light running citations may indicate that traffic signals need updating or that enhanced enforcement is needed. Cooperative efforts and good communication between transportation agencies, local law enforcement, and state patrol can help improve overall traffic safety and citation record sharing.

Maintenance Records

A complete traffic records system should include pertinent maintenance records for activities such as guardrail repair, filling edge ruts, and slope grading near horizontal curves. In addition, maintenance records may provide information about roadway deficiencies not completely identified in crash records.

For example, many run-off-road incidents are not reported for various reasons; however, unreported impacts may cause damage to roadside obstacles, such as trees and utility poles. The location of these potential hazards may result in more serious crashes in the future, which is where maintenance records may be useful for noting these incidents and identifying potential hazards.

Agencies may want to develop an employee reporting form for specific types of maintenance, such as those activities already listed. The information provided on these forms should then be reviewed for needed safety improvements that can be addressed proactively.

Law Enforcement, Citizen, and Staff Input

The value of a cooperative approach to address agency traffic safety concerns are discussed later in this chapter. The insights, experiences, and advice of law enforcement professionals are integral aspects of this process. Establishing and following a program for receiving and responding to officer observations and recommendations can provide effective responses to many traffic safety problems before a crash pattern develops.

Citizen complaints can be distracting and time consuming for agency employees. However, for safety considerations, citizen input can present beneficial information about potential hazardous conditions and locations. Furthermore, once an agency has been notified of a perceived problem, this input can be considered "official notice."

If injuries result from previously-reported deficiencies and if appropriate steps have not been taken to address the issue, legal liability can result. However, exposure to liability can be reduced or even eliminated if an agency has established and follows a procedure to receive and address citizen complaints and suggestions in a timely manner.

An established procedure might include using a citizen complaint form to document not only the issue of concern but also the agency's response. A sample complaint form is shown in Figure 3.5. It is particularly important to note the date and time, complainant identification, nature of the issue, and agency response. A compilation of complaints can be used to locate potential safety hazards and higher-risk crash sites for immediate mitigation or prioritization.

Local agency officials and staff can provide equally valuable information and should be encouraged to report any deficiencies observed while traveling as part of their normal work activities or during personal trips. Observations of nighttime sign and pavement marking visibility, tire marks at specific locations, and traffic signal defects are all important issues for traffic safety.

As with citizen complaints, an excellent method of receiving and recording employee input is through the use of reporting forms. A similar form to that used for citizen complaints can be adopted for use by employees and elected officials. Appropriate agency action to address these concerns is also imperative.

Analysis of Reported Incidents

A compilation of incidents not resulting in crashes can provide a significant resource for detecting safety needs. These incidents might be reported by law enforcement, agency staff, or even citizens and can be categorized by type and location. Unreported roadway departure incidents and commonly occurring acts of vandalism are examples that could yield safety benefits with appropriate mitigation response. Agency staff may want to examine documented, reported incidents occasionally to identify possible actions to benefit safety.

Safety Management System
Safety Action Request

Caller Information

Taken Via ☐ Phone ☐ Letter ☐ On-Site ☐ Radio ☐ Fax ☐ Other	Request Date	Request Time	**Request Number**
Caller Type ☐ Citizen ☐ School District ☐ Other Dept. ☐ Council/Mgmt. ☐ Public Works ☐ Other		Received By	
Name (Last, First)		Address	
City	State	Zip Code	Home Phone	Work Phone

Service Request Information

Street Address	Name or Number	Milepost	Cross Street
Direction From	Distance in Ft.	Other Location Data	GPS Coordinates N W
Request Description			**Diagram**
Request Referred To	Date Referred	Time Referred	

Service Findings and Action

Request Type	Date Received	Time Received
Initial Investigation By	Investigation Date	Investigation Time
Findings/Action Taken		

Contact Log

Mode	Date	Time	Comments and by Whom

Mode: P = Phone I = In Person N = Note U = Unable to Contact

Request Type Codes

G - General
- GA - Abandonded Vehicle
- GC - Spill Cleanup
- GD - Drainage
- GL - Landscape Related
- GP - Sidewalk/Path
- GS - Snow/Ice
- GU - Utility Related
- GV - Illegal Use of R/W

T - Traffic
- TD - Debris on Roadway
- TF - Speed Limit
- TI - Dangerous Intersection
- TL - Signals
- TP - Pavement Markings
- TS - Sight Distance
- TT - Traffic Sign

D - Damage/Condition
- DA - Spray Application
- DF - Flooding
- DG - Guardrail Damage
- DH - Pothole
- DM - Shoulder Maintenance
- DP - Pavement Condition
- DS - Washout/ Slide
- DW - Lid Missing (CB, MH)

I - Information
- IC - Construction Inquiry
- ID - Roadside Object
- IM - Maintenance Inquiry
- IN - Request for Information
- IT - Trash/Litter on R/W
- IX - Misc. Requests

LAF Form 004 EF
7/97

TransAid
Washington State Department of Transportation

Figure 3.5. Sample safety action request form (Washington State Department of Transportation)

As-Built Plans

Most agencies prepare and retain completed project plans that depict a road or street improvement "as-built." If consulted as part of a safety review, these documents can provide valuable insight into geometric and other physical features, such as roadway widths, grades, geometrics, and drainage, which might have an impact on certain crash patterns. Be sure to supplement as-built plan office reviews with field visits to verify actual conditions.

Field Visits

Field visits are covered in Chapter 4: Identifying Potential Problem Locations.

Maintenance of Data

For any data to be useful to the maximum extent, it must be current, accurate, and fully accessible to interested staff. Establishing a filing system that allows efficient and easy cross-referencing is also important. Database type and accessibility varies with agency size. The most common data sources include manual (paper) files, spot maps, and electronic record systems.

Multi-Disciplinary Approach to Roadway Safety

When professionals in law enforcement, engineering, planning, driver education, traffic safety advocacy, and the news media collaborate on highway safety, the collaboration can have a dramatic impact. For example, the Iowa Traffic Safety Alliance (ITSA) (which was formerly the Safety Management System Coordinating Committee/SMSCC) has developed the Toolbox of Highway Safety Strategies, presented an older drivers conference, and supported numerous research studies and safety initiatives. The ITSA includes members from federal, state, and local government, professional associations, insurance interests, universities, and advocacy groups, and has been supported by the Iowa DOT and the Iowa GTSB for more than 10 years. This group worked together to develop Iowa's Comprehensive Highway Safety Plan (CHSP).

Local agencies may wish to establish their own cooperative working groups to meet on a regular schedule, discuss traffic safety issues, and develop effective programs to address concerns. The GTSB and/or the Iowa DOT TAS can help agencies develop and maintain inter-disciplinary safety collaboration.

Who is Involved in a Local Multi-Disciplinary Safety Team?

Diverse perspectives are key to an effective safety group. When developing a multi-disciplinary safety team (MDST), agencies should consider inviting the following professionals and groups to participate:

- Local, state, and federal engineers to identify safety problem locations, stratify options for improvement, conduct appropriate studies, and review crashes

- Planning organizations to facilitate collaboration between agencies and other interested groups
- Design and construction engineers to suggest physical improvements
- Agency maintenance staff to furnish maintenance-related assistance and report observed deficiencies
- Federal agencies such as the FHWA, the National Highway Traffic Safety Administration (NHTSA), and the Federal Motor Carrier Safety Administration (FMCSA) to provide advice, support, and possible funding sources
- State and local law enforcement officers who can report observed violations and citations at potentially hazardous locations, conduct targeted enforcement, and provide opinions of driver behavior and other factors that might influence mitigation choices
- Schools and driver education instructors to teach new drivers about unsafe driving actions that might contribute to crashes and advise the group of possible safety deficient locations
- News media to cover safety initiatives and programs and publicize information about the causes of specific crashes and implications of unsafe driving habits (They may appreciate being included and they can become an ally for sharing important issues with the public)
- Pedestrian and bicycle supporters to provide input on pedestrian and bicyclist concerns and needs
- Driver associations and safety advocacy groups to assist in educating drivers about behaviors that contribute to crashes, promote safety programs and initiatives, and support legislation that addresses transportation safety issues
- State and local legislators and officials who can support budget items that include transportation safety funding and support and advocate for safety initiatives such as speed limit restrictions, seat belt usage, and Operating While Intoxicated (OWI) legislation

The representatives from many of these groups can provide valuable advice and support for safety efforts and will benefit from learning more about the issues involved.

What Can a Local Team Do?

An MDST can identify safety problems and select solutions. Common ways to enhance roadway safety involve physically improving the site (engineering) and/or are directed toward driver compliance (enforcement and education).

Engineering responses can include upgrading traffic control devices and/or modifying a site's design. Enforcement and education responses can include targeted enforcement activities and public education campaigns. As an example, a multi-pronged approach to address red light running at intersections might consider the following options, either concurrently or sequentially.

Engineering

- Larger signal heads to improve visibility
- Back plates for signal heads, again, for improved visibility
- Signal head over each approach lane for better recognition by drivers
- Re-time signals to reduce delays and driver frustration
- Install two-way progression to improve traffic flow and reduce delay

Education and Marketing

- News releases using crash history examples
- Driver educator emphasis
- Local presentations at service clubs, etc.

Enforcement

- Focused enforcement efforts at problem intersections
- Officer presentations at schools, service clubs, etc.
- Use of automated enforcement (as last resort)

Other examples of possible initiatives by a variety of stakeholders can be found in references such as NCHRP Report 500, Volume 5, *A Guide for Addressing Unsignalized Intersection Crashes* and Volume 12, *A Guide for Addressing Signalized Intersection Collisions*.

A similar approach could be applied in a rural area where crash and incident data have revealed a high percentage of crashes involving impaired driving and/or younger drivers at curve locations along a section of roadway. Again, an opportunity for a multi-pronged approach to reduce crashes would be available.

Engineering

- Improve signing, add chevrons and/or delineators
- Upgrade pavement markings
- Remove obstructions within the clear zone
- Flatten slopes

Enforcement

- Establish focused enforcement efforts to address impaired drivers

Education

- Work with driver educators in high schools by providing pertinent crash data illustrating younger driver involvement
- Provide data and interview opportunities to news media

Many other suggestions for possible countermeasures are included in Chapter 6 of this manual.

Value of Cooperative Initiatives

A successful transportation safety program will be augmented significantly through the cooperative and supportive efforts of like-minded professionals in various fields. Several interdisciplinary organizations have been effectively functioning in Iowa for several years and the value of these efforts are evident. The potential benefit of cooperative safety efforts by such diverse groups as law enforcement, engineering, planners, schools (and particularly, driver educators), advocacy groups, and news media can be dramatic.

Other proactive agency initiatives that can prove beneficial in addressing traffic safety include the following:

- Develop and adopt policies and procedures for specific safety issues
- Provide appropriate and timely training for all staff
- Establish working relationships between departments and agencies with similar safety interests such as law enforcement, engineering, education, and emergency responders at both state and local levels
- Stay up to date with new technology and methods
- Maintain an open and cooperative relationship with news media and citizen groups
- Be sure office staff is equipped with current filing and analysis capabilities for management of pavement features, access restrictions, traffic control devices, and crash history
- Seek and rely on advice of experienced experts in federal and state agencies, as well as peers
- Be aggressive in seeking solutions to identified problems/don't be overly cautious in implementing new or unfamiliar methods
- Thoroughly document all actions, both successes and disappointments

Governor's Traffic Safety Bureau Safety Enforcement Initiatives

An excellent example of focused law enforcement efforts can be found in the programs supported and promoted by the Iowa GTSB.

Background

When the Iowa 5 Percent Most Severe Safety Needs initiative was first formulated (per Section 1401 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act/SAFETEA-LU: A Legacy for Users), statewide enforcement efforts, as coordinated by the Iowa GTSB, were being directed at corridor-based enforcement. Thus, basing selection and response on identification of corridors related to enforcement-related topics such as speeding, driver impairment, and unbelted drivers or passengers was initiated.

However, the GTSB has refocused their method of operation to promote inclusion and saturation based on regions or areas in lieu of corridors. Now, rather than encouraging enforcement efforts on a particular corridor or particular topic, the efforts are directed toward covering large areas and encouraging all enforcement agencies within the areas to be more involved and to capture violations across topics, thereby intending to foster greater sustainability of enforcement efforts and awareness of these efforts by the public to affect a change in mindset with regard to traffic safety.

Programs

The GTSB has divided the state of Iowa into five somewhat overlapping regions: three proceeding from north to south and spanning the state from east to west (Southern Exposure, Operation Midway, and Northern Lights) and two dividing the state east and west (Eastern Heat and Westward Expansion). Using these five regions and two additional statewide operations, the GTSB encourages enforcement agencies within the regions to participate in region-wide enforcement awareness efforts through seven annual efforts as detailed in Table 3.1.

Table 3.1. Iowa GTSB annual region-wide enforcement awareness efforts

Name of Effort	Two Days In	Region
Southern Exposure	April	Southern third of Iowa
Operation Midway	May	Middle third of Iowa
Northern Lights	June	Northern third of Iowa
Operation "I"s	July	Statewide interstates
Eastern Heat	August	Eastern half of Iowa - east of I-35
Child Passenger Safety and Mobile Eyes Corridor	September	Statewide
Western Expansion	October	Western half of Iowa - west of I-35

In addition, the GTSB sponsors five statewide special Traffic Enforcement Program (sTEP) waves as detailed in Table 3.2.

Table 3.2. GTSB-sponsored special Traffic Enforcement Program (sTEP) waves

Holiday/Name	Duration	Month/Timing
St. Patrick's Day	5 days	March
Memorial Day/C.I.O.T. (Click It Or Ticket)	14 days	May/June
Independence Day	4 days	July
Labor Day/Over the Limit - Under Arrest	14 days	August/September
Thanksgiving	7 days	November

Note that, while some of these efforts describe specific programs or topics, enforcement agencies are encouraged to maintain their awareness across all topics. In addition, the special sTEP events on Memorial Day and Labor Day are scheduled in conjunction with national efforts.

Through these GTSB programs, although not targeted specifically to the Iowa *5 Percent Most Severe Safety Needs Report* for corridors, enforcement efforts throughout the state cover each county a minimum of eight times throughout each year, hopefully encouraging sustained enforcement efforts and awareness by the public.

Additional Information

A more detailed discussion on the application of data is presented in Chapter 5: Analyzing Data, with additional information in Chapter 6: Countermeasures.

TAS provides both data and software for crash analysis. Training for using these programs is available without cost to local agencies. Available software includes the Incident Mapping Analysis Tool (IMAT), the Crash Mapping Analysis Tool (CMAT), and the Safety, Analysis, Visualization and Exploration Resource (SAVER). CMAT and IMAT allow user-friendly determination of basic crash history information, such as crash types, numbers, severities, and locations, which can be used for benefit-cost calculations. SAVER can be employed for more-detailed analysis. These are described in more detail in Chapter 9: Crash Analysis Software in Iowa.

Any of these software programs can provide spot maps, charts, and reports of crash history for desired time periods and locations. A spot map provides a visual display of crash locations and can be coded for severity, type, roadway feature involved, or other desirable data. In addition, the Iowa DOT annually prepares Safety Improvement Candidate Location (SICL) lists for the state roadway system and these listings are a valuable tool for comparing crash history to location and route.

Another excellent source for crash data analysis is the Iowa Traffic Safety Data Service (ITSDS) at InTrans at Iowa State University (ISU). ITSDS can furnish detailed, expert analysis in a timely manner for most specific crash problem locations and types. This service is described in more detail later in this manual.

Chapter 4: Identifying Potential Problem Locations

Before embarking on a detailed analysis of available crash data, an agency may want to ascertain that the process to be followed will meet the desired goals. For example, if the goal is to reduce the total number of fatalities in a jurisdiction, some of the steps described below may not be important or even necessary. The scope of the analysis needs to be decided and defined from the outset.

For many crash data investigations, the location in need of crash analysis has already been determined. The location may have been suggested from a question or complaint from a citizen, supervisor, or law enforcement officer. The location may be part of a road safety audit or a maintenance or construction project, or it may have been determined through a systematic process of identifying "high-crash" locations or sites with the potential for improvement (e.g., via the Iowa DOT TAS SICL list of top 200 intersections or the Iowa *5 Percent Most Severe Safety Needs Report* for corridors).

Agency staff may want to conduct a general crash investigation of the entire jurisdiction as part of an established safety management plan. Adopting and following a systematic procedure to identify sites and roadway segments with potential or actual safety concerns is a valuable asset to a proactive safety program.

As noted in the introductory chapter of this manual, NCHRP Report 440, *Accident Mitigation Guide for Congested Rural Two-Lane Highways*, describes a six-step process that agencies can adopt to locate and mitigate safety deficient locations (*1):*

1. Identify potential and/or actual safety problem locations
2. Evaluate crash history
3. Examine field conditions
4. Analyze contributing factors and possible countermeasures
5. Assess and select appropriate mitigation
6. Implement improvements and evaluate the effectiveness

The following sections explain these steps in more detail.

1. Identify Potential and/or Actual Safety Problem Locations

Begin this process by gathering information. Several data sources can be used to identify areas of possible concern:

- Local agencies can obtain a multiyear history of crashes from the Iowa DOT TAS or from ITSDS at InTrans.
- Agencies can also investigate their crash data utilizing DOT provided software programs such as CMAT and/or SAVER.
- Other useful data may include traffic operation characteristics; field observations; input from citizens, law enforcement, and other professional staff; and approximations where crash data are limited or non-existent.
- TAS develops an annual intersection SICL list that, using criteria of severity, frequency, and rate, identifies sites most likely to be candidates for safety improvement based on crash history (*2*). The most current list can be found using the link at the bottom of this page: www.iowadot.gov/crashanalysis/top200.htm.
- In cooperation with InTrans, TAS develops an annual *5 Percent Most Severe Safety Needs Report* that identifies sites most likely to have problems related to several different crash types (*3*). That report can be accessed at www.iowadot.gov/crashanalysis/fivepercent/fivepercentneeds.htm.
- TAS periodically develops a series of County, City, and District crash profiles. These profiles include all counties, cities with population of roughly 5,000 and above, and each Iowa DOT district. These profiles currently address 15 selected crash-related topics. These profiles can be accessed under Crash Data at www.iowadot.gov/crashanalysis/data.htm.
- TAS annually develops crash rates and crash densities in Iowa by road system, which provides average rates and densities across each crash severity and injury status category by several road classification levels. That data can also be found at www.iowadot.gov/crashanalysis/data.htm under Comparables.
- In addition, the TAS website has a data request form at www.iowadot.gov/crashanalysis/crashdatarequests.htm and the ITSDS program website has one at www.ctre.iastate.edu/itsds/requestform.cfm. Either or both of these services can be used to acquire desired crash data for a specific site or need.

2. Evaluate Crash History

Access to reliable crash data is an important asset in conducting safety assessments. However, the assembly and presentation of these data can be equally crucial, and it is here that crash analysis perhaps becomes more of an art than a science.

Iowa's extensive database contains more than ten years of crash history but earlier data can be difficult to access. In general, at least three years of data should be examined for higher-volume roads. For lower volumes or where only a few total crashes have occurred, a

minimum of five years is suggested. In very low-volume locations, up to 10 years of records might be needed for acceptable statistical validity.

The database provides a great deal of detailed crash information. However, depending on the analysis software employed, not all of the details might be accessible. CMAT accesses sufficient data for most analyses, but SAVER includes all crash information in the database except for personal information, diagrams, and narratives. While personal information should never be of value except in rare instances, crash diagrams and narratives provided by the investigating officer might be instructive at times. However, access to this information can generally only be obtained through a specific request to TAS or the Iowa DOT MVD/ODS.

Two important factors for mitigation selection are crash cause and contributing factors. Information needed for these assessments can be determined by reviewing the sequence of events for individual crashes and by reviewing the contributing circumstances fields in the database related to driver, roadway, and environment. Other important factors might include initial direction of travel, vehicle action, point of initial impact, driver condition, time, and light conditions. Manner of collision may or may not be valuable.

Crash history can be summarized in many ways: frequencies, severities, densities, rates, or a combination of several indices designed to normalize data that are dependent on several factors. Taken individually, each of these methods may yield misleading results.

For example, a higher-volume roadway may experience a corresponding high frequency of crashes but a relatively low rate. The converse may be true for a lower-volume road, however.

Crash density is also highly influenced by traffic volume and, in fact, volume alone is probably the most reliable crash predictor. More traffic almost always results in more crashes on a given roadway.

Crash severity is a preferred measure in many agencies, but this choice purposely does not consider total crash numbers.

A combination of approaches might be recommended in order to consider the total crash frequency while not being overly influenced by the traffic volume factor.

Once measurement criteria have been selected, they can be employed to identify potentially hazardous locations, which can then be further examined for needed safety improvements. Numerous methods for using crash data to identify “high-crash” locations have been

developed and used successfully by agencies across the country. Many of these methods are described in Chapter 5: Analyzing Crash Data.

Even after an agency has identified locations with high crash numbers and/or rates, it can be instructive to compare those roadways to similar facilities across the state to assess safety performance more completely. Several resources are available for that purpose.

TAS has developed and maintains a listing of statewide average comparable crash performance values, including frequencies, rates, and densities for various roadway classes. Using these data, an agency can compare the computed values from a site of interest in their jurisdiction to the average statewide value for similar roads in Iowa. These data can be accessed at www.iowadot.gov/crashanalysis/comparablesprofilesmain.htm.

In addition, crash prediction models have been recently developed, and these models are also available to compare observed crash history for a given roadway segment or intersection with values calculated from formulas using traffic volume and various environmental factors as criteria.

The results from the selected comparative mode may indicate that a given site, even with seemingly higher crash numbers or rates, may in fact be performing at an average or above average safety level for similar roads. This result shouldn't indicate that safety improvements would not be beneficial, but that knowledge might temper expectations for a dramatic decrease in crashes.

3. Examine Field Conditions

Crash history provides the core information for analysis. These data describe instances where drivers, vehicles, and roadway conditions may have failed to function properly. However, crash data have several limitations.

For example, crash history neither records near misses nor indicates the potential for crashes. For that knowledge, other sources of information are needed (as discussed in Chapter 3: Addressing Traffic Safety Concerns in Iowa). In addition, and especially for lower-volume roads and streets, crash occurrence can be quite infrequent and scattered and other methods for identifying safety concerns are necessary.

Examination of field conditions will be necessary to identify potential crash contributors before a significant number of incidents are recorded. Mitigation of common possible safety concerns can then be accomplished on a systemic basis, resulting in a safer driving environment for travelers.

Examples of potential safety issues might include condition of traffic control devices, existing warning for obstacles such as narrow structures, curvature of the roadway, and roadside hazards within the clear zone including trees, poles drainage structures, and steep slopes. Traffic operations can also be observed and conflicts noted for possible reduction when feasible.

A proven and effective approach for field reviews includes other disciplines in addition to engineering. Law enforcement advice for addressing identified safety concerns can be critical for desired success, for example. A productive field review team should include experienced professionals from a variety of disciplines. These teams can identify potential problem locations and recommend effective mitigation, even when access to detailed crash data is not possible.

A field visit can possibly provide a driver performance assessment. In addition, important physical features and conditions can be observed and noted. Driving through the study area from all directions, observing conditions, and making stationary observations of vehicle flow from a road user perspective all add valuable information to a review. Issues of particular interest for a field visit include the following:

- Visibility and condition of signs, pavement markings, and traffic signals
- Sight distance for road users at conflict points
- Parking conditions
- Lighting
- Speed limit compliance
- Turning movement difficulties
- Pedestrian presence and conflicts

Use a checklist and prepare condition diagrams to ensure a more complete investigation. Good examples of these tools can be found in the figures from NCHRP Report 457, *Engineering Study Guide for Evaluating Intersection Improvements* and in Chapter 2 of NCHRP Report 440, *Accident Mitigation Guide for Congested Rural Two-Lane Highway*. Figures 4.1 and 4.2 are examples of an on-site observation report from Report 457and a condition diagram from Report 440, respectively (*4*, *1*).

ON SITE OBSERVATION REPORT

LOCATION: *Kelly Drive & Tall Trees Lane* DATE: *3/3/00*

CONTROL: *Stop control on Tall Trees Lane* TIME: *4:30 P.M.*

	No	Not Sure	Yes
Isolated and Non-Isolated Intersections			
1. Do road curvature, vegetation, buildings, parked cars, etc. block drivers' views of conflicting vehicles?	✓		
2. Is the intersection skew angle so sharp that it makes it difficult to view conflicting vehicles or complete turns?	✓		
3. Do vehicle speeds appear too high?		✓	
4. Does the delay for the minor-road right-turn appear excessive?		✓	
5. Does the delay for the minor-road through appear excessive?	✓		
6. Does the delay for the minor-road left-turn appear excessive?			✓
7. Does the delay for the major-road left-turn appear excessive	✓		
8. Does the queue for the major-road left-turn ever impede major-road through traffic?	✓		
9. As major-road vehicles slow to turn, do they impede other vehicles?			✓
10. Do parking maneuvers impede other vehicles?	✓		
11. Are drivers not complying with the traffic control devices?	✓		
12. Is there evidence that one or more curb radii are too small?	✓		
13. Do pedestrians appear to cause conflict with vehicular traffic?	✓		
14. Are there guidance or control problems that could be mitigated by raised-curb channelization?	✓		
Non-Isolated Intersections			
A. Do queues from adjacent signalized intersections spillback into the subject intersection?	*na*		
B. Do vehicles slowing to turn at adjacent intersections or driveways contribute to the delay to major- or minor-road drivers?	*na*		
C. Is it possible that some drivers are diverting to the subject intersection because of congestion on a nearby arterial street?	*na*		
D. Does the arrival pattern of major-road traffic platoons contribute to the delay to minor-road drivers?	*na*		

na = not applicable.

Comments:

Figure 4.1. Sample on-site observation report (from NCHRP Report 457)

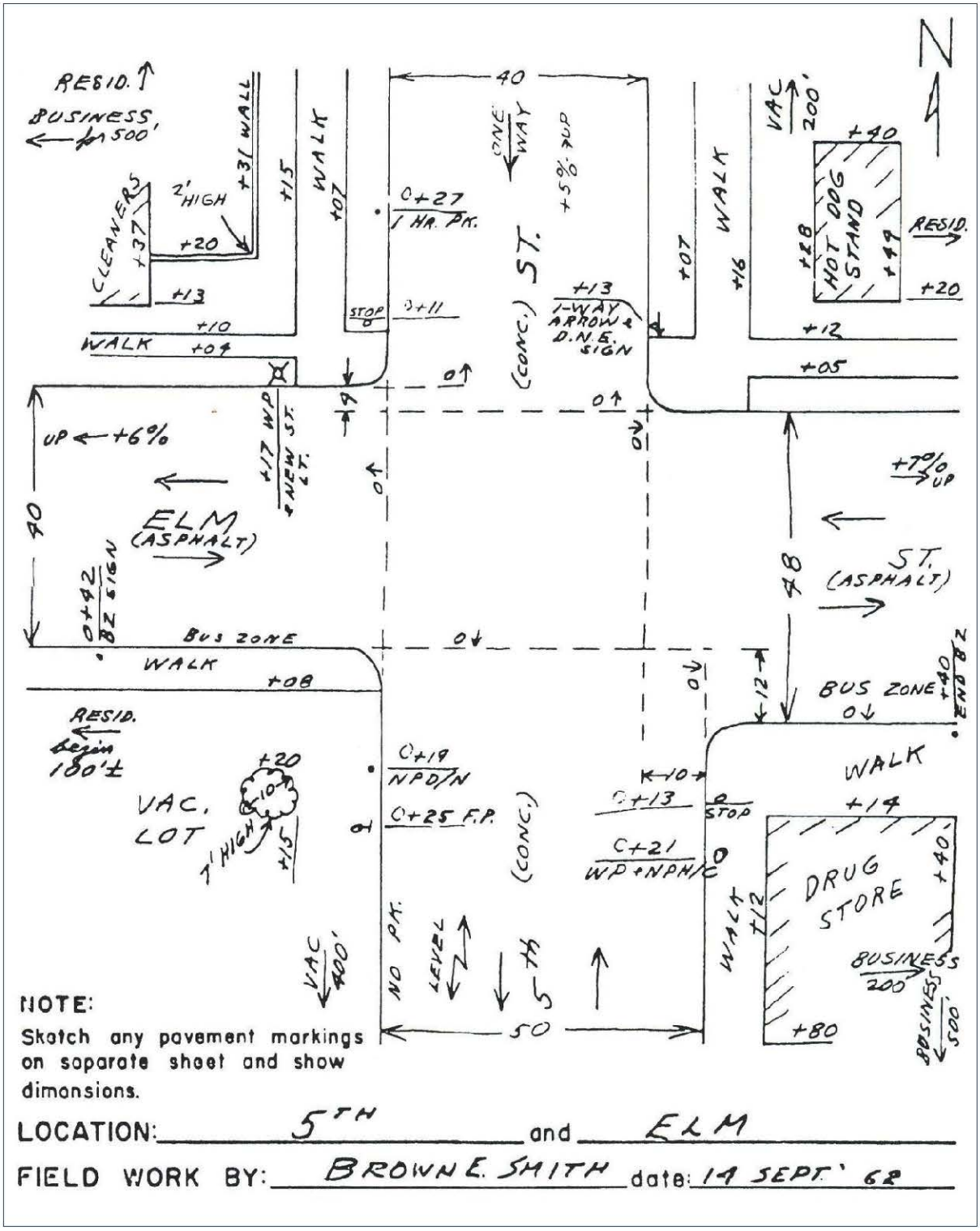


Figure 4.2. Sample condition diagram (from NCHRP Report 440)

Safety Review Checklist

The following checklist, developed in Iowa and adapted for this manual, can be used to help identify and address roadway safety concerns and it can be used effectively during field reviews.

General advice/questions to ask:

- If fixed objects cannot be moved to the calculated clear zone, can they be moved part of the distance? (e.g., six feet from the back of the curb is better than at the back of curb)
- If it is cost-prohibitive to correct all substandard cross slopes at intersections and entrances, those on the outside of curves or where a near-vertical face exists should be corrected first.
- If not all the poles/trees can be moved/eliminated, are there some that can be addressed? (for example, unused or single-line drop poles are usually easiest to eliminate, move, or combine)
- Pay special attention to areas that a crash history review has identified as areas of concern.

Specific issues and potential countermeasures:

- **Objects in clear zone**
  - May need to remove/protect objects beyond clear zone in some instances
  - Remove trees/brush that have been allowed to grow in the foreslope or at the toe of a traversable foreslope
  - Move utility poles from outside of curves to inside (if feasible)
  - Move/remove poles/trees
  - Fill large gullies in foreslopes or at the toe of a foreslope
- **Access points**
  - Correct/relocate drives/entrances with poor sight distance
  - Identify any access points that could create a sight problem with future development
- **Horizontal curves**
  - Add/correct superelevation
  - Pave shoulder outside/inside and add rumble strips/stripes
  - Flatten outside foreslopes
  - Add delineators, chevrons, and/or enhanced pavement markings
  - Use a ball bank to determine advisory speed and add advisory plaques
  - Add/enhance advance warning signs where needed
- **Horizontal/vertical curve combinations**
  - Downhill to the left is the worst for run-off-road incidents
  - If curve combinations cannot be corrected
    - o Pave shoulders and add rumble strips/stripes
    - o Delineate
    - o Add signing
    - o Flatten foreslopes

- **Pavement markings**
  - Review worn areas where vehicles are having problems choosing or following the desired path
  - Consider applying a wider edge line
  - Consider dotted lines across intersections, especially if located in a curvilinear alignment
  - Consider whether higher-grade materials should be used (i.e., durable markings, milled-in installations, or wet-weather visible)
- **Intersections**
  - Intersection angle—can those less than 75 degrees be adjusted closer to 90 degrees?
  - For Y configuration intersections at a horizontal curve, is there an opportunity to close one of the legs?
  - Are improved traffic signs needed?
  - Pave shoulders through intersections to help control debris on the roadway, especially in horizontal curves
- **Safety dikes (escape ramps)**
  - Install opposite of T intersections where feasible
  - Keep free of fixed objects
  - Be aware of what is "beyond" the dike; potential hazards posed by natural or man-made obstacles may require other mitigation
- **Daylighting of intersections and entrances**
  - Remove high vegetation, if possible, including crops and ornamental bushes
  - Re-grade high backslopes, if possible, within right-of-way
  - Add appropriate warning signs where above suggestions are not possible
  - Relocate traffic control signs or utility poles that restrict visibility
- **Turn lanes**
  - Check warrants for needs, including crash history
  - Right-turn lane—offset from through lane to improve visibility from side road
  - Left-turn lanes—consider offsetting from through lane
- **Medians**
  - Use raised medians to control left turns where needed
  - Use high-tension cable guardrail to reduce severity of cross-median crashes
- **Street name signs**
  - Follow *MUTCD* requirements for lettering size and retroreflectivity
  - Place on mast arms if available
  - Place additional signs in advance of intersection on higher-volume roads
- **Rumble strips/stripes**
  - Use milled-in rumble strips/stripes in paved shoulders
  - Use in advance of stop signs, especially if crash history shows pattern of failure to stop
  - Effectively maintain rumble strips and stripes
  - Install rumbles in Portland cement concrete patches in hot-mix asphalt roads

- **Traffic signals**
  - Add backer plates to signal heads, especially on mast arms
  - If only pedestal heads exist, add mast-arm-mounted signal heads
  - If only mast-arm signals exist, add far left-side pole mounted signal
  - Install individual signal heads for each through or turn lane
  - Replace smaller lamps with 12 inch diameter units
  - Combine poles for signals/lighting (if possible)
  - Periodically check detectors for proper functioning
  - Will any patching, milling, or overlay activities impact detectors?
  - Install pedestrian countdown signals and push buttons
  - Check timing for compliance with Institute for Transportation Engineers (ITE) recommendations
- **Lighting**
  - Use breakaway or slip bases in clear zone
  - Maintain surrounding earth elevation to assure intended breakaway or slip base function properly
  - Add destination or intersection lighting where warranted
- **Traffic control devices**
  - Check for retro-reflectivity compliance and legibility
  - Follow *MUTCD* for proper use and placement
  - Remove vegetation that impacts visibility
- **Alignment guidance**
  - Use the *MUTCD*, Chapter 2 for primary guidance
  - Use delineators on horizontal curves of less than six degrees
  - Use chevrons on curves greater than or equal to six degrees and occasionally for any curve less than six degrees if vegetation or a combination of vertical/horizontal curvature reduces sight distance to curve; also use chevrons where crash history indicates a need for improved delineation
  - Use appropriate object markers for obstacles near a roadway, such as short culverts or narrow bridges
  - Consider snow-plowable, raised pavement markers, rumble stripes, or milled-in wet weather visibility pavement markings through curves with run-off-road history
- **Pavement edge drop-offs**
  - If caused by poor shoulder drainage, consider paved shoulders
  - If caused by traffic, check signing and pavement markings in the area
  - Pave shoulders (totally or partially) and install rumble stripes
- **Curbs**
  - If traffic encroaches on curbs in intersections, study increasing radius
  - Correct locations where drainage is not satisfactory
  - Consider using a nine-inch "barrier" curb in low-speed areas to control access
- **Intakes**
  - Check for breaks that can lead to localized roadway collapse
  - If units are blocked or become ineffective, repair or revise as needed

- **Bridges**
  - Install and maintain proper delineation at approaches
  - When feasible, upgrade existing guardrail to current standards
  - Upgrade bridge railing:
    - o Use concrete retrofits
    - o Carry beam guardrail through narrow structures
- **Cattle passes**
  - If not in use, fill in unless there is evidence of deer use
  - If still active, install beam guardrail and/or delineate as needed
- **Culverts**
  - Extend when feasible and/or add to Resurfacing, Restoration, Rehabilitation (3R) projects
  - Consider grates for structures with larger openings
  - Install beam guardrail to shield larger openings
  - Study use of drop inlets where feasible
  - A combination of narrow shoulders and short-length culvert openings can result in a passenger possibly falling into the opening when exiting a vehicle parked on the shoulder. Be sure to consider both vehicle and passenger safety.
- **Guardrail installations**
  - Update installation or at least the end terminals to current standards with 3R projects or when crash damage offers the opportunity
  - Check and adjust mounting height (check appropriate design standards)
  - Consider paving the shoulder to the guardrail face to control height changes due to poor drainage or mounding from excess shoulder material
  - Remove fixed objects in front of the guardrail or within deflection area behind the rail
  - Extend as needed to shield secondary hazards
  - Check for deteriorated wooden posts and missing hardware and replace as needed
- **Mailboxes**
  - Should be mounted on breakaway supports and securely attached
  - Visit with property owners where potentially hazardous supports are noted; offer to assist in an effort to make compliant
- **Utility poles**
  - Visit with utility company about
    - o Moving poles from outside to inside of curves
    - o Reducing numbers by combining poles
    - o Relocating guy wires and braces away from traveled way where possible or using breakaway design
    - o Marking guy wires for snowmobiles
    - o Relocating to right-of-way line

- **Trees/brush**
  - Remove from clear zone (may also reduce animal collisions)
  - Be sure to not obstruct sight triangle at intersections
  - Check for sign visibility during growing season
- **Foreslopes**
  - Watch for locations that could be beneficial to flatten, such as the outside of horizontal curves; use waste ditch cleaning material for this purpose
  - If flattening is not feasible, clear all fixed objects on foreslope and at toe
- **Ditches**
  - Is draining satisfactory?
  - Is reshaping needed?
  - Could reshaping material be used to flatten steep slopes?
- **Backslopes**
  - Are agricultural practices encroaching on right-of-way?
- **Entrance and intersection cross slopes**
  - Flatten where feasible
  - If pipe is presenting a potential hazard, consider:
    - o Cutoff ends to match slope
    - o Regrading exposed ends to avoid snagging an errant vehicle
    - o Sloped grates over ends where feasible
- **Riprap in right-of-way**
  - On back slopes, any size specified may be acceptable from safety standpoint
  - In ditches, on foreslopes, and at toe of slopes, try to specify maximum size at four inches or less:
    - o May use larger sized riprap and fill in with smaller material
    - o Do NOT create a vertical wall within clear zone

Note: Many of the suggestions identify potential safety hazards that should be considered to improve the safety environment along existing roadways. A good opportunity to accomplish this work is with 3R projects, but the work could also be addressed as stand-alone improvements. If potential hazards are not included in rehabilitation projects, it is recommended that the reasons for not doing so be documented.

If operational and/or safety problems are noted during field reviews, additional engineering evaluations may be needed, including studying issues such as capacity, travel time, sight distance, speed, skid resistance, and traffic signal warrants.

If a field visit is not practical or if supplemental visual information is desired, there are several other ways to "view" a road section. Google Earth (googleearth.com/) and Google Maps have some very detailed road views (with 360 degree visual rotation from the road user perspective).

Road View files that incorporate roadway viewing can also be requested from the Iowa DOT Office of TransData.

Other Studies

In addition to crash history and the other information described, several other studies can be undertaken to potentially improve road and street safety and operating efficiency, including the following:

- Advisory speed determination for safe operating speeds at curves
- Sight distance at intersections
- Traffic conflicts and incidents
- Travel times and delays
- Roadway and intersection capacities
- Available gaps for pedestrian crossing
- Queue length of traffic platoons
- Skid resistance of pavement surfaces
- Lighting needs
- Weather-related factors
- School crossings
- Railroad crossings
- Specific pedestrian and bicycle needs

Suggestions for performing these studies can be found in the ITE *Traffic Control Devices Handbook* or in the InTrans *Handbook of Simplified Practice for Traffic Studies*. The latter reference is available at www.intrans.iastate.edu/research/detail.cfm?projectID=428.

4. Analyze Contributing Factors and Possible Countermeasures

After the predominant contributing causes of traffic crashes have been determined, potential mitigation or countermeasures can be considered. However, this process can be challenging because some improvements may not be as effective as anticipated and others may have unintended consequences.

Investigating acceptable countermeasures could include reviewing several information sources, using supplemental engineering studies (such as speed and sight distance), utilizing past experience, and referencing technical literature, which can include NCHRP reports, such as those referenced in this manual; other states' manuals, such as Missouri's *Manual on Identification, Analysis, and Correction of High Accident Locations* available at epg.modot.org/files/8/86/905.1_HAL_Manual.pdf, and Chapter 6: Countermeasures, in this manual.

5. Assess and Select Appropriate Mitigation

An analytical approach is recommended to evaluate possible mitigation alternatives, even though the final selection of improvements also relies on engineering judgment. The following are issues for consideration:

- Account for all possible options, including doing nothing
- Use of a combination of alternatives
- Understand practical limitations and constraints, including funding
- Anticipate the effect of each option, such as crash reductions and off-site impacts (if the selected alternative results in diverting traffic elsewhere)
- Note other traffic operational or increased vehicle costs that may result

Generally, evaluations are made by estimating the cost of improvements and by comparing that estimate to the predetermined public savings from anticipated crash loss reductions. These comparisons are referenced as benefit-cost ratios, and other analyses, such as the AASHTO net return method, are also available and commonly used.

With any monetary comparison, certain assumptions must be made, which can be critical to the reliability of the results. Current dollar losses for various crash severities are necessary, and crash reduction factors must also be applied to any proposed mitigation. Economic analysis of safety improvements is detailed in Chapter 7: Economic Analysis Procedures.

Cost effectiveness of individual improvements and the agency safety program in general can also be expressed in terms of crash reduction per dollar spent. Although not as thorough and accurate as the other methods described, this calculation yields a broad benefit assessment and does not require using crash loss data.

For example, if a $200,000 roadway improvement is expected to annually reduce the number of crashes from 10 to eight over a five-year period, then an investment of $10,000 per crash reduced would result. This simplified calculation does not consider economic factors or possible operational savings.

The analysis process for any countermeasure considered and selected should be completely documented. This documentation will be valuable for evaluating option effectiveness, assessing the selection method for future applications, and for justifying decisions that are made.

6. Implement Improvements and Evaluate the Effectiveness

The final step in the safety improvement process is implementing the selected countermeasures and assessing the resultant impacts. Comparing actual results to predicted effects can help evaluate the benefit of individual projects or of an overall safety program; however, this analysis is often omitted.

The FHWA *Highway Safety Evaluation: Procedural Guide* (*5*) proposes a six-step procedure for appraising the effectiveness of safety improvements:

1. Develop an evaluation plan
2. Collect and review data
3. Compare measures of effectiveness (MOEs)
4. Apply statistical tests
5. Compute economic analysis
6. Document findings

Following these recommended procedures provides a valid and detailed assessment of the value of safety improvements; however, the process may be too time-consuming for many agencies. A basic evaluation procedure, such as comparing before-and-after crash statistics, might also yield valuable results. However, relying on crash reduction statistics can be misleading, because some improvements, such as installing a traffic signal, may actually increase the number of certain crash types while reducing the overall crash severity at an intersection.

Many safety improvements are justified with benefit-cost assessments that use anticipated crash reductions and estimated project costs for the computations. Following project completion, actual construction costs are known; after an acceptable period (perhaps three years minimum) for valid comparison, the actual number and severity of crashes can be used to calculate the actual benefit-cost ratio. This information can be very valuable for future safety improvement decisions, because successful types of projects can be readily identified.

In 2001, the Center for Transportation Research and Education (CTRE) at ISU completed a study that analyzed the effectiveness of certain Iowa DOT-funded safety improvements (*6*). The study, *Effectiveness of Roadway Safety Improvements*, concluded that crash reductions did occur for all safety projects studied but that the benefit-cost comparison varied widely.

Adding turn lanes with appropriate signal phasing indicated the highest mean crash reduction, but replacing pedestal mounts with overhead signals showed the best resultant benefit-cost ratio. This study concentrated on safety improvements involving traffic signal

installations and intersection modification. A similar comparison could also be used effectively for lower-cost safety projects.

Available Analysis Tools

The Iowa DOT does not currently utilize, support, or endorse the products described in this section. Investigation of potential benefits by local agencies should be considered on a unilateral basis only. In addition, these tools were developed using national—not state-specific—data and, therefore, data calibration is needed for accurate results in individual states. The accuracy of results for very low-volume roads should also be examined.

FHWA Interactive Highway Safety Design Model

The FHWA has supported several innovative approaches to safety analysis. One approach is the Interactive Highway Safety Design Model (IHSDM), a suite of software analysis tools designed to evaluate safety and operational aspects of geometric design considerations on two-lane rural highways (*7*). However, IHSDM is not just intended for new construction—it can be successfully applied to existing situations.

Initially containing five modules (Crash Prediction, Design Consistency, Intersection Review, Policy Review, and Traffic Analysis), a sixth module, Driver/Vehicle, was added later. This software is available from the FHWA at no cost. Technical support and training are also provided. This resource can be accessed at www.tfhrc.gov/safety/ihsdm/ihsdm.htm.

The Crash Prediction module allows an agency to assess the theoretical safety performance of a spot location, such as an intersection. Here, the most important predictive crash factor, traffic volumes, is utilized. This tool has three important uses: identify potential problem locations, assess safety benefits capability of proposed improvements, and develop crash modification factors for various intersection upgrades.

NCHRP Report 486, *Systemwide Impact of Safety and Traffic Operations Design Decisions for 3R Projects*, presents formulas that can be utilized to predict crash frequency at several types of rural intersections ranging from T intersections to signalized intersections (*8*). The resultant computed crash frequency can then be compared to actual observations to determine if a site is in fact a "problem" location. This process is expanded and described in more depth in the AASHTO *Highway Safety Manual* (HSM) (*9*).

SafetyAnalyst

Another analytical resource that can be employed to assess both rural and urban locations is SafetyAnalyst. SafetyAnalyst is a set of software tools that uses a strong, cost-effective analysis approach (*10*). Highway agencies can use the software to improve programming site-specific safety improvements. The software includes administrative and management features as well as a series of modular analytical tools with the following capabilities:

- Network Screening Tool—identifies sites with potential for safety improvement
- Diagnosis Tool—analyzes the nature of safety concerns at selected locations
- Countermeasure Selection Tool—assists in selecting countermeasures to reduce crash frequency and severity
- Economic Appraisal Tool—performs economic assessments of selected or alternative countermeasures
- Priority Ranking Tool—provides a priority listing of sites and proposed improvements based on benefit-cost estimates
- Countermeasure Evaluation Tool—includes the capability for conducting before-and-after evaluations of safety improvements

Safety Performance Factors (SPFs) can predict crash performance for various types of urban and rural segments and intersections using SafetyAnalyst tools. For example, SPFs could be used to predict safety performance for various sites with specific characteristics. Using the Empirical Bayes (EB) method, the observed site safety performance and the SPF-predicted safety performance can be combined to estimate the anticipated crash frequency for that location.

These tools could provide analysts with vastly expanded capabilities for reviewing existing sites as well as for planning potential safety improvements. More information about SafetyAnalyst can be found at www.safetyanalyst.org/.

AASHTO Highway Safety Manual (HSM)

Another valuable reference is the recently developed HSM by AASHTO with support from the Transportation Research Board (TRB) (*9*). This manual is similar in intent to the TRB *Highway Capacity Manual* (*11*).

The HSM is expected to provide a greatly increased role for safety in the planning, design, construction, and maintenance of roadways. Content of the manual includes background information, safety effects of various roadway features and elements, suggested predictive methods, safety management of a roadway system, and evaluation procedures. To learn more about this resource, visit www.highwaysafetymanual.org/Pages/default.aspx.

Predicting Safety Performance with the HSM

Predictive methods are one topic discussed in the HSM. This section describes a comprehensive procedure that can be used to predict safety performance on both existing and proposed rural and urban segments and intersections. All roadway types are included, even those with added passing lanes or short four-lane sections.

Using the HSM analysis methodology or other prediction models, anticipated crash frequencies can be calculated for roadway segments, intersections, or for a combination of these features. Three types of at-grade intersections are used: three-leg with STOP control,

four-leg with STOP control, and four-leg signalized. In addition, the effects of many geometric and traffic control features are considered.

The safety prediction methodology is composed of three basic elements: base models, crash modification factors (CMFs), and calibration factors.

Base models are used in the predictive analysis procedures to predict safety for pre-established basic conditions, such as 12 foot traffic lanes or 6-foot wide paved shoulders. The major variables for these computations are geometric design and traffic control features unique to the highway segment or intersection and traffic volume. The calculated crash frequency estimates are then adjusted with CMFs to account for specific design and traffic control elements.

CMFs are applied to adjust base model computations to specific site conditions. An expert panel conducted a comprehensive review of current literature to determine these values. CMFs presented for consideration in roadway segments include lane width, shoulder width and type, horizontal curves, superelevation, grades, entrance frequency, passing and turning lanes, and roadside hazard ratings. Other CMFs are used for intersection analysis. Refer to the Crash Modifications Factors Clearinghouse at www.cmfclearinghouse.org/ for more information.

Calibration factors are necessary to assure that the safety analysis procedure accurately assesses individual state or local conditions. Because the base models were developed using data from only a few states, calibration procedures are needed to adapt the analysis methodology to unique conditions in other areas.

Factors that might affect safety differences can include climate, animal populations, number and types of drivers, and crash reporting and investigation details. Calibration factors compare predicted crash frequency with actual compiled historic data. Because safety conditions evolve continually, it is recommended that these factors be recalculated every two to three years.

In addition to total crash frequency, these safety analyses can also predict the crash severity and type expected on roadways. These values should also be calibrated to meet individual state crash experience.

The procedures presented in the HSM permit safety predictions to be calculated whether or not historic crash data are available. When data are available as in Iowa, an EB method is used to combine predicted safety estimates with actual site-specific crash data.

The process for predicting a roadway's safety can be summarized into these steps:

1. Select a roadway segment, intersection, or project for analysis.
2. Apply the appropriate base model.
3. Utilize specific calibration factors.
4. Implement applicable crash modification factors.
5. Determine predicted crash frequency, severity distribution, and type.
6. Prepare an analysis report.

The HSM is expected to provide valuable assistance for analyzing safety conditions on existing roadways and for predicting potential safety exposures for planned improvements.

HSM for Local Agencies

The three-volume edition of the HSM is quite detailed and use by smaller local agencies may be limited. However, the FHWA has developed a training course through their Resource Center that agencies with limited resources should find interesting and valuable. This course, as well as many other types of related training and materials are described on the FHWA safety website at http://safety.fhwa.dot.gov/hsm/.

Simplified Methods of Assessment

Some agencies may be interested in a less detailed analysis or may lack the experienced staff or time to perform a detailed assessment. Chapter 7: Economic Analysis Procedures discusses other assessment methods available in Iowa, such as benefit-cost calculations and comparison comparables. For more information about crash reduction factors, see the FHWA website safety.fhwa.dot.gov/tools/crf/.

Chapter 4 References

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Chapter 5: Analyzing Crash Data

Once data have been collected and problem locations have been identified, the next step is to analyze the crash data. This chapter presents a suggested analysis procedure for both corridors and intersections or spot-specific locations.

Analysis can be undertaken on road or street segments, corridors, or spot locations (e.g., intersections, driveway entrances, or structures). Rural segments are usually one to five miles in length. Roadway condition uniformity and definable termini are generally used as criteria for selecting the appropriate roadway limits for investigation and analysis. In urban areas, other criteria might be used and the segments are much shorter, typically defined by blocks.

During the initial analysis, always look for crash clustering at any point along a segment or corridor because the problem might be isolated and this clustering can help focus mitigation strategies. Corridors selected for analysis should be as consistent throughout as possible.

Defining spot location limits can be even more challenging. The Iowa DOT TAS advises using a distance of 150 feet from a rural spot location and 75 feet from urban intersections for systematic intersection analysis. However, these distances are not absolute; it may be valuable to revise the limits to include all crashes that have traffic operation implications at the point in question. Perhaps a more extensive area should be included initially and then narrowed based on the contributory factors for recorded crashes. All crashes that occurred within the final selected limits would be included in the crash analysis.

All crashes that were recorded within the selected analysis period should be included, but be sure that no significant improvements have been made during that time. If improvements have been made in the study area, the analysis should be broken into before and after improvement periods. If crash clusters are noted near the selected analysis area, they should be separately investigated for contributing causes and then perhaps included with the subject intersection or spot location if the causes seem to indicate a relationship.

Analysis Process

When selecting an analysis process, always remember that data and statistics can be easily misinterpreted. In some situations, crash frequencies might be most important; in others, rates and/or densities are more descriptive. It may be advisable to use a combination of these measures for a more complete analysis or to compare the findings with published statewide comparable values. The actual number of serious crashes may be the most valuable statistic to consider, because reducing deaths and major injuries should be a primary goal of all safety advocates.

This chapter describes several methods for analyzing crash data, although other methods not described here are also available. Select the method or methods most applicable for the analysis.

Before you begin, determine how many years of data are needed for a statistically-valid sample. The number of years of data needed depends on the traffic volume and crash frequency, with more dependence on the latter, as the scope of crash history most directly affects the reliability of the results. If crash frequency and traffic volume are low, then a longer time period (potentially up to 10 years) is likely needed for valid results. For sites with higher traffic volumes and/or crash frequencies, three to five years of data may be adequate.

Another factor to decide, especially when conducting analysis based on crash severity, is whether to use incident- or driver-based figures. When working with higher speed and volume roadways, these two data may not agree. For example, a single serious crash could involve multiple fatalities and/or injuries.

Depending on which figures are used, differing analysis results will be obtained. While there is no decidedly correct approach to use, it is best to be consistent in that decision and to always thoroughly explain that choice in any analysis reporting.

This basic analysis process is suggested for either segments or spot locations:

1. Check the SICL list (currently only intersections) or the *5 Percent Most Severe Safety Needs Report* on the TAS website at www.iowadot.gov/traffic/index.htm.
2. Map the crashes. Note that the primary analysis tools used in Iowa basically require this step as the initial part of the operation.
3. Examine the map for crash clusters that may require further investigation.
4. Determine crash frequencies (usually by severity) using either SAVER or CMAT.
5. Calculate a crash rate (segments, corridors, and intersections) and/or a crash density (segments and corridors) and compare the rate and/or density to similar sites (perhaps by consulting the statewide comparable values or by developing agency-specific values).
6. Generate a stacked map (segments and corridors) or collision diagram (intersections).
7. Generate a report with details of individual crashes.
8. Look for patterns on the stacked map or collision diagram and/or the details report.
9. Refer to official crash report forms if more information is needed to get an accurate picture of what might actually be occurring.

Application of the Analysis Process for a Segment or Corridor

1. Check the SICL List or the 5 Percent Most Severe Safety Needs Report

Check to determine whether the subject location is an intersection on the SICL list or is in the 5 Percent report. The SICL list is available at www.iowadot.gov/crashanalysis/top200.htm and the report is at www.iowadot.gov/crashanalysis/fivepercent/fivepercentneeds.htm. Funding for improvements might be obtained more easily if the location is listed.

2. Map the Crashes

To help visualize the potential safety issues along a segment or corridor, use the mapped spatial crash data available from the Iowa DOT TAS (see Figure 5.1).

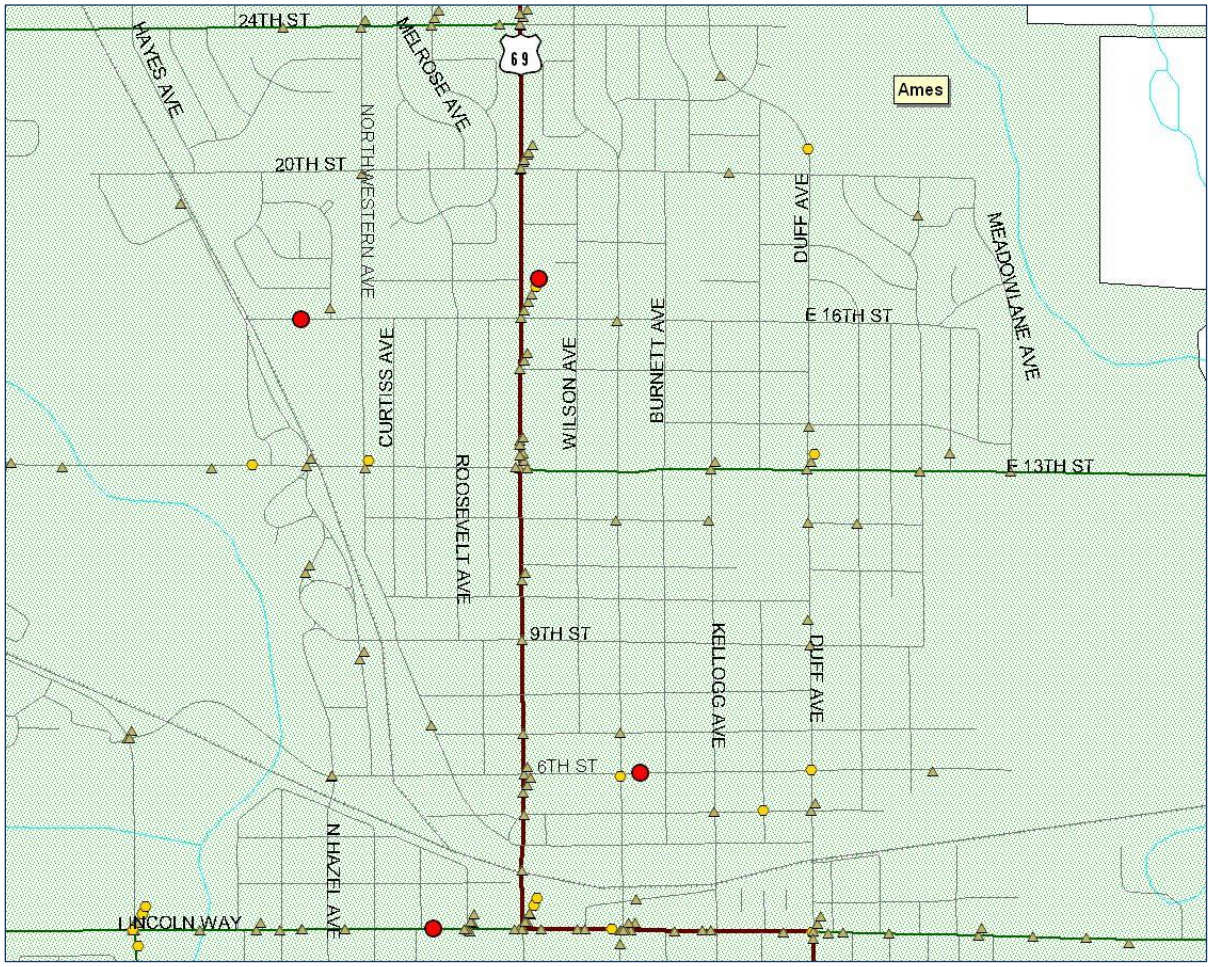

Figure 5.1. Sample mapped special crash data from the Iowa DOT TAS

TAS distributes the data for use within existing Geographic Information Systems (GIS) and also with multiple GIS-based analysis tools discussed in this manual and described at www.iowadot.gov/crashanalysis/. Contact TAS for more information.

3. Examine the Map for Crash Clusters

With the crashes mapped, certain points along the segment or corridor may appear to have several crashes in the same location (see Figure 5.2). Investigating these clusters can be important for determining countermeasures.

For example, if a lengthy corridor shows crash clusters at points of curvature, some type of curve-related countermeasure is likely to be beneficial. On the other hand, if no crash clusters are evident, one or more crash-contributing factors may be having an impact on the entire segment or corridor. For example, perhaps the pavement or shoulders along the segment or corridor are poor, resulting in numerous run-off-road crashes. Both the existence and the non-existence of crash clusters may indicate a need for further analysis and consideration.

4. Determine Crash Frequencies (Usually by Severity)

The next step is to determine the total crash frequencies or crash counts, which usually involves summing the crashes by injury severity. The GIS-based analysis tools described earlier can be employed for this purpose.

5. Calculate Crash Rates and Densities (Total and by Severity)

For a segment or corridor, calculate an overall crash rate as well as crash rates for shorter sections within the corridor that exhibit crash clusters. Then, compare the calculated crash rates to data from similar sites by consulting the TAS-provided statewide comparables or by developing agency-specific values.

To calculate the crash rate, the volume along the corridor will be needed. Both SAVER and CMAT can provide the estimated roadway Average Annual Daily Traffic (AADT) value or the data can be obtained from DOT traffic maps. When using this information, note that the AADT may vary along the corridor.

For a segment or corridor, the crash rate can be determined using equation 5-1.

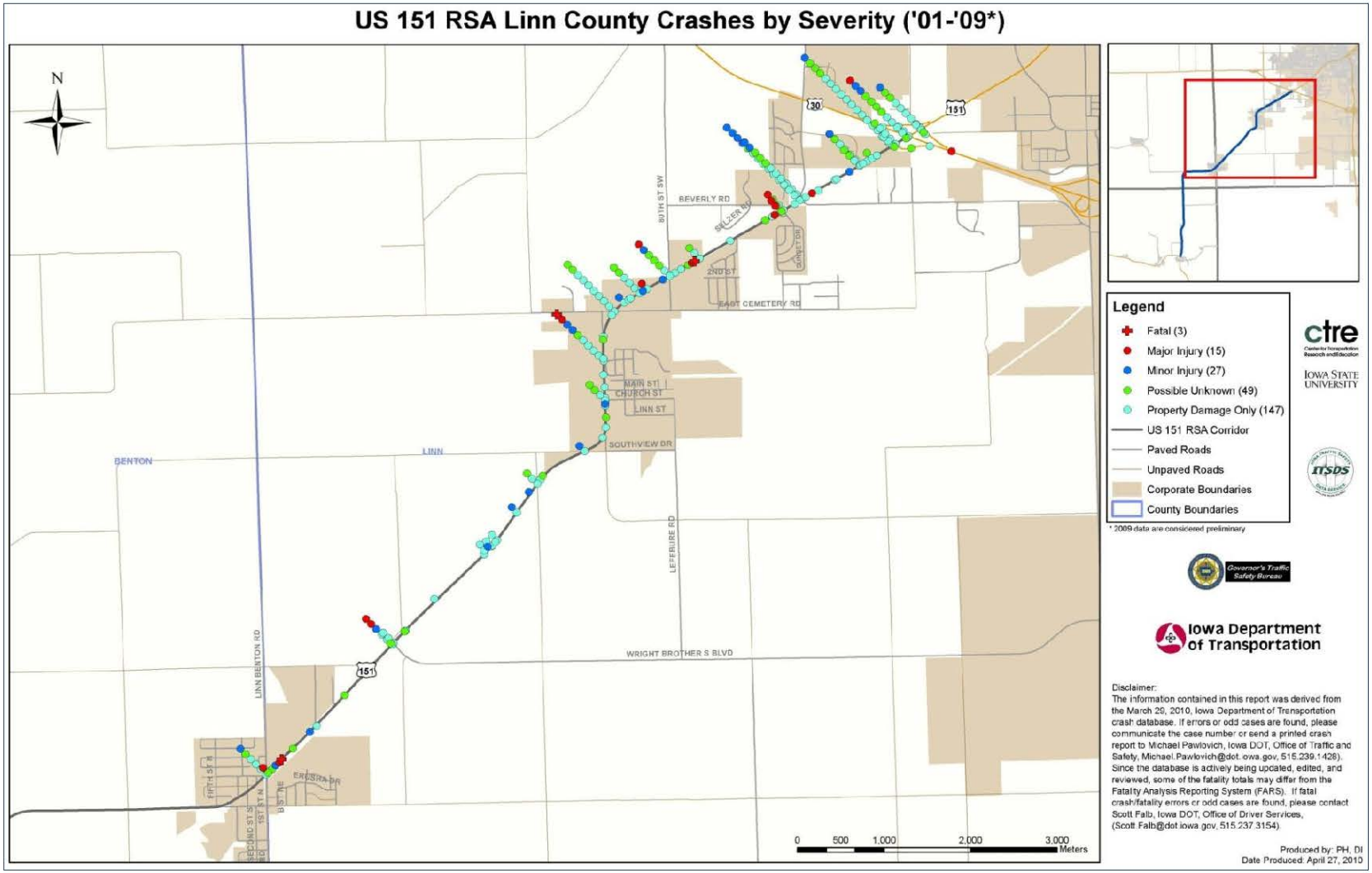

Figure 5.2. Sample crash map, by severity, illustrating crash location clusters

$$CR = \left(\frac{N}{A \times Y \times 365 \times L} \right) \times 10^8 \quad \textbf{(5-1)}$$

where *CR* is the crash rate in crashes per million vehicle miles traveled (HM VMT), *N* is the crash frequency during the analysis period (*Y*), *A* equals the AADT, *Y* is the analysis period in years (typically avoid partial years to avoid seasonality), and *L* equals the segment or corridor length in miles:

Crash density can be determined using equation 5-2.

$$CD = \frac{N}{Y \times L} \quad \textbf{(5-2)}$$

where *CD* is the crash density in crashes per mile (crashes/mile/year) and where *N*, *Y*, and *L* are the same as defined for equation 5-1.

As an example, assume these values for a rural two-lane roadway:

- 30 total crashes over a five-year period
- 5,000 vehicles per day
- 5 mile study length

Inserting these values into the formulas results in a calculated rate 65.75 crashes/HM VMT and a density of 1.2 crashes per mile per year.

$$CR = \left(\frac{30}{5000 \times 5 \times 365 \times 5} \right) \times 10^8 = 65.75 \text{ crashes/HM VMT} \quad \textbf{(5-3)}$$

$$CD = \frac{30}{5 \times 5} = 1.2 \text{ crashes/mile/year} \quad \textbf{(5-4)}$$

These values can then be compared to statewide average rates and densities (comparables) for similar routes based on roadway type (Interstate, primary, or local) and on whether the route is rural or urban .The comparables for Iowa are available on the TAS website at www.iowadot.gov/crashanalysis/comparablesprofilesmain.htm.

Considering the example above, the calculated crash rate could be below the statewide average, but the crash density could be above. With the given traffic volume, fewer total crashes than expected have been recorded but slightly more crashes have occurred along the corridor than average for that type of road. These results suggest further analysis is warranted, such as possible clustering along certain sections of the corridor.

Calculating the rate and density by severity (e.g., fatal crash rate, fatal and major injury crash rate, or fatality rate) and comparing these results to average severity-based values might also be considered. Sometimes a segment or corridor might be average or below from a total crash viewpoint but have an extraordinarily high rate or density of severe crashes.

Adjusting the termini of the study segment or corridor might also be considered to assess how the segment length affects the rates and densities. The computed rates can sometimes be impacted by locations with greater crash propensity, such as intersections, sharp curves, and narrow bridges. If crash clusters seem evident on the crash map, further analyses of these sites may be necessary. Opportunities for site-specific improvements, such as larger chevrons and/or rumble stripes along sharp curves, could prove beneficial.

6. Generate a Stacked Map for the Segment or Location

From the crash map developed in step 2, a crash histogram or bar chart (i.e., stack) can be generated to better depict the crash frequency along the segment or corridor. Both SAVER and CMAT (or IMAT for law enforcement) provide a feature that can depict the total crash frequency at specific locations and can map by crash severity. Once this stack map has been generated, examine the segment or corridor for clusters.

7. Generate a Report with Details of Individual Crashes

After the crashes have been mapped and concerns visualized, examine the crash data to determine potential countermeasures by identifying common crash contributors and patterns.

Both SAVER and CMAT provide a feature that can produce reports with details of individual crashes. These reports can then be analyzed to identify multiple occurrences of a variety of crash factors. In addition, year-to-year trends for certain suspected issues could be examined and SAVER can generate year-based reports for this purpose (see Table 5.1).

8. Look for Patterns

Within the stacked map and/or detailed crash reports, look for patterns that might indicate locations or crash factors of note. Be sure to also consider driver contributions to crashes. Operating while impaired, speeding, and/or lack of seat belt restraints can all contribute to higher crash occurrence and severity. Addressing these concerns will require consultation with law enforcement and education professionals.

Table 5.1. Sample table from a report showing 2001-2009 crashes by major cause for a roadway segment

Year	Major Cause																													Total
	Animal	Ran Traffic Signal	Ran Stop Sign	Crossed Centerline	FTYROW: From Stop Sign	FTYROW: From Yield Sign	FTYROW: Making Left Turn	FTYROW: From Driveway	FTYROW: Other	Traveling Wrong Way or on Wrong Side of Road	Driving too Fast for Conditions	Exceeded Authorized Speed	Made Improper Turn	Followed too Close	Operating vehicle*	Swerving/ Evasive Action	Over Correcting/ Over Steering	Equipment Failure	Ran Off Road - Right	Ran Off Road - Straight	Ran Off Road - Left	Lost Control	Inattentive/distracted by: Passenger	Inattentive/distracted by: Fatigued/asleep	Other: Vision Obstructed	Other: Other Improper Action	Unknown	Other: No Improper Action	Not Reported	
2001	1		1	1	2		2		1		2			1			1				1	1			1			2		**17**
2002			1	1	3	1		1	1		2			6	1	1			1			2				1	1			**23**
2003	2			1	2		3		1		1	1	1	5		1		1	2								2			**23**
2004	3			3	9		1	1			1	1	1	5		7			1			1				1	1	2		**38**
2005	3		2	2	1		1		1		4	1	1	3	1	3								1		2	1	1	1	**29**
2006	2			2	5	1	3	1	1	2	3		1	3					1				1				1			**27**
2007	3	1		2	3		2					1		6	1	2	1		2		2	1					2	2		**31**
2008	5			1	3	1	1	1		1	2			1		1					3	3			1	1	4			**29**
2009	6	1		1	4		1	1			3		1			2			1	1		2								**24**
Total	**25**	**2**	**4**	**14**	**32**	**3**	**14**	**5**	**5**	**3**	**18**	**4**	**5**	**30**	**3**	**17**	**2**	**1**	**8**	**1**	**6**	**10**	**1**	**1**	**2**	**5**	**12**	**7**	**1**	**241**

***** Operating vehicle in an erratic/reckless/careless/negligent/aggressive manner

Numerous factors may aid in determining potential countermeasures, including the following:

- Crash Types
- Time Series
- Day/Night
- Alcohol
- Animals
- Fixed Objects
- Snow/Ice
- Elderly
- Young
- Speeding/Reckless Driving

Crash Types: The crash types, or major causes of crashes, can be instructive for selecting beneficial mitigation. Typical "high-crash" types on rural two-lane roads might include run-off-road, too fast for conditions, and animal related. Another important issue to consider is driver-contributing circumstances, such as lost control, driving too fast for conditions, and failure to yield at an intersection. Each of these causes or crash types has differing suggested mitigation approaches.

Time Series (e.g., trends or patterns that develop over time)**:** Crash history may indicate definite trends, either upward or downward, over time. Several time divisions could be studied—annually, monthly, daily, or hourly—each yielding potentially different conclusions. If crashes are increasing on an annual basis but traffic volumes are not, a more detailed investigation of causes is needed. Monthly variations could be weather related. Daily or hourly fluctuations, perhaps indicating higher traffic volumes during commuting, might present opportunities for enhanced law enforcement and/or education.

Day/Night: Although nighttime travel volumes are generally lower than daytime, nighttime crash rates can be higher. In addition, nighttime crashes tend to be more severe than daytime crashes for a variety of reasons, such as higher speeds, reduced seat belt use, and impaired driving. A high ratio of night to day crashes might indicate a need for improved traffic control device visibility and/or intersection lighting. Enhanced enforcement might also be beneficial.

Alcohol: A high number of crashes where Under the Influence is noted for driver condition indicate the need for enhanced enforcement activities. When the location of the crashes is mapped, it might be possible to locate the generating source for these drivers.

Animals: A high number of animal-related crashes is common on rural Iowa roads and is many times the major cause. Although it may be tempting to discount these crashes as non-preventable, there are several potentially beneficial responses available. Effective options

have been employed, such as enhanced warning signs, news media releases at certain times of the year when impact opportunities are higher, clearing high vegetation along the roadside, and deer fences where property owner access is not impacted. Deer fences might prove effective near a stream crossing where a high number of animal crashes have occurred and where crossing animals can be directed under a road structure with high fencing.

Fixed Objects: Fixed objects along the roadside might include trees, utility poles, structures, or other potentially hazardous obstacles. Any non-breakaway or non-traversable object within the clear zone should be investigated for removal or crash-worthiness, regardless of whether data indicate past crashes.

Snow/Ice: Roadway and weather conditions that contribute to crashes do not present many viable mitigation options. However, sharing past crash data with the media prior to winter driving conditions might raise driver awareness. If a high concentration of crashes seems to occur in isolated locations, adjusting the maintenance activity timing could also be beneficial.

Elderly: A high number of crashes involving elderly drivers may indicate the need for enhanced signing and pavement markings. In addition, these data can be shared with the media to improve public awareness.

Young: A high number of crashes involving younger drivers might indicate the need for data sharing with local news media and schools. Sharing crash data that involves younger drivers with driver educators can be particularly effective and successful results can be initiated through high school programs.

Speeding/Reckless Driving: Crashes related to excessive speed/reckless driving are another opportunity for enhanced law enforcement activities. Discuss this option with local law enforcement, the Iowa State Patrol (ISP), and the Iowa GTSB.

9. Refer to Official Crash Report Forms

If the previous steps don't provide sufficient insight, it may be helpful to examine more details on the actual crash reports. This step can be time consuming and, in most instances, probably will not yield any useful data beyond what is available from standard crash summaries. However, two data elements on crash reports that are not included in the summaries are narratives and diagrams, which the investigating officer prepares.

Certain unique crashes, such as those involving pavement edge drop-offs, vehicles other than cars or trucks, or bridge rail impacts, might merit more in-depth review using the actual crash reports. However, because these reviews can be burdensome and often non-productive, perhaps only crashes involving fatalities and/or major injuries should be

considered for report form evaluation. Special authorization from the Iowa DOT is needed to access the complete crash reports.

Example of an Intersection or Spot Location Data Analysis Using the Iowa Method

Note that most of the steps described for intersections or spot locations are quite similar to those described for segments or corridors and will not be totally repeated.

The Iowa method for intersection analysis can be found at www.iowadot.gov/crashanalysis/pdfs/iowa_safetyimprovementcandidatelocation_method_20070220.pdf.

1. Check the SICL List or the 5 Percent Most Severe Safety Needs Report

Both the SICL and the *5 Percent Most Severe Safety Needs Report* list intersection sites that are candidates for potential safety improvements. The SICL focuses on a combination of severity, rates, and frequencies for all sites throughout Iowa, while the *5 Percent Most Severe Safety Needs Report* focuses on severe injury (fatality or major injury) crashes. The SICL list is available at www.iowadot.gov/crashanalysis/top200.htm and the report is at www.iowadot.gov/crashanalysis/fivepercent/fivepercentneeds.htm.

2. Map the Crashes

Collision diagrams help map intersection and spot location crashes. These diagrams can be prepared using SAVER. Site-specific data can also be obtained with CMAT. Crash diagrams can also be requested from ITSDS at InTrans (www.ctre.iastate.edu/itsds/index.htm). Figure 5.3 shows a sample collision diagram that was created using Diagram Magic with SAVER.

3. Examine the Map for Crash Factors

Collision diagrams, in addition to sketching the site, show the approximate location of crashes, which can help identify additional crash factors. Direction of travel, crash type, severity, fixed object struck, and many other crash details are summarized. These data can be examined for common factors, such as intersection quadrant, direction of travel, and crash type—all valuable information when selecting countermeasures.

4. Determine Crash Frequencies (Usually by Severity)

As with segments or corridors, the next step is to determine the crash frequencies or crash counts, which usually involves summarizing the crashes by severity. The GIS-based analysis tools that TAS distributes enable this operation.

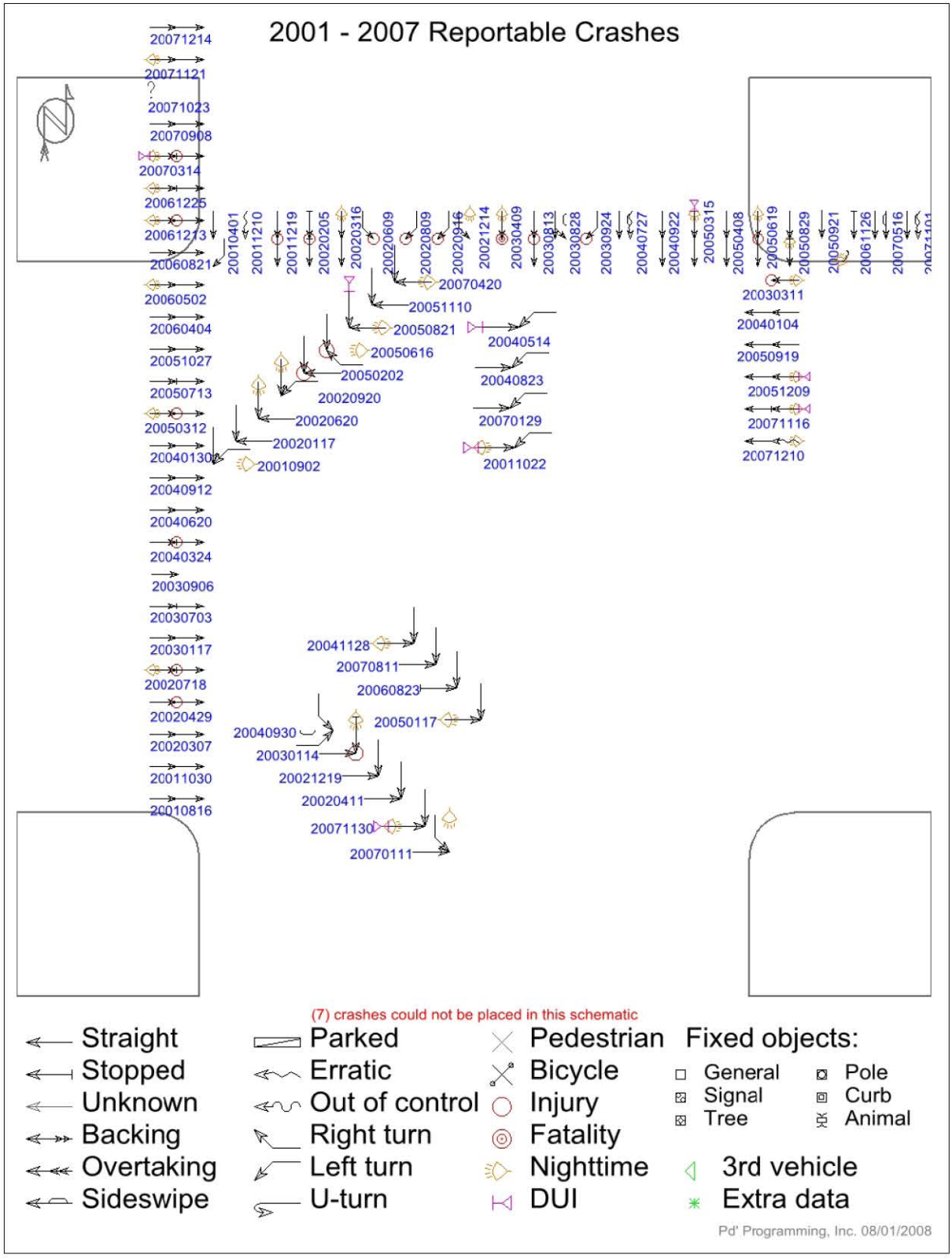

Figure 5.3. Sample collision diagram for an intersection

5. Calculate Crash Rates by Frequency and Severity

To calculate the crash rate, the traffic volume entering the site or intersection is needed. The AADT can be estimated using SAVER and CMAT or from crash maps provided by the DOT.

For a specific site or intersection, the crash rate can be determined using equation 5-5.

$$CR = \left(\frac{N}{\frac{A}{2} \times Y \times 365} \right) \times 10^6 \qquad \textbf{(5-5)}$$

where *CR* is the crash rate in crashes per million daily entering vehicles (crashes/M DEV), *N* is the crash frequency during the analysis period (*Y*), *A* is the sum of AADT on all approaches, and *Y* is the analysis period in years (typically avoid partial years to avoid seasonality).

Crash frequency can be determined using equation 5-6.

$$CF = \frac{N}{Y} \qquad \textbf{(5-6)}$$

where *CF* is the crash frequency in crashes per year (crashes/year) and *N* and *Y* are the same as defined in equation 5-5.

As an example, assume these values:

- 4 leg rural intersection of a primary road with a secondary road
- 10 total crashes over a five-year period
- 5,000 vehicles per day (vpd) on the major road legs and 2,000 vpd on the minor road legs (note that there are two major road legs with 5,000 vpd each and two minor road legs with 2,000 vpd each)

Inserting the data into the formulas gives a crash rate of 0.78 crashes/M DEV and a crash frequency of 2 crashes/year as shown in equations 5-7 and 5-8.

$$CR = \left(\frac{10}{\frac{5000}{2} + \frac{5000}{2} + \frac{2000}{2} + \frac{2000}{2} \times 5 \times 365} \right) \times 10^6 = 0.78 \text{ crashes/M DEV} \qquad \textbf{(5-7)}$$

$$CF = \frac{10}{5} = 2 \text{ crashes/year} \quad \textbf{(5-8)}$$

These values can then be compared to statewide average rates (comparables) for similar intersections. The Iowa comparables can be found at www.iowadot.gov/crashanalysis/data.htm.

In this example, the rate is slightly above statewide averages (0.78 vs. 0.7) and the frequency is also above average comparable (2 vs. 1.7). With the given traffic volume, more crashes are occurring than at similar intersections and the crash rate is higher. These results suggest that further analysis, perhaps into types of crashes occurring at the intersection, is warranted to aid in selecting possible mitigation measures.

It might also be beneficial to consider calculating the rate and frequency by severity (e.g., fatal crash rate, fatal and major injury crash rate, and fatality rate) and to compare the results with average severity-based values. Sometimes an intersection might be average or below average from a total crash viewpoint but have an extraordinarily high rate or frequency of more severe crashes.

6. Generate a Stacked Map

From the crash data, a crash histogram or bar chart (i.e., stack) can be generated to better depict the crash frequency at the spot location and for the roadway segments leading into that location because the area of concern might extend beyond the spot location (see Figure 5.1 for an example). As described in step 2, a collision diagram should be generated for intersections and spot locations (see Figure 5.2).

7. Generate a Report with Details of Individual Crashes

Generate a report with details of individual crashes to help identify common crash contributors and patterns and determine potential countermeasures.

Both SAVER and CMAT (and IMAT for law enforcement) can produce reports with the details of individual crashes. These reports can then be analyzed to identify multiple occurrences of a variety of crash factors. In addition, year-to-year trends for certain suspected issues should be considered and the SAVER analysis program will produce year-based reports for that purpose.

8. Look for Patterns

The list of factors to be considered here is similar to those listed earlier for segments or corridors and includes major crash contributors, trends over time, day/night crash ratios, driving while impaired, fixed objects, driver age, excessive speed, and weather related.

As an example, intersections with a significant number of nighttime crashes may indicate the need for improved lighting and/or traffic guidance. To calculate an accurate crash rate, night traffic volume estimates are needed. The Iowa DOT can provide average traffic volume estimates by hour for application at specific locations.

The Iowa DOT recommends the following criteria as warrants for lighting at an intersection:

- Average Daily Traffic (ADT) > 1,750 daily entering vehicles (DEV)
- Channelized, T configuration, or major route change or
- Night-to-day crash rate ratio greater than or equal to 1.0 and
- Minimum of two reportable nighttime crashes in a five-year period

Reports of operational problems that can be rectified with lighting may also justify installing intersection illumination. Many states, including Iowa, recommend certain minimum traffic volumes as an additional warrant for this improvement.

Determining which crashes have occurred during reduced natural lighting periods can be problematic for analysis. The crash report form includes light conditions, but many times Unknown is entered. In those cases, use the U.S. Naval Observatory lighting condition records for a detailed and accurate analyses. SAVER actually derives the lighting conditions (e.g., day, dark, dawn, and dusk) based on the National Oceanic and Atmospheric Administration (NOAA) time history of sunset and sunrise. Civil Twilight determines the time frames.

As another example, in urban areas, crashes involving pedestrians and bicyclists are of concern, as are those related to traffic signals. Mitigation for these crashes entails specific responses that are addressed in Chapter 6: Countermeasures.

9. Refer to Official Crash Report Forms

As described earlier for the segment or corridor analysis, if the previous steps don't provide sufficient insight, it may be helpful to look at more details on the actual crash reports. This can be time consuming and, in most instances, probably will not yield any useful data beyond what is available from standard crash summaries.

Two data elements on crash reports that are not included in the summaries are narratives and diagrams, which the investigating officer prepares. Certain unique crashes at intersections, such as those involving failure to yield from stop sign or signal or those with pedestrian impact, might merit a more in-depth review of actual crash reports. However, because these reviews can be burdensome and often non-productive, perhaps only crashes involving fatalities and/or major injuries should be considered for report examination.

Other Analysis Methods

Several other crash analysis methods, not used by the Iowa DOT are available and used in other states to locate areas of safety concern, such as the following:

- Spot map method
- Equivalent property damage only (EPDO)
- Severity weighting
- Crash probability index
- Severity index
- Critical crash rate

For example, the critical crash rate method allows an agency to eliminate many locations from further review and concentrate on the areas where improvement is needed most. However, even sites with below-average crash rates may greatly benefit from safety improvements.

Other methods have been developed that do not specifically concentrate on crash history but that consider sites with promising potential for safety improvement, while not having yet developed an adverse crash history. Relying entirely on crash history requires large data volumes, accepting errors in the data, expensive periodic evaluations, "regression-to-the-mean"* phenomena, and possibly identifying sites with no feasible mitigation. In addition, crash history analysis primarily addresses reactive solutions and not necessarily proactive initiatives. The potential value of crash predictive measures as described in Chapter 4: Identifying Potential Problem Locations presents some advantages.

* Regression-to-the-mean is a term in statistical probability defined as the predictable return of an observed event over time to the mean level of similar events. Because crashes are substantially random occurrences, high crash numbers in a given year will most likely decline in the succeeding short term to a mean average established over a longer history, regardless of any mitigation. Regression-to-the-mean effects can be minimized by a statistical analysis method, such as a Bayesian approach.

Chapter 6: Countermeasures

Selecting Countermeasures

After a crash analysis has identified the potential for reducing crashes, mitigation options for addressing deficiencies can be considered and selected. In some instances, a wide range of possible choices may exist, and several approaches or a combination of initiatives might be considered.

While Chapter 3: Addressing Traffic Concerns in Iowa discusses cooperation between agencies and professional groups in more depth, some of the advantages of this cooperation become obvious when selecting countermeasures. Solutions to problems might be found in engineering improvements, educational efforts for drivers, or focused law enforcement. Occasionally, a combination of these options is particularly beneficial.

An example might be an intersection with an abnormally high crash history due to signal violations. A city might initially react by increasing enforcement at the location, and this strategy might yield short-term benefits. However, compiling citation and crash statistics for the intersection and requesting a story in the local news media could help educate drivers. Flyers or temporary informational signs could also be employed.

While these approaches are short-term solutions, a long-term solution to the observed problem might be an engineering approach. Enhancing the visibility of signal heads, improving signal timing, and even synchronizing the signal with adjacent signals are effective techniques to reduce signal violations. As a final option, automated enforcement could be recommended. Thus, a multidisciplinary approach is worthwhile in this instance.

This chapter presents an extensive list of options for addressing safety concerns at "high-crash" locations or in a systemic approach. These options could also be effectively applied in a proactive fashion to reduce potential traffic safety concerns before crashes occur.

Improvement options are presented in the fields of engineering, enforcement, and education. However, these options should not only be viewed individually but also in combination to increase effectiveness.

Implementation cost is an important factor, with engineering solutions generally resulting in a higher investment of funds. Multi-disciplinary cooperation can present a phased option for addressing identified problem areas. Beginning with an educational effort and supplemented by increased enforcement, a long-term engineering solution could be accomplished when funding becomes available.

Emergency responders can also provide valuable advice and opportunities for reducing crash severity. These professionals should be included in efforts to improve safety; however, this manual does not address options in this area.

Benefit-Cost Comparisons

While physically improving the roadway environment may be an attractive solution, initial cost may impact any ultimate benefit for the public. Benefit-cost computations are addressed in Chapter 7: Economic Analysis Procedures.

Based on national FHWA evaluation data, Table 6.1 lists approximate benefit-cost ratios for various common safety improvements (*1*). This information is presented for comparative purposes only. Actual benefit-cost ratios must be computed for each proposed improvement and may vary widely from the average data shown in Table 6.1.

Table 6.1. FHWA common roadway safety improvements with the highest benefit-cost ratios for 1974–1995

Rank	Improvement	B/C Ratio
1	Illumination	26.8
2	Upgrade Median Barrier	22.6
3	Traffic Signs	22.4
4	Relocated/Breakaway Utility Poles	17.7
5	Remove Obstacles	10.7
6	New Traffic Signals	8.5
7	Impact Attenuators	8.0
8	New Median Barrier	7.6
9	Upgrade Guardrail	7.5
10	Upgrade Traffic Signals	7.4
11	Upgrade Bridge Rail	6.9
12	Improve Sight Distance	6.1
13	Median for Traffic Separation	6.1
14	Groove Pavement for Skid	5.8
15	Improve Minor Structure	5.3
16	Turning Lanes and Channelization	4.5
17	New Railroad Crossing Gates	3.4
18	New Railroad Crossing Flashing Lights	3.1
19	Pavement Markings and Delineation	3.1
20	New Railroad Crossing Lights and Gates	2.9

Source: FHWA *1996 Annual Report on Highway Safety Improvement Programs* (*1*)

The age of the data may also impact some individual comparisons. However, the distinct and relative comparative value of some relatively low-cost improvements can be seen in this data.

Expected Life and Crash Reduction Factors

The expected life of roadway improvements must also be considered in making decisions for traffic safety enhancements. Table 6.2 shows typical improvements with a compilation of anticipated service life comparisons and average crash reduction percentages.

Table 6.2. Quick reference to expected service life and average crash reduction factors

Improvement	Expected Service Life (years)	Average Reduction Factor (%)
Intersection and Traffic Control		
Construct left-turn lanes	15-20	34
Construct right-turn lanes	15-20	13
Provide lane channelization (physical)	15-20	43-67
Install/Upgrade traffic signs	10	15
Install chevrons on horizontal curves	10	20-50
Install delineators	10	11
Install/Upgrade pavement markings	2	10-50
Install intersection illumination	15	39-50
Upgrade traffic signals	15	up to 49
Install traffic signals	15	30
Convert to roundabout	20	35-48
Structures		
Widen/Modify bridge	20	45-55
Replace/Eliminate bridge	50	45
Replace/Improve minor structure	20*	45
Upgrade bridge rail	10*	20
Install guardrail (at bridge)	15	21
Install bridge illumination	15	59
Install bridge delineators	10	43
Roadway and Roadside		
Widen traveled way (no new lanes)	20	50
Resurface pavement and improve superelevation	15	28
Add lane	20	26
Construct median for traffic separation	20*	48
Widen/Improve shoulders	20	3 per ft widened 20 average overall up to 57
Install shoulder rumble strips	15	26
Pave shoulder	15	15-25
Realign roadway	20	58
Improve pavement/overlay for skid improvement	10-20	22
Groove pavement for skid improvement	10	21-37
Remove/Relocate utility poles	10*	40
Upgrade guardrail	15	21
Install median barrier	15*	up to 86
Install impact attenuators	10	29
Flatten/Regrade entrance slopes	20	44

Improvement	Expected Service Life (years)	Average Reduction Factor (%)
Remove obstacles in clear zone	20*	38
Increase level of access control	20	25-31*
Pedestrian and Bicycle Safety		
Construct sidewalk	20*	74
Construct pedestrian and bicycle overpass/underpass	30*	13-86
Construct bike lanes	20*	36
Replace with countdown signals/Add pedestrian phasing	15	25-34
Install refuge islands	15-20	56
Provide paved shoulder	15-20	71
Install illumination	15	21
Increase traffic speed enforcement		70
Railroad Crossings		
Install crossing gates	10	91*
Install RR signs and markings	10*	25
Install illumination	15	62
Install/Upgrade gates with flashing lights and sound signals	10	45*
Close RR crossing	50	75
Install grade separation structure	50	39
Relocate highway to eliminate crossing	30*	75

Expected Service Life figures based primarily on Iowa DOT Office of Traffic and Safety, July 2009 (*2*), except for the ones marked with an *, which are from Mn/DOT HES Program Criteria, November 2004 (*3*).
Average Reduction Factors derived primarily from the FHWA *Desktop Reference for Crash Reduction Factors*, September 2007 (*4*), except for those for Railroad Crossings, which are primarily from the Iowa DOT Office of Local Systems, Instructional Memorandum (I.M.) 3.216, October 2001 (*5*), except for the ones marked with an *, which are from the Crash Modifications Factors Clearinghouse (*6*) at www.cmfclearinghouse.org/.

More detailed crash reduction factors (including study citations and references) can be found in the FHWA *Desktop Reference for Crash Reduction Factors* (*4)* and the Crash Modifications Factors Clearinghouse (*6*) at www.cmfclearinghouse.org/.

Crash Modification Factors versus Crash Reduction Factors

Crash modification factors (CMFs) and crash reduction factors (CRFs) sound similar but, in fact, are quite different methods of expressing the expected impacts of safety improvements. The following explanation is given on the Crash Modification Factors Clearinghouse website at www.cmfclearinghouse.org/:

"The main difference between CRF and CMF is that CRF provides an estimate of the percentage reduction in crashes, while CMF is a multiplicative factor used to compute the expected number of crashes after implementing a given improvement. Both terms are presented in the Clearinghouse because both are widely used in the field of traffic safety.

Mathematically stated, CMF = 1 - (CRF/100). For example, if a particular countermeasure is expected to reduce the number of crashes by 23 percent (i.e., the CRF is 23), the CMF will be 1 - (23/100) = 0.77. On the other hand, if the treatment is expected to increase the number of crashes by 23 percent (i.e., the CRF is -23), the CMF will be = 1 - (-23/100) = 1.23." (*6*)

The tables in this Chapter provide a general idea of expected crash reduction factors, usually for all crash types and severities. For funding applications submitted to the Iowa DOT TAS, always use the more specific CRFs from the Crash Modifications Factors Clearinghouse (*6*) at www.cmfclearinghouse.org/.

Low-Cost Safety Improvements

Safety improvements on Iowa's roads and streets can often be accomplished at relatively low cost. These options are especially attractive when an agency desires to apply substantive rather than basic nominal applications on low-volume roads. Much of the information in this chapter was obtained from the 2006 FHWA *Low Cost Safety Improvements* workshop (*7*) and various NCHRP reports, including Report 440, *Accident Mitigation Guide for Congested Rural Two-Lane Highways* (*8*).

Signing and Pavement Markings

As shown in Table 6.1, following lighting, improved signing has been shown as the third highest benefit-cost option for enhancing safety on two-lane roadways. Agencies can achieve a desirable payback for investing in a quality sign and marking program, which includes adopting appropriate policies and procedures, establishing a formal sign management program with dedicated staff and an inventory system, assuring knowledge of current materials and practices, and providing periodic training for all staff involved in these activities.

In addition to the *MUTCD* and the *ITE Traffic Control Devices Handbook*, the FHWA safety web site at safety.fhwa.dot.gov/ is a good reference.

Table 6.3 shows some specific areas, primarily from the 2006 FHWA *Low Cost Safety Improvements* workshop (*7*), where low-cost improvements can be beneficial. Note that results vary widely depending on the condition of signing initially and crash history.

Improving guide sign use and placement is often overlooked when regulatory and warning sign needs are prioritized. However, improving guide signs is beneficial, especially for non-local drivers. Larger, more visible street name signs, route markings, and directional signing improve traffic operations and safety. Agency staff should review these important signs to ascertain that drivers are provided proper and intended guidance. Enhanced and combined lane use and route marker signs have also been proven effective when used.

Table 6.3 Potentially-beneficial low-cost improvement areas primarily for intersections

Improvement	Average Reduction Factor (%)
Improve warning signs	up to 25
Enhance curve warning signs	25
Increase sign size	up to 19*
Double the number of regulatory or advance warning signs directly opposite or staggered but not sequential	31
Use Be Prepared to Stop signs with flashers	30-40
Install advance rumble strips	28-35*
Install double Stop signs	11
Place Stop signs in islands at intersections with wide radii	11

Average Reduction Factors are primarily from the 2006 FHWA *Designing and Operating Intersections for Safety* workshop (*7*), except for the ones marked with an *, which are also derived from the FHWA *Desktop Reference for Crash Reduction Factors*, September 2007 (*4*).

To improve individual sign visibility, consider:

- Flags on signs
- Fluorescent and very high-intensity sheeting for specific signs
- Color-coded sleeves for Stop or warning signs
- Oversized backing for signs, either fluorescent yellow or fluorescent yellow-green
- LED flashers in Stop and/or warning signs
- Flashing beacons on signs

Enhanced and improved pavement markings are beneficial for guidance, especially for older drivers. Consider durable markings, wider lines, milled-in, all-weather markings, and raised pavement markings for specific problem locations. Transverse rumble strips can effectively alert drivers when they are approaching a Stop condition.

For schools and other high pedestrian locations, several options are available to improve driver alertness and performance:

- Your Speed electronic displays
- Temporary or permanent in-street signs for crossings
- Flashing LED lights in Stop paddles for crossing guard use

Roadside Hazards and Adequate Clear Zones

In selecting countermeasures to reduce the number and/or severity of crashes associated with hazardous roadside obstacles, the AASHTO *Roadside Design Guide* (*10*) recommends these options in rank order:

1. Remove the obstacle
2. Redesign the obstacle so it can be safely traversed
3. Relocate the obstacle to a point where it is less likely to be struck
4. Reduce impact severity by using an appropriate breakaway device
5. Shield the obstacle with a longitudinal traffic barrier designed for redirection or use a crash cushion
6. Delineate the obstacle if the above alternatives are not appropriate

Single-vehicle, run-off-road crashes are among the most common on Iowa's rural roads. Establishing adequate clear zones can help reduce the incidence and severity of these crashes. The following information describes the most common obstacles struck by errant vehicles upon leaving the travel way and provides some possible improvements:

- In Iowa, the most frequently impacted obstacles are foreslopes, backslopes, and ditches, along with the cross slopes of field entrances and driveways. Flattening foreslopes to a minimum 3:1, especially in run-off-road high-incidence areas, such as horizontal curves, can be very effective in reducing severity of crashes.
- Trees should be removed from clear zones. Not only can larger trees (greater than four inches in diameter) pose a hazard for run-off-road vehicles, but also, vegetation from trees and brush can hamper visibility and hide large animals.
- Utility poles are occasionally located near roadways. Agencies should work with utility companies to relocate poles to near the right-of-way line. A crash reduction of 30 to 40 percent may be possible in high-exposure locations. Modest relocations of even a few feet can reduce the incidence of impact.
- The *MUTCD* (*9*) requires sign supports to be breakaway, shielded, or located outside the established clear zone. Wood sign posts larger than four by four inches are not considered breakaway. Drilling larger wood sign supports should be undertaken when these devices are located within the clear zone.
- Mailbox supports should also be a breakaway or yielding design, similar to sign supports. Work with property owners and the mail service to achieve compliance.
- Larger pipes and culverts (horizontal openings six feet or greater) are considered a potential hazard for errant vehicles. Consider treatments using the standard priority of options, with extension preferred over beam guardrail installation.

Table 6.4, which originated in the Zegeer et al. report, *Cost-Effective Geometric Improvements for Safety Upgrading of Horizontal Curves* (*11*) illustrates approximately how common potential obstacle impacts can be reduced by removing or relocating the obstacle away from the roadway traveled area

Table 6.4. Obstacle impact reduction by increased offset from roadway

Increase in Obstacle Distance from Roadway (ft)	Trees (%)	Mailboxes, Culverts, Signs (%)	Guardrails (%)	Fences/Gates (%)
3	22	14	36	20
5	34	23	53	30
8	49	34	70	44
10	57	40	78	52
13	66	NF	NF	NF
15	71	NF	NF	NF

NF = Generally not feasible to locate these obstacles at these distances
Source: *Cost-Effective Geometric Improvements for Safety Upgrading of Horizontal Curves*, 1990 (*11*)

Replacing outdated guardrail and other hardware should also be considered.

Edge rumble strips that supplement painted edge lines can reduce run-off-road crashes by 20 to 50 percent on two-lane roads and by 15 to 70 percent on four-lane divided highways.

Centerline rumble strips are also becoming more popular in many states to reduce the incidence of crossed centerline crashes, which can be quite severe.

Rumble strips in either location can also provide additional paint marking visibility in wet weather when the markings are placed directly on the vertical faces of the rumble strips. When the rumble strips are painted, they are referred to as rumble stripes. Narrow (four-inch-wide) rumble stripes have been shown effective on lower-volume rural roads for reducing run-off-road crashes and for improving wet-weather visibility of pavement markings. Wider edge lines—six to 12 inches—have been proven effective in some states for improving visibility for drivers at night.

Pavement edge drop-offs of sufficient magnitude can exacerbate errant driver loss of control. Specific locations, such as horizontal curves, severe vertical grades, mailbox turnouts, and intersections, are particularly susceptible to edge drop-off incidents.

Agencies should adopt maintenance practices to reduce the occurrence of pavement edge drop-offs in excess of two to three inches. Paving all or part of the inside shoulder at horizontal curves can be effective in reducing run-off-road crashes at these locations, while also reducing persistent maintenance requirements. Resurfacing projects should include provisions to address the resultant elevation differentials, such as using temporary rock or earth fillets or the safety edge design.

Horizontal curves are common run-off-road locations on rural roads. Chapter 2C of the 2009 *MUTCD* contains good guidance for selecting and locating warning signs, with and without advisory speed plaques, installing chevrons and/or delineators, and for other enhancements to help reduce crashes at these locations.

Intersections

Because intersections entail a higher probability of vehicle conflicts, crashes at these locations are common, especially in urban areas. For example, T intersections present nine possible conflict points while four-leg intersections have 32. By contrast, single-lane roundabouts only include eight potential conflict locations. The reduced number of conflict points commonly results in a much lower crash frequency and severity at roundabouts compared to conventionally designed intersections.

Addressing observed intersection-related crashes can be challenging for agencies. Table 6.5 provides several improvements that can be considered at problem locations. Also, refer to NCHRP Report 500, Volume 5, *A Guide for Addressing Unsignalized Intersection Collisions* for more options and discussion. This report can be accessed at onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v5.pdf. It should be noted, however, that not all of these improvements would be considered low cost.

Table 6.5 Improvements to consider at problem intersections

Improvement	Potential Reduction (%)
Upgrade signing and pavement markings	15-50
Improve traffic control in this order as warranted: - No control - Yield signs - Stop signs on minor approaches - Four-way Stop signs - Signalize	
Modify existing configuration - Install right-turn lane - Install left-turn lane	 26 50
Restrict adjacent access -An approximate 250 ft restriction might be desirable	
Install lighting	39-50
Improve sight distance (visibility)	17
To provide positive enforcement of No Left Turn ordinances at entrances, consider installing tubular markers (Super Dux) on through road or street centerline	

Potential Reduction Factors derived primarily from the FHWA *Desktop Reference for Crash Reduction Factors*, September 2007 (*4*).

Signalized Intersections

Installing traffic signals at a high-volume intersection may not significantly reduce the total number of crashes at that location but may only modify the type and severity. In addition, signal violations or red light running can also occur.

To address observed crash and operational problems at signalized intersections, the list of relatively low-cost countermeasures shown in Table 6.6 are available. Many more options and an expanded discussion can be found in NCHRP Report 500, Volume 12, *A Guide for Reducing Collisions at Signalized Intersections*, which can be accessed at onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v12.pdf.

Table 6.6 Relatively low-cost countermeasures for signalized intersections

Improvement	Potential Reduction (%)
Change yellow interval*	15-30
Add all-red clearance interval*	15-30
Improve signal visibility	
- Install larger lenses	11-46
- Install one signal over each approach lane	46
- Install backer plates	13
- Install red T signal heads (two horizontal red lamps above yellow and green lamps)	36
Change permissive to protected left-turn signals	27-63
Add advance warning signs with flashers	35-45
Remove late-night/early-morning flash mode	29
Coordinate signals	15, as well as improved traffic flow and lessened congestion
Remove unwarranted signals*	50-100
General upgrade of traffic signals, including retiming	20-25 and improved traffic flow
If high crash numbers persist, consider adopting automated enforcement in selected locations if signal violations are significant	

Potential Reduction Factors derived from the FHWA *Desktop Reference for Crash Reduction Factors*, September 2007 (*4*).
* See the ITE *Manual of Traffic Signal Design* and the ITE *Traffic Control Devices Handbook* and the *MUTCD* (*12*, *13*, *9*) for guidelines and recommendations.

Lighting

Roadway lighting should be considered at intersections where a high night-to-day crash ratio is observed. Installing lighting has been found to reduce nighttime crashes by up to 50 percent. Many times, a single destination light can help drivers visually notice an intersection at night, especially at isolated rural locations.

At-Grade Railroad Crossings

Motor vehicle collisions with trains are less common in Iowa today than in the past, but these crashes often result in fatalities, severe personal injuries, and significant property damages. Appropriate warning and protection of at-grade crossings is important for public safety.

In addition to the references listed earlier in this chapter, other excellent references on this topic are NCHRP Report 470 *Traffic-Control Devices for Passive Railroad-Highway Grade Crossings* and the U.S. DOT Technical Working Group's 2002 *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings.*

Countermeasures in the following areas may be productive and should be studied at crossings:

- Stopping sight distance to the crossing for approaching vehicles
- Signing and pavement markings
- Sight distance (visibility), especially at passive crossings
- Lighting
- Enforcement of crossing gate violations

Stopping Sight Distance

Drivers approaching a highway-rail grade crossing must have adequate visibility of the location to take necessary actions to stop and avoid a collision. If approach roadway geometrics do not allow sufficient visibility of the crossing, warning signs should be located to provide appropriate notice.

Signing and Pavement Markings

Part 8 of the *MUTCD* presents several new warning signs for grade crossings. These signs provide more flexibility for warning and advising drivers and pedestrians of varying situations. In addition, the *MUTCD* now requires the installation of positive control—either Yield or Stop signs at all passive crossings—regardless of roadway traffic volume (*9*). Pavement markings on paved roads can also provide additional warning for approaching vehicles.

Sight Distance (Visibility)

At passive (non-signalized) crossings, visibility along the tracks for oncoming trains is imperative. A clear sight distance triangle similar to roadway intersections should be sought. For at-grade crossing with visibility restrictions, the following options are available:

- Remove obstructions, trim vegetation, etc. (discuss need with rail company)
- Install appropriate warning signs
- Install Stop signs in lieu of Yield signs

- Reduce motor vehicle approach speed
    - o Use advisory speed plaques as a minimum
    - o Use regulatory speed reduction if reasonably enforceable

For problem at-grade highway-rail crossings, agencies can consider the following options, in priority order:

1. Close the crossing
2. Install Yield or Stop signs as appropriate
3. Install signalized crossing gates
4. Relocate or reconfigure the crossing
5. Construct a grade separation structure

Impatient drivers or pedestrians who violate activated signals and crossing gates can pose safety concerns. Automated video enforcement, similar to that available for signalized roadway intersections, has proven effective when utilized. Activated gate violations have been significantly reduced when this enforcement method was employed.

Additional information on low-cost improvements can be found in the American Traffic Safety Services Association (ATSSA) publication *Low Cost Local Road Safety Solutions* at safety.fhwa.dot.gov/intersection/resources/fhwasa09027/resources/Low%20Cost%20Local%20Road%20Safety%20Solutions.pdf.

Countermeasures for Specific Problems

Specific crash types often have definable causes that might be addressed in several possible ways. The information shown in Table 6.7 was taken from the *SEMCOG Traffic Safety Manual* and from the Roadway Safety Foundation *Road Safety Guide* (*14*, *15*).

Table 6.7. Suggested countermeasures for specific roadway crash problems

Suspected Crash Cause	Possible Countermeasures
Restricted Sight Distance	-Install no passing zones -Add No Passing pennants -Reduce obstructions on inside of curves -Lower roadbed on hill crests -Offset opposing left-turn lanes
Inadequate Pavement Markings	-Supplement with raised pavement markers -Replace painted markings more often -Use durable pavement markings -Add markings where none are used -Install raised median
Narrow Lanes	-Eliminate parking -Widen lanes -Reduce number of lanes (four lanes to three lanes)
Inadequate Roadway Shoulders	-Upgrade shoulder type and condition -Remove/relocate obstacles near travel lane

Suspected Crash Cause	Possible Countermeasures
Inadequate Maintenance	-Repair/replace roadway surface -Repair/replace shoulder surface -Place widening units adjacent to travel lane
Severe Curves	-Post curve warnings/advisory speeds -Install chevron warning devices -Flatten roadway curves
Excessive Speed	-Post/reduce speed limit -Increase enforcement - Selectively employ speed trailer
Inadequate Gaps in Opposing Traffic	-Add two-way Stop/Yield control -Revise two-way to four-way Stop -Signalize intersection -Upgrade signals with left-turn phase
Inadequate Signalization for Left Turns	-Retime signals -Provide lead/lag or split phasing -Add exclusive left-turn signal phase -Install dual left-turn lanes -Prohibit turns -Convert to one-way operation -Reroute left-turn traffic
Inadequate Signal Change Interval	-Increase yellow change interval -Add all-red clearance interval
Unexpected Stops at Signals	-Retime signals -Upgrade signal controller -Provide signal progression/coordination -Install signal actuation
Restricted Sight Distance at Signal	-Reduce obstructions in sight triangle -Eliminate parking near signal -Close/relocate driveways near signal
Proper Stopping Position Unclear	-Add stop bars/crosswalk marking -Add/improve lighting at intersection
Poor Visibility of Signal	-Remove signal sight obstructions -Install Signal Ahead signs -Install/replace signal head visors -Add signal head backing plates -Install larger signal lenses -Add signal head for each approach lane -Install flashers on advance warning signs -Replace conventional lenses with light-emitting diodes (LEDs)
Unsafe Right Turn on Red (RTOR)	-Reduce RTOR sight obstructions -Add right-turn channelization -Provide right-turn signal phase (green arrow) -Add appropriate regulatory signs (i.e., No Right Turns While Children Present) -Prohibit right turns on red
Slippery Surface	-Post Slippery When Wet signs -Improve drainage -Groove pavement -Overlay pavement

Suspected Crash Cause	Possible Countermeasures
Crossing Pedestrians with Signals	-Add stop bars/crosswalk markings -Install Ped Xing advance warning signs -Install advance warning pavement markings -Install pedestrian signal phasing: Walk/Don't Walk -Add/improve intersection lighting -Reroute pedestrians to safer crossing
Crossing Pedestrians without Signals	-Add stop bars/crosswalk markings -Install Ped Xing advance warning signs -Install advance warning pavement markings -Add/improve intersection lighting -Reroute pedestrians to safer crossing -Install pedestrian crossing signalization
Fixed Objects in Clear Zone	-Remove/relocate object -Install breakaway features -Shield with guardrail -Install crash cushions -Delineate/retroreflectorize
Unexpected Slowing and Lane Changing	-Upgrade guide signing -Install larger signs -Upgrade to more visible sign sheeting -Install Lane-Use control signs
Nighttime Crashes	-Install or improve lighting -Upgrade pavement markings -Review and upgrade sign visibility

Sources: SEMCOG Traffic Safety Manual, September 1997 and the Roadway Safety Foundation *Road Safety Guide* (no date) (*14*, *15*)

Another valuable resource is the NCHRP 500 Series. Currently, about 20 volumes are included, addressing a wide variety of potentially problematic topics in roadway safety. These documents can be accessed online at safety.transportation.org/guides.aspx or at safety.transportation.org/htmlguides/default.asp.

The information in Table 6.8 is adapted from the FHWA *Road Safety Fundamentals* (*16*) and it lists potential countermeasures to mitigate safety issues depending on the associated possible causes.

The information in the tables should not be considered exhaustive and complete but may prove beneficial to agencies in selecting possible corrective measures to address safety issues after completing a crash analysis and identifying contributing causes. However, it should be observed that almost all of these listed countermeasures are engineering improvements.

In accord with discussion elsewhere in this manual, the contribution of law enforcement, education professionals, and news media should not be neglected when considering options for addressing roadway safety and driver performance.

Table 6.8. Safety issues and countermeasures based on possible causes

Safety Issue	Possible Cause	Countermeasures
Pedestrian Related	Crossing street	-Pedestrian crossing signs -Pedestrian crosswalks -Curb bulb-outs
	School children	-Use crossing guards -Bus transportation
	Walking in street	-Install sidewalks -Install shoulders (rural)
Disabled Pedestrians	Using street for travel	-Install/upgrade curb ramps
	Sight-impaired issues	-Install tactile warning
Head-On/Opposite Direction Sideswipe Collisions	Inadequate passing sight	-No passing zones
	Crossing centerline	-Improve pavement marking -Curve delineation -Centerline rumble strips
	Edge drop-offs	-Stabilize/repair paved shoulder -Seal edge ruts -Replace/stabilize unpaved shoulder material -Safety edge
Rear End Collisions	Inadequate sight distance to intersection	-Advance warning signs -Driveway sign assembly
	Driveway traffic	-Turn restrictions -Adopt/enforce access control -Two-way left-turn lane
	Left turn, waiting in traffic	-Turn restrictions -Left-turn lanes
	Poor pavement friction	-See skidding/wet weather
	Signal timing	-Adjust to ITE timing recommendations
Run Off Road	General	-Improve clear zone -Edge line pavement markings/rumble strips -Repair edge drop-off -Stabilize shoulders
	Sharp/unexpected curves	-Warning signs -Chevrons, arrow signs, or delineators -Super-elevate curve
	Poor pavement friction	-See skidding/wet weather
	Fixed object/steep slopes	-Treat roadside hazards -Reshape ditches and side slopes
Right Angle	Traffic control visibility	-Check/adjust regulatory sign/signal head locations -Install larger signs -Add advance warning signs
	Intersection visibility	-Add advance warning signs -Install double arrow across from T intersection -Remove vegetation
	Conflicting traffic visibility	-Improve sight distance -Realign skewed approaches -Adopt/enforce corner clearance standards
	Inappropriate intersection traffic control	-Install four-way Stop -Install traffic signals -Install roundabout

Safety Issue	Possible Cause	Countermeasures
Nighttime	Old/outdated traffic control devices	-Review retroreflectivity of signs/pavement markings and update as needed
	Poor visibility due to darkness	-Delineate roadway with pavement markings, signs, and/or delineators -Add lighting
Skidding or Wet Weather Related	Polished pavement surface	-Surface treatment/overlay, mill and repave, use high-friction aggregate
	Bleeding pavement surface	-Reclaim/mill and replace pavement surface -Place seal coat
	Gravel or dirt on road	-Add driveway aprons
	Improper cross slope	-Correct cross slope -Divert rainfall runoff
	Poor drainage	-Install edge drains
Left Turn	Poor sight distance	-Prohibit left turns
	Inadequate signal timing	-Improve sight distance -Retime signal -Add protected turn phasing

Source: FHWA Road Safety Fundamentals, July 2004 (*16*)

Needs of Special Road Users

The *MUTCD* emphasizes agency responsibility to consider the needs of all potential road and streets users, not just passenger and commercial vehicles (*9*). Of particular interest in many Iowa communities are three groups of special users: older drivers, pedestrians, and bicyclists. The unique safety considerations and accommodations for these travelers, as well as those of motorcyclists, should be included in analysis and management programs.

Older Drivers

Iowa is among the highest ranked states in both numbers and percentages of drivers over 65 years of age and that population is growing. Older drivers present potential challenges for transportation agencies due to decreasing visual acuity, reduced perception and reaction times, and increasing difficulty in dividing attention between rapidly changing conditions in roadway features and traffic information.

More attention is merited for the needs of these frequent road users. A complete analysis of safety history should include a review of older driver involvement so any identified problem areas can be addressed.

Older drivers experience particular difficulties at decision points, such as intersections, work zones, or dramatic changes in alignment. Left turns, in particular, can pose challenges for many older drivers in heavy traffic areas.

Agency action steps and countermeasures for identified older driver problem areas might include the following:

- Establish and maintain communications with older drivers and advocacy groups, such as the AARP (formerly known as the American Association of Retired Persons)
- Periodically review crash records for incidents involving older drivers
- Adopt use of larger lettering on important signing, such as minimum six-inch letters for street name signs, even on low-speed roadways
- Use overhead mounting with eight to 12 inch letters for street name signs at major intersections
- Use advance street name signing on higher-speed roadways
- Review all traffic control devices and pavement markings at night for minimum visibility compliance
- Consider protected-only left turn phasing at higher-traffic-volume signalized intersections, especially on higher-speed roadways
- Review traffic signals for needed visibility enhancements

It should be noted that these and many other relatively low-cost improvements prove beneficial for all road users, not just older drivers. More information and guidance for addressing the needs of the aging driving population can be found in NCHRP Report 500, Volume 9, *A Guide for Reducing Collisions Involving Older Drivers* (available at onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v9.pdf), and with TAS at the Iowa DOT, as well as in many other references listed in this manual.

Pedestrians

Crashes involving pedestrians in Iowa have been decreasing in recent years; however, 20 to 25 pedestrians die in traffic crashes annually and many more are injured. Safety of pedestrians should be a priority for transportation agencies, especially in urban locations.

Very young and older pedestrians are the most common victims of traffic crashes, but physical fitness interest has exposed joggers and walkers of all ages to potential hazards inherent with exposure to motor vehicle traffic. Agencies have several options for addressing observed and potential safety hazards for pedestrians, including the following:

- Educational efforts through schools and news media, emphasizing the benefits of highly-visible apparel for walkers and joggers, especially in low-light conditions
- Promoting the use of properly-trained and attired crossing guards at schools
- Because many pedestrians involved in crashes are alcohol impaired, cooperative enforcement efforts may be advisable
- Use of intersection crossing enhancements, such as count-down pedestrian signals, in-road lighting, etc.
- Analyzing pedestrian-related crashes to identify other potentially-beneficial safety enhancements

The FHWA maintains a website that provides detailed information on pedestrian crash countermeasures at intersections: safety.fhwa.dot.gov/saferjourney/Library/matrix.htm).

Bicyclists

Bicycling for recreation and general transportation is becoming more popular in Iowa and with that comes potential for conflicts with motor vehicles. In contrast with pedestrians, bicyclists are also quite common in rural areas (as well as urban), so all agencies should apply appropriate attention to potential safety needs for this transportation mode.

As with pedestrians, crashes involving bicyclists have been decreasing in Iowa despite more exposure of bicyclists to motorists. Still, several bicyclists are killed each year and several hundred suffer injuries. Agencies should consider several options for addressing and improving roadway safety for bicyclists:

- Educational campaigns through schools, parent associations, and advocacy groups emphasizing the benefits of safety etiquette in traffic and the value of helmets and high-visibility apparel for riders.
- Special signing, such as Share the Road plaques can draw attention of motor vehicle drivers to significant bicycle use areas
- Consider installation of dedicated bicycle lanes or paved shoulders where justified by high demand
- Any bicycle-related crash should be carefully analyzed to determine a possible countermeasure to prevent recurrence

Motorcycles

Motorcycle ownership and use has grown significantly in recent years and that increase in exposure has resulted, unfortunately, in higher fatality and injury numbers among cycle riders. Despite a decrease in motor vehicle fatal crashes in the past few years, that trend has not occurred with motorcycles. Those statistics have exhibited a steady increase.

Proactive measures to address motorcycle safety are available for interested agencies (and many are quite similar to those listed for bicycle safety).

- Access the Iowa DOT website at www.iowadot.gov/mre/# for information about events and training related to motorcycle safety.
- Through educational efforts, encourage cycle riders to participate in the events.
- Work with rider associations and advocacy groups in promoting safety. Examples include A Brotherhood Aimed Towards Education (ABATE) of Iowa, the American Motorcyclist Association (AMA), the Goldwing Road Riders Association (GWRRA), and the Skilled Motorcyclist Association-Responsible, Trained and Educated Riders, Inc. (SMARTER), along with many others.
- Use special warning signs recently introduced in the MUTCD related to motorcycles.

- Encourage riders to wear highly-visible apparel and helmets, as well as riding with headlights on and consider using modulating headlamps for added visibility for other road users.
- Review crash reports where motorcyclists were involved to determine alcohol usage, animal crashes, visibility deficiencies, etc. where beneficial mitigation could be applied.

For more information, contact the Iowa DOT MVD or TAS. A visit to the FHWA website at safety.fhwa.dot.gov/mac/ also provides good resources and information.

Another excellent reference is NCHRP 17-18, Volume 3, *A Guide for Addressing Collisions Involving Motorcycles*, which is available at safety.transportation.org/htmlguides/addressCollision/default.htm

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Chapter 7: Economic Analysis Procedures

For any civic improvement, it is necessary to analyze the potential benefits for the public and compare those to the expected costs. The historic means of accomplishing an analysis, used by many agencies including the State of Iowa, has been computation of a benefit/cost (B/C) ratio.

Other options for economic analysis are available as well, such as Cost/Effectiveness Analysis, Net Benefit Method, or Incremental B/C Ratio. Each of these are described briefly in this chapter, but most of the emphasis is on the more common benefit/cost analysis used in the State of Iowa.

An economic analysis can be used to determine whether a proposed safety improvement is tenable at the concept stage. A project with a B/C ratio of less than 1.0 would cost more than the resultant benefit of the anticipated improvement. Note that other types of economic analyses could be used to compare between multiple improvements.

A good deal of subjectivity is inherent in benefit/cost computations. To produce valid and tenable results, an agency must assure that subjectivity is minimized to the greatest extent possible. This can be achieved by using industry-accepted crash reduction factors and current severity loss values.

Accurate projected estimates of crashes avoided and reduction in severity of those experienced are key elements in the anticipated benefits of safety improvements. Equally important is a precise and complete evaluation of countermeasure costs, including not only construction expenditures, but also those for design, maintenance, and operation of the selected improvement. If applicable, user costs for motorists such as increased delay time and/or out of distance travel are also appropriate to consider.

Use of Iowa DOT Benefit/Cost Computation Resource

Instructions and forms for completing an application for Traffic Safety Funds (TSF) are included on the TAS website at www.iowadot.gov/tsip.htm.

TAS also maintains a partially automated benefit-cost spreadsheet as part of its Traffic Safety Improvement Program (TSIP), which is used by applicants for Traffic Safety Funds, but can also be employed to evaluate other safety projects. This spreadsheet tool is also available at www.iowadot.gov/tsip.htm.

The spreadsheet includes separate worksheets for road segment improvements and site-specific or intersection projects. Also included are instructions for completing the forms, a link to crash reduction factors, a service life estimate for several improvements, and output forms showing yearly costs and benefits.

To complete a benefit/cost analysis for a proposed road section project, open the spreadsheet, read the Instructions, and select the proper worksheet. After completing the general information at the top, the pertinent data needed to calculate the B/C ratio can be added as outlined below.

Under Improvement:

Estimated Improvement Cost may include more than anticipated construction costs. General average costs for most improvements can be obtained from the Iowa DOT or other sources, but some costs may be difficult to quantify at the concept stage, especially those impacting the public such as delay or detour expenses.

Right of way costs should also be included. Any salvage value can be deducted from total project cost. For Traffic Safety Improvement Program (TSIP) applications, the final cost used should be the lesser of the amount of safety funds being requested, the cost of the project, or $500,000. Costs also cannot include engineering, design, or construction inspection for these applications.

Estimated Improvement Life values for many countermeasures can be found on the TAS web site, in this manual, or other sources. If a difference exists, use the time period over which the selected countermeasure is expected to reduce crashes, not the predicted life of the total project.

Where countermeasures with unequal service lives are combined in a single project, an overall service life equal to the least common multiple of a combination of those service lives should be used. Another option would be to analyze each countermeasure individually.

Crash Reduction Factor for many common safety related countermeasures can be found at the TAS website link cited above or elsewhere in this manual. (Some analysis procedures use crash modification factors in lieu of crash reduction factors. For a comparative explanation of these two criteria and a conversion formula, refer to Chapter 6: Countermeasures.) Whereas several crash modification factors can simply be multiplied together to obtain a cumulative factor, crash reduction factor combinations require the use of equation 7-1.

$$CRFcom = 1 - [(1\text{-}CRF1) \times (1\text{-}CRF2) \times (1\text{-}CRF3) \ldots] \quad \textbf{(7-1)}$$

where CRF_{com} is the combined crash reduction factor for the project and CRF_1 is the highest value countermeasure crash reduction factor, CRF_2 is the next highest, CFR_3 is the third highest, and so on.

For example, for a project that includes three countermeasures with crash reduction factors of 45, 30, and 25 percent, the combined crash reduction factor for the project would calculate to 71 percent, as shown in equation 7-2.

$$CRFcom = 1 - [(1-0.45) \times (1-.30) \times (1-.25)] \text{ or } 1 - [.55 \times .70 \times .75] \text{ or } 1 - .29 \text{ or } 71\% \quad \textbf{(7-2)}$$

The Office of Local Systems at the Iowa DOT describes a procedure in Instructional Memorandum (I.M.) 3.216 that yields the same results and is available at www.iowadot.gov/local_systems/publications/county_im/im_3_216.pdf.

For a more precise analysis, crash reduction factors for each crash severity type may be used if that information is available. References that explain this process include the SEMCOG *Traffic Safety Manual* and Missouri's HAL system. If CRFs by severity are not available, average reduction factors for the selected countermeasure should be used.

Other Annual Costs include the difference between operating and maintenance costs before and after the improvement is made. If a reduction is expected, a negative figure should be entered.

For countermeasures with a shorter life than the complete project, such as pavement markings, periodic replacement should be included in the annual cost. Some improvements, such as signs, have very minimal operating and maintenance costs; whereas, traffic signals may have annual costs approximating $2,500. (Applications to the Iowa DOT for Traffic Safety Funds should not include annual costs because those costs will need to be paid by the local agency.)

Under Traffic Volume Data:

The next value to determine is *Average Annual Daily Vehicle Miles* or average annual daily traffic (AADT). Traffic volumes do not affect the benefit-cost analysis, but are included in the spreadsheet for documentation and to calculate a crash rate for the site.

Although the volume of traffic does not influence the B/C calculation, the percent growth and service life of the project are used to project past crash history into the future. The Iowa DOT maintains records of AADT for all roads in the state. However, it is up to the analyst to determine the annual growth over the life of the project. For roads in Iowa, a two percent growth rate is generally accepted.

Note that these calculations are incorporated into the spreadsheet and not included this manual.

Under Crash Data:

Care should be taken when selecting the time period for the crash history to ascertain that sufficient years are included to provide a representative trend, without including a time when conditions were different from present day.

For most projects, the most recent five years of crash history is suggested, with up to 10 years of data recommended if the traffic volumes are lower, and fewer years needed if the volumes are higher. Enter the numbers of crashes by severity, as well as the frequency and total value of each injury severity using the crash loss values in Table 7.1. From these data, the loss per crash and crash rate can be computed for the project. Be sure to ascertain with the DOT that the severity loss figures are still accurate before using.

Table 7.1. Loss values by crash severity*

Severity	Cost per Injury
Fatality**	$3,500,000
Major Injury	$240,000
Minor Injury	$48,000
Possible Injury	$25,000
Property Damage Only	Actual if available, or $2,700 per crash

* Values are updated periodically, so be sure to use the most current ones.
** For Traffic Safety Funds (TSF) applications, the first fatality at any site is valued as a major injury to reduce the likelihood that a single, rare fatal crash at an otherwise safe location will unduly have an impact on the B/C analysis.

Calculation of Benefit/Cost Ratio:

Benefit (BEN) for road segments is determined by relating the crash costs, crashes avoided, crash rate, discount rate, and projected traffic growth as shown in equation 7-3.

$$BEN = \frac{AVCR \times AAR}{(INT - G)}\left(1 - \left(\frac{1+G}{1+INT}\right)^{Y}\right) \quad \textbf{(7-3)}$$

where AVCR is average cost per crash, AAR is crashes avoided first year, INT is the discount rate, G is the projected traffic growth, and Y is estimated service life..

The benefit equation for spot locations or intersections is similar, as shown in equation 7-4.

$$BEN = \frac{AVC \times AAR}{(INT - G)}\left(1 - \left(\frac{1+G}{1+INT}\right)^{Y}\right) \quad \textbf{(7-4)}$$

where AVC is average cost per crash, AAR is crashes avoided first year, INT is the discount rate, G is the projected traffic growth, and Y is estimated service life.

If the computed B/C ratio appears to be low (i.e., below 1.0) for any particular safety improvement, additional considerations may be advisable:

- Comparison of project crash rate to statewide average for similar roadways
- Whether the type of crashes experienced are properly addressed by the selected improvement
- Severity of crashes experienced
- Countermeasure cost compared to entire project cost
- Potential environmental and social effects of the countermeasure
- Whether any other, lower-cost improvements might be effective

Other Economic Analysis Procedures

If traffic safety funding from the Iowa DOT is not sought, other options for assessing the value of proposed safety improvements or for comparing alternatives could be employed, including the Net Benefit Method, Incremental B/C Method, and Cost Effectiveness Analysis.

Net Benefit Method

The Net Benefit Method compares the difference between the equivalent uniform annual benefits with the equivalent uniform annual costs. Using this method, countermeasure alternatives can be ranked in descending order to determine a priority of action, with the most favorable option having the highest net benefit.

The Net Benefit Method tends to identify higher cost improvements, which could limit the number of projects an agency could undertake. In contrast, the Benefit/Cost Ratio Method described in more depth earlier somewhat favors lower-cost projects. (While such improvements may provide high benefits for tax dollars expended, admittedly, many times low-cost options do not provide long term reductions in crashes at a given location.) Sometimes a higher cost, but lower B/C ratio option will result in safer conditions over a longer period of time.

Incremental B/C Method

The Incremental B/C Method can offer an alternate analysis that compromises the disadvantages observed with the Benefit/Cost Ratio and Net Benefit methods. Incremental B/C allows project or countermeasure selection to be made based on whether additional increments of cost are justified.

This method can also be used to determine the optimal level of expenditure for a specific location, given several alternatives. To employ this method, alternatives having a B/C ratio exceeding 1.0 are listed by increasing cost, beginning with the least costly.

Then, for each ascending cost option, the increased anticipated benefit is divided by the increased cost, resulting in the incremental B/C ratio for each alternative.

The method will then identify the most economically attractive countermeasure, or the most costly option that exhibits additional benefits higher than the additional costs. More information about this analysis method can be found in the SEMCOG *Traffic Safety Manual* and the 1986 FHWA *Local Highway Safety Improvement Program User's Guide.*

As noted, a benefit-cost analysis can be quite laborious, depending on the level of accuracy and degree of confidence desired by the analyst. In addition, a certain degree of subjectivity is encountered in such values as crash severity losses and crash reduction factors. These values have been modified continuously over time as inflationary effects and research efforts have improved knowledge of contributing factors.

Cost Effectiveness Analysis

One analysis technique does not require the use of crash cost data. Cost Effectiveness Analysis (CEA) can be used to compare competing alternatives by considering the outcome in terms of investment. For example, the effectiveness of various countermeasures can be expressed in terms of the number of crashes reduced per dollar of cost.

The CEA process is most useful in analyzing projects where improved safety is the most prevalent result. Where significant traffic congestion and operational benefits are also achieved, CEA may not be an appropriate measure of comparison.

For More Information

For more information about Cost Effectiveness Analysis, please refer to the NCRHP Report 440 and NCHRP Report 500 Appendices. A comparison of benefit-cost ratio and cost per crash eliminated can be found in Appendix J of the 1987 TRB Special Report 214, *Designing Safer Roads Practices for Resurfacing, Restoration, and Rehabilitation*.

Chapter 8: Funding for Safety Improvement Projects

Overview

After crash histories have been analyzed and safety deficiencies noted, funding for needed improvements must be identified. Local agencies, in particular, must deal with limited construction budgets and prioritization of needs as necessary.

Current design standards include requirements for incorporating minimum safety measures into all Federal or state funding assisted projects. These safety improvements are part of the total project costs and thus require no specific or dedicated funding.

Rehabilitation, restoration, and resurfacing projects, commonly known as 3R projects, also require adherence to prescribed design standards if Federal or state funding is sought, albeit lower standards than those for new construction. With proper justification, additional safety improvements can be incorporated into these improvements and accomplished with 3R project funding.

Specific Funding Programs Administered by the Iowa DOT

Several explicit funding sources are available for needed safety improvements through the Iowa DOT. A few of the most common traffic safety funding sources are listed briefly below.

County-State Traffic Engineering Program (C-STEP)

C-STEP is for traffic operation and safety improvements with primary (state-owned) road involvement outside of incorporated cities. A maximum of $200,000 per project is allowed. Either spot locations like intersections with a county road or linear improvements are eligible.

Urban-State Traffic Engineering Program (U-STEP)

Any Iowa city is eligible to participate in this program, which addresses operational and safety improvements on primary roads within those cities. A $200,000 limit for spot locations and a $400,000 maximum for linear improvements are stipulated and a local match is required.

Traffic Engineering Assistance Program (TEAP)

TEAP provides traffic engineers with technical expertise for traffic studies. Common services offered include analysis of intersection conflicts, traffic delays, obsolete traffic control devices, and other issues. No local match is required for these studies, but any actual improvements must be funded from other sources.

Traffic Safety Improvement Program (TSIP or TSF)

Funds are available to cities, counties, or the Iowa DOT in three categories:

- Site-Specific Improvements at sites with identified traffic safety or operation deficiencies. Site specific funding cannot exceed $500,000 per project.
- Traffic Control Devices, including purchase of materials to replace obsolete traffic control devices.
- Safety Studies, which includes research, studies, and educational efforts; also with a maximum annual funding of $500,000.

For more information on this program, consult the Iowa DOT TAS web site at www.iowadot.gov/tsip.htm

High Risk Rural Roads (HRRR) Program

The HRRR Program is Federally-funded and supports safety improvements on low-volume rural roads that meet certain criteria regarding safety. Candidates must be on rural roads classified functionally as a major or minor collector or local road and have a fatal and major injury rate above the statewide average for those functional classes or be likely to experience a traffic volume increase that could result in crash rates above that average. Maximum funding per project is $500,000 and several Federal requirements must be met. More information about this program can be obtained from the Iowa DOT Office of Local Systems at www.iowadot.gov/local_systems/programs/hrrr.htm

Safe Routes to School (SRTS) Program

SRTS is another Federal program that provides funds for infrastructure or non-infrastructure projects for any state, local, or regional agencies to encourage more and safer walking and biking to school by kindergarten through eighth-grade students. No local match is required, but certain maintenance requirements may apply. Applications are available at www.iowadot.gov/saferoutes.

For More Information

A detailed description of these and many other funding sources is available in the Iowa DOT *Guide to Transportation Funding Projects,* which can be accessed at www.iowadot.gov/pol_leg_services/Funding-Guide.pdf.

Chapter 9: Crash Analysis Software in Iowa

Three crash analysis software programs have been developed and are available for use in Iowa. All three, together with data and training, are available free of cost to any public agency, consultant, researcher, and others in the state. These programs are described briefly in this chapter. For more detailed information and/or to schedule training, refer to the Office of Traffic and Safety website at www.iowadot.gov/crashanalysis/index.htm.

Two closely-related software analysis programs, the Crash Mapping Analysis Tool (CMAT) and Incident Mapping Analysis Tool (IMAT), were developed in Iowa and are described in more detail in this chapter.

Both CMAT and IMAT are derived from the Location Tool, which is used to locate incidents in the Traffic and Criminal Software (TraCS), a data collection software tool also known as "the National Model."

Charts, filters, and reports were added to the Location Tool to create CMAT, which includes only crashes in the dataset. CMAT code was later used to create IMAT, which includes four datasets in addition to crash data. The Mobile Accident Reporting System (MARS) also includes these datasets: crime (Compliant Incident Report Form/CIRF), citations (Electronic Citation COmponent/ECCO), operating while impaired (Mobile Operating While Intoxicated/MOWI), and commercial vehicle inspection (Vehicle Services Inspection System/VSIS). With a greater variety of datasets, additional filters and charts were added to IMAT.

Crash Mapping Analysis Tool (CMAT)

CMAT is an easy-to-use program that features access to Iowa's crash data through a GIS interface. This program was developed at CTRE (now InTrans) under the direction of TAS at the Iowa DOT.

The most current version of CMAT in use is version 3.7.0, which was released in 2011. The features of this package include the most recent 10 years of crash data, crash stacking capability, a crash information tool, several summary report options including major cause, driver information, and time summaries, and roadway speed limits and traffic volumes. (Version 4.5.1 is set to be released in first quarter 2012.)

Free half-day training on the use of CMAT can currently be scheduled with Robert Schultz, Iowa DOT trainer, at rlspc@schultzgroup.org. To obtain a copy of the software and loaded crash data, contact the Office of TAS at www.iowadot.gov/crashanalysis/data.htm.

Examples showing some CMAT features are included in Figures 9.1 through 9.4.

Iowa Department of Transportation

Major Cause Summary

2001-2004

Analysis Years: 2001 [12], 2002 [11], 2003 [7], 2004 [21]

Crash Summary:

Fatal	-
Major Injury	2
Minor Injury	12
Possible/Unknown	10
PDO	27
Total Crashes	51

Injury Summary:

Fatal	-
Major Injury	3
Minor Injury	14
Possible	13
Unknown	1
Total Injuries	31

Surface Condition Summary:

Dry	39
Wet	2
Ice	1
Snow	3
Slush	-
Sand/Dirt/Oil/Gravel	-
Water	-
Other	-
Unknown	1
Not Reported	5
Total Crashes	51

TOT Property Damage: $274,493

AVG Property Damage: $5,382

Major Cause Summary:

2	Animal
6	Ran Traffic Signal
	Ran Stop Sign
	Crossed Centerline
1	FTYROW: At Uncontrolled Intersection
3	FTYROW: Making Right Turn on Red Signal
2	FTYROW: From Stop Sign
	FTYROW: From Yield Sign
13	FTYROW: Making Left Turn
1	FTYROW: From Driveway
	FTYROW: From Parked Position
	FTYROW: To Pedestrian
	FTYROW: Other (explain in narrative)
	Traveling Wrong Way or on Wrong Side of Rd
2	Driving Too Fast for Conditions
	Exceeded Authorized Speed
1	Made Improper Turn
	Improper Lane Change
4	Followed Too Close
	Disregarded Railroad Signal
	Disregarded Warning Sign
	Operating Vehicle in Reckless/Aggressive Manner
	Improper Backing
	Illegally Parked/Unattended
1	Swerving/Evasive Action
	Over-Correcting/Over-Steering
	Downhill Runaway
	Equipment Failure
	Separation of Units
	Ran Off Road - Right
	Ran Off Road - Straight
	Ran Off Road - Left
2	Lost Control
	Inattentive/Distracted By: Passenger
1	Inattentive/Distracted By: Use of Phone or Other
1	Inattentive/Distracted By: Fallen Object
	Inattentive/Distracted By: Fatigued/Asleep
1	Other (explain in narrative): Vision Obstructed
	Oversized Load/ Oversized Vehicle
	Cargo/Equipment Loss or Shift
4	Other (explain in narrative): Other Improper Action
4	Unknown
1	Other (explain in narrative): No Improper Action
	Not Reported

Selection Filter:

None

Figure 9.1. Sample CMAT major cause summary report

Iowa Department of Transportation

Driver and Time Summary

Crash Time of Day Summary:

From / To	00:00 01:59	02:00 03:59	04:00 05:59	06:00 07:59	08:00 09:59	10:00 11:59	12:00 13:59	14:00 15:59	16:00 17:59	18:00 19:59	20:00 21:59	22:00 23:59	NR	Total	%
SUN	-	-	-	-	-	-	-	-	-	-	-	-	-		
MON	-	-	-	-	1	1	2	-	-	-	-	-	-	4	11
TUE	-	-	-	-	-	-	1	3	2	1	-	-	-	7	19
WED	-	-	-	-	-	-	2	-	-	-	-	-	-	2	6
THU	-	-	-	-	-	-	2	1	1	-	1	-	-	5	14
FRI	-	-	-	-	-	1	3	3	2	1	1	-	-	11	31
SAT	-	-	-	-	-	-	2	1	1	1	2	-	-	7	19
Tot.					1	2	12	8	6	3	4			36	
%					3	6	33	22	17	8	11				100

Driver Age/Gender Summary:

Age	Male	Female	NR	Drivers	%
<14	-	-	-		
14	-	-	-		
15	-	1	-	1	1
16	1	2	-	3	4
17	2	4	-	6	8
18	1	3	-	4	5
19	1	1	-	2	3
20	1	1	-	2	3
21 to 24	4	1	-	5	7
25 to 29	-	3	-	3	4
30 to 34	2	1	-	3	4
35 to 39	3	1	-	4	5
40 to 44	7	2	-	9	12
45 to 49	5	1	-	6	8
50 to 54	3	2	-	5	7
55 to 59	-	2	-	2	3
60 to 64	-	2	-	2	3
65 to 69	2	2	-	4	5
70 to 74	4	2	-	6	8
75 to 79	3	1	-	4	5
80 to 84	1	-	-	1	1
85 to 89	-	1	-	1	1
90 to 94	-	-	-		
95 plus	-	-	-		
NR	-	-	1	1	1
Drivers	40	33	1	74	
%	54	45	1		100

Drug/Alcohol Summary:

	Total	%
Drug		
Alcohol, Less than Statutory		
Alcohol, Statutory		
Drug/Alcohol, Less than Statutory		
Drug/Alcohol, Statutory		
Refused		
Under Influence of Alc/Drugs/Meds		
None Indicated	36	100
Total Crashes	36	100

Fixed Object Struck Summary:

	Vehs.	%
Bridge/Bridge rail/Overpass		
Underpass/Structure Support		
Culvert		
Ditch/Embankment		
Curb/Island/Raised Median		
Guardrail		
Concrete Barrier		
Tree		
Pole - Utility/Light/Etc	1	1
Sign Post		
Mailbox		
Impact Attenuator		
Other Fixed Object		
None	73	99
Total Vehicles	74	100

Selection Filter:

None

Analyst:

Notes:

11/3/2006 Crash Mapping Analysis Tool 3.6.0 Page: 1 of 1

Figure 9.2. Sample CMAT driver and time summary report

Figure 9.3. Sample CMAT crash stacking map

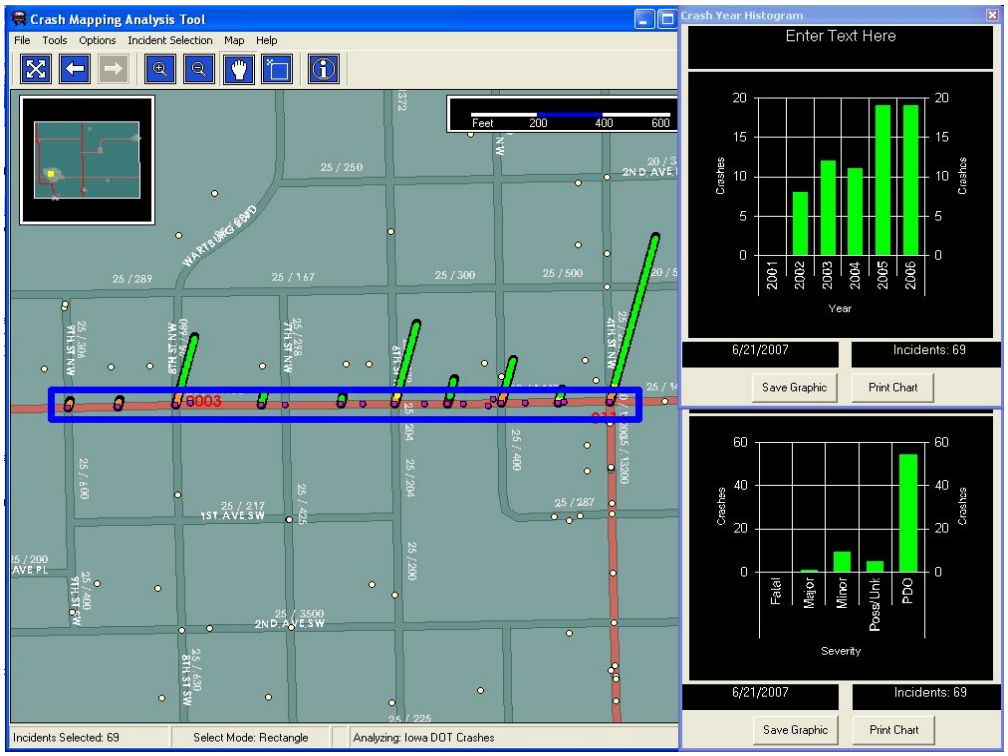

Figure 9.4. Sample CMAT crash summaries along a corridor

Incident Mapping Analysts Tool (IMAT)

The IMAT software program, which is intended for use primarily by law enforcement, works with other software to provide a visual representation of traffic-related data on a map. The additional software programs include TraCS, which provides the functionality necessary to record and retrieve any crash or incident data from a remote location, significantly reducing paperwork and administrative duties for law officers.

The Incident Location Tool (ILT) was designed to allow officers to designate the location of crashes and incidents on a map. This tool can be used in conjunction with TraCS or alone. Use of this tool by officers while investigating crashes reduces the amount of work needed during crash investigations in locating crashes and improves accuracy of data collected. In Iowa, the IMAT tool is distributed to law enforcement agencies that use the TraCS data collection software.

CMAT and IMAT have some similarities and differences. CMAT is distributed to any agency that requests a copy. Because of licensing restrictions, access to IMAT is much more limited, and only the law enforcement agencies that generate a large volume of citations, crashes, criminal activities, etc. are eligible to receive IMAT.

Another difference between CMAT and IMAT is the source of data. CMAT relies on the statewide crash database, maintained by the Iowa DOT. IMAT uses the local agency TraCS database of locally-collected data for real-time analysis.

More information describing these software programs in more detail can be found at www.tracsinfo.us/.

Using IMAT

The analysis procedure for IMAT is much the same as for CMAT. The user has a choice between four manual selection tools (point/circle selection, rectangle, polygon, or route segment) and 10 menu selection tools (City, County, Crash – Agency Case Number, Intersection-Road/Rail, Intersection-Road/River, Intersection-Road/Road, Map Coordinate, Mile Post, Node, Township).

After making a selection using one of the tools, locations appear on a map (see Figure 9.5) showing the incidents in the selected area.

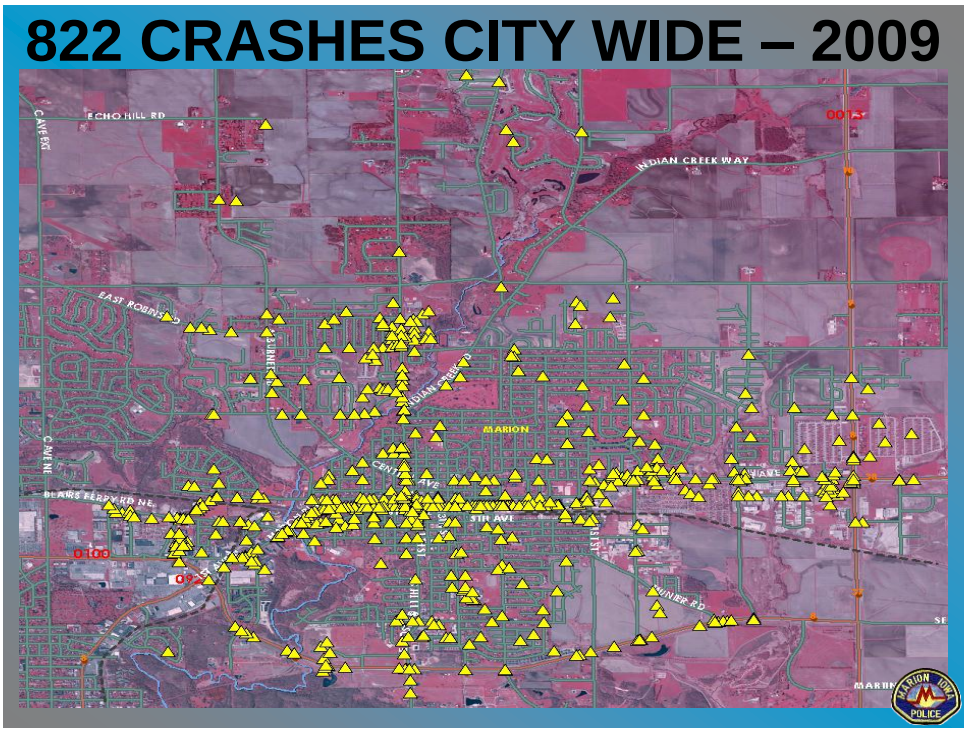

Figure 9.5. Sample IMAT crash location map

From here, the user either uses the map as a report, creates a vertical bar chart, or uses the filters to refine the search before creating another map or creating a chart.

Maps and charts can be inserted into PowerPoint slides for presentations or copied to Microsoft Word documents to serve as graphics for more-detailed narrative style reports.

Maps and charts can also be saved as individual files in folders labeled with either a case number or a project name and saved as archives or used for a variety of meetings and presentations.

Examples showing some IMAT features are included in Figures 9.5 through 9.8.

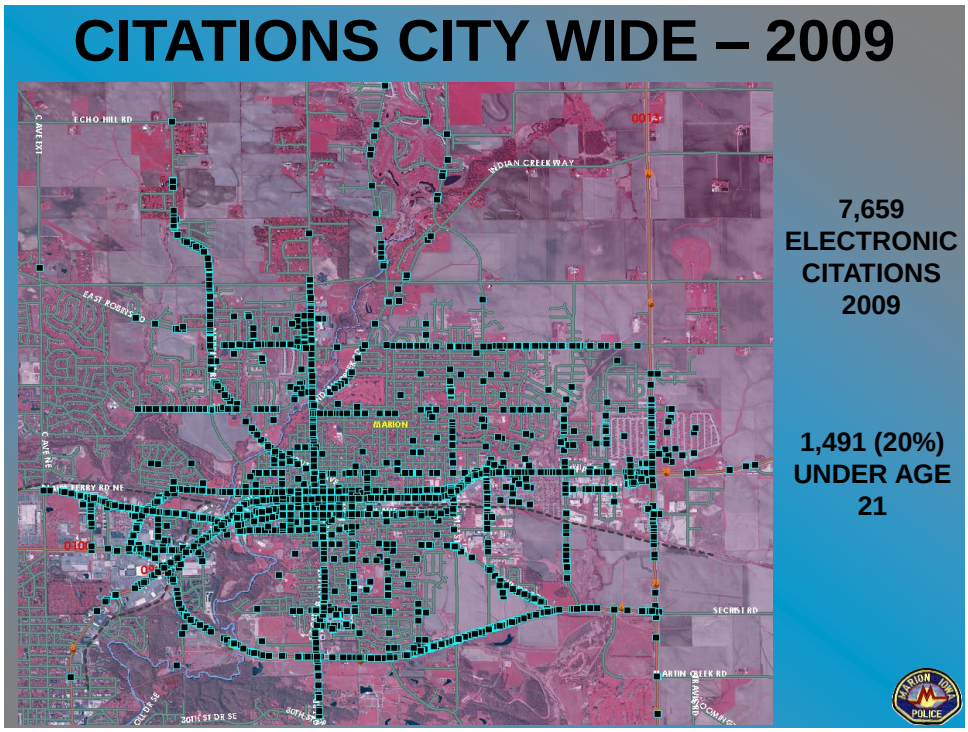

Figure 9.6. Sample IMAT citation location map

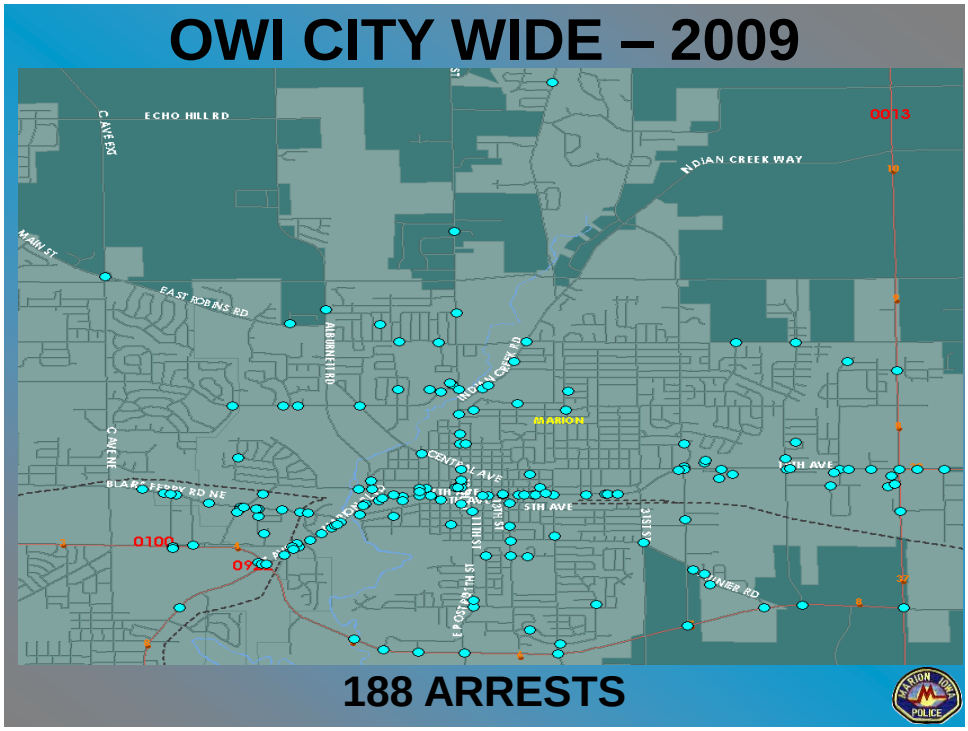

Figure 9.7. Sample IMAT operating while intoxicated location map

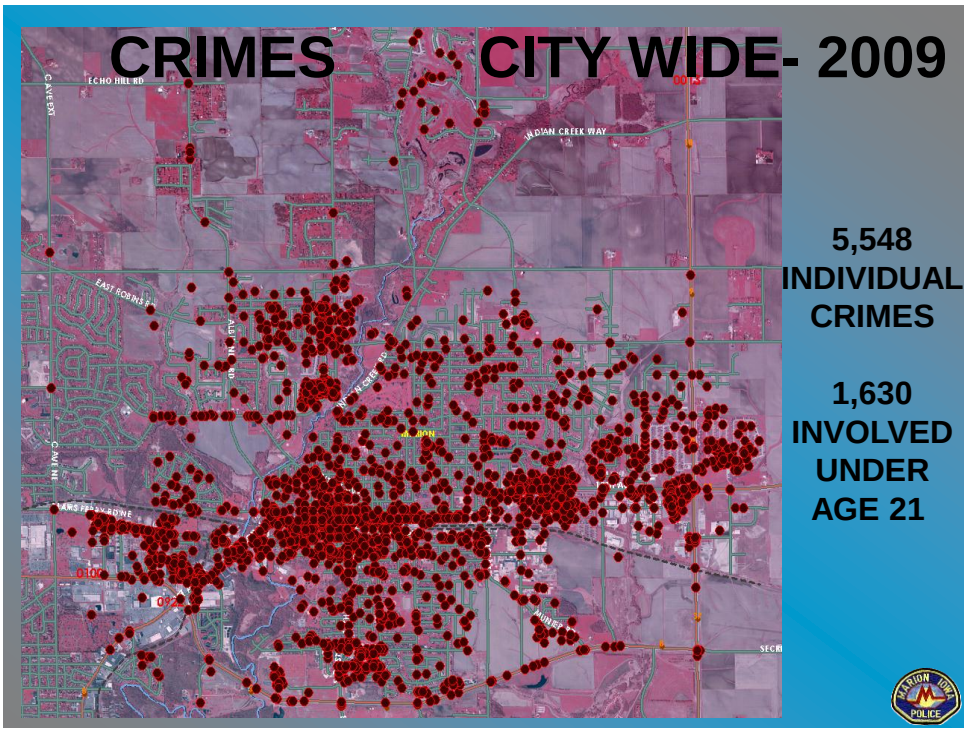

Figure 9.8. Sample IMAT crime location map

Safety Analysis, Visualization, and Exploration Resource (SAVER)

SAVER is a robust analysis program primarily designed to permit in-depth safety analysis, but also to provide additional information such as roadway, rail, river, and corporate limit data that can be quite useful for analysis purposes (see Figure 9.9).

SAVER also has the ability to read certain data from the National Model/TraCS such as traffic citations, crime incidents, and operating while intoxicated.

More detailed information about SAVER can be obtained at www.iowadot.gov/crashanalysis/savermain.htm.

The website features downloads, informational handouts, and presentations about SAVER, as well as a training guide, manual, and formats.

To obtain a copy of SAVER and/or training, contact Michael Pawlovich with TAS at Michael.Pawlovich@dot.iowa.gov.

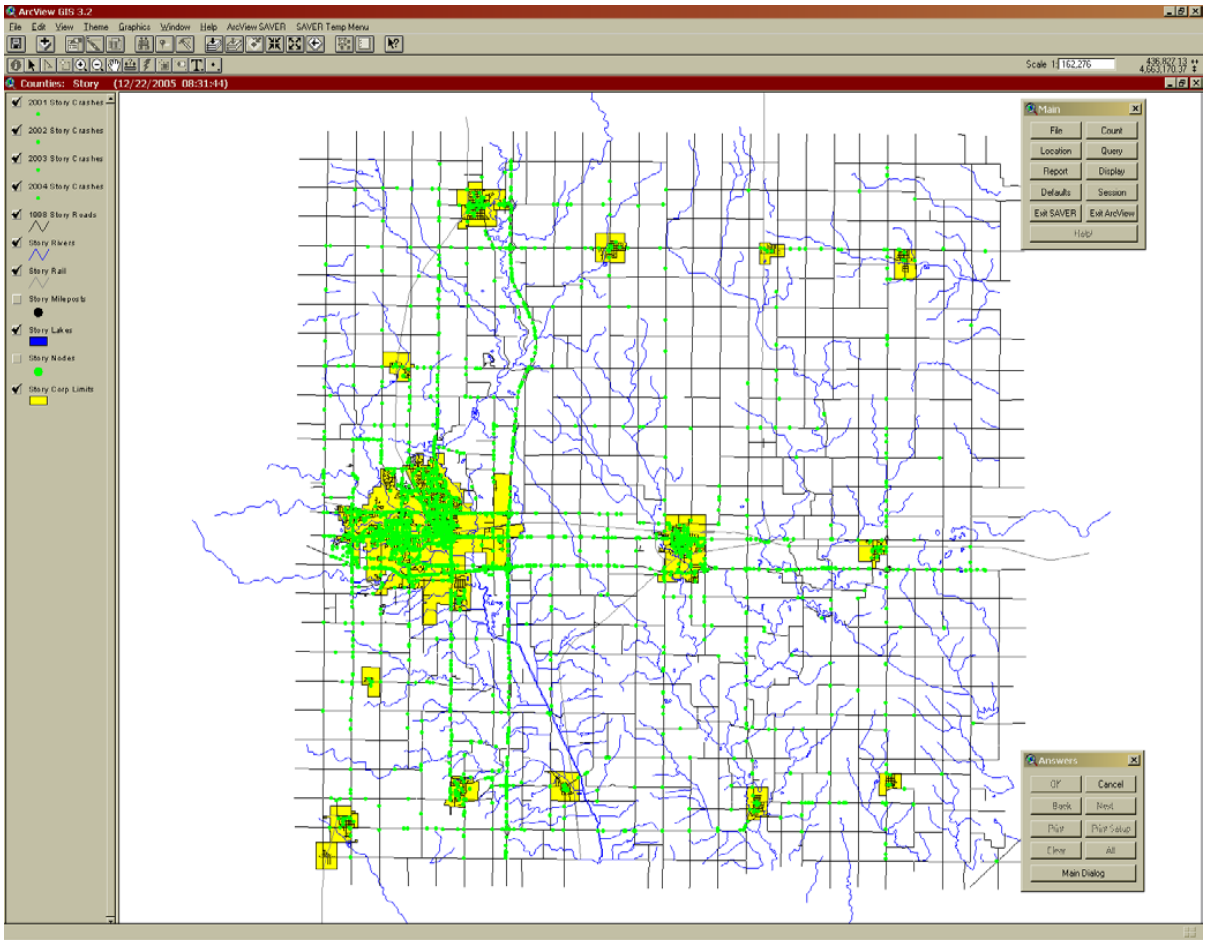

Figure 9.9. Sample SAVER crash map

Glossary of Traffic Safety Analysis Terms

This glossary is a handy reference to common traffic safety analysis terms. Most of the terms are used in this manual, but you'll find definitions of other terms here as well. Many of these definitions were adapted from various other sources.

85th Percentile Speed – The speed at or below which 85 percent of motorists drive on a given road or street under free flow conditions.

Average Daily Traffic (ADT) – The average 24 hour traffic volume or the total traffic volume during a stated period divided by the number of days in that period. Unless specifically stated, the period is usually one year. ADT corrects for seasonal changes in traffic by using a year-round average.

Benefit/Cost (B/C) Ratio – When used in conjunction with safety improvements, the annual economic value of the reduction in fatalities, injuries, and property damage; divided by the annual costs of the crash-reducing countermeasures.

Clear Zone – The total roadside border area, starting at the edge of the traveled way, that is available for an errant driver to stop or regain control of a vehicle. Also, the distance from the edge of the travel way to the nearest roadside hazard. This area might consist of a shoulder, a recoverable slope, and/or a non-recoverable, traversable slope with a clear run out area at its toe. The width of desirable clear zone is calculated based on vehicle speeds, traffic volume, roadside slope, and roadway curvature.

Collision Diagram – A schematic showing the direction of vehicle travel prior to a crash, the type and severity of crash, and any vehicle or pedestrians whose presence might have contributed to the crash. Collision diagrams are not generally drawn to scale, but represent the approximate crash location. Collision diagrams can be prepared for intersections or locations between intersections.

Condition Diagram – A scaled drawing of the important physical condition of a roadway location or section and the surrounding features. It is used in conjunction with a collision diagram as an aid in interpreting crash patterns and to relate those patterns to the roadway and operating factors.

Corner Angle – The included angle between two intersecting roads or a road and driveway. Preferably between 75 and 105 degrees for safest operation, with 90 degrees best.

Correctible Crashes – Crashes that could be reduced by means of a feasible safety related countermeasure at the study site.

Cost Effectiveness Analysis – A technique for assessing the relative value of various strategies by comparing the cost per unit of desired outcome, such as dollars expended per crash saved.

Countermeasure (Improvement) – A physical or operational measure designed to reduce the severity and/or frequency of traffic crashes.

Countermeasure Analysis – A procedure to determine the best countermeasure from a group of alternatives using economic considerations.

Crash (Traffic Crash) – An unplanned event that results in the occurrence of a fatality, injury, or property damage.

Crash Rate – The number of crashes that occur during a specified period of time divided by a measure of the extent of vehicular exposure over that same period; for intersections, expressed as crashes per million entering vehicles (MEV); for sections between intersections, expressed as crashes per 100 million vehicle miles traveled (HM VMT) on that section.

Crash Reduction Factors – Estimates of the percent of crash reduction likely to be experienced due to adopting a countermeasure; derived from previously-observed and documented crash reductions on other safety improvement projects.

Crash Severity – A measure of the seriousness of a crash or all crashes at a roadway location. Crash severity is usually expressed in terms of number of fatalities, injuries, or property damage crashes.

Crash Type – Classification of the specific crash occurrence as related to the general movements of the involved vehicle(s). Examples of crash types are right angle, rear end, head on, and fixed object.

Critical Slope – A slope parallel to the road that is steeper than 3:1. A vehicle passing over a critical slope has a high probability of rolling over.

Decision Sight Distance – The distance required for a driver to recognize unexpected information or a condition in the roadway or surroundings, recognize the condition or threat, select an appropriate speed and path, and complete an avoidance maneuver safely and efficiently.

Design Speed – The maximum safe speed that can be maintained over a specified section of roadway when conditions are so favorable that design features of the roadway govern.

Early Warning Analysis – A procedure to identify high crash locations using only three to six months of crash data.

Economic Analysis – Determination of the cost effectiveness or B/C ratio of a project by comparing the benefits derived to the costs incurred.

Engineering Judgment – The evaluation of available pertinent information, and the application of appropriate principles, standards, guidance, and practices for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device or other improvement. Engineering judgment shall be exercised by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. Documentation of engineering judgment is not required.

Engineering Study – The comprehensive analysis and evaluation of available pertinent information, and the application of appropriate principles, standards, guidance, and practices for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device or other improvement. An engineering study shall be performed by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. An engineering study shall be documented.

Equivalent Property Damage Only (EPDO) Number – A weighted crash number giving fatal and injury crashes more importance than property damage only crashes.

Expectancy – How drivers view the road or street ahead, based on past experience or similar situations.

Exposure – A measure of the frequency that vehicles are exposed to collisions; for intersections the unit is million entering vehicles, for sections between intersections, the unit is 100 million vehicle miles traveled.

Fatal Crash – A crash event involving at least one fatality.

Fatal Crash Rate – The number of fatal crashes per 100 million vehicle miles of travel (HM VMT).

Fatality – The death of any person resulting from injuries received in a traffic crash within 30 days of the crash.

Fatality Rate – The number of fatalities per 100 million vehicle miles of travel (HM VMT).

First Harmful Event – The initial event during a traffic crash that causes an injury (fatal or nonfatal) or property damage.

Fixed Object – A roadside object such as a tree, pole, structure, etc., of sufficient mass to cause severe personal or property damage if impacted.

Functional Class – A manner of classifying roads and streets on a priority basis according to role played in transportation network; i.e. local, collector, arterial, freeway.

Geometry or Geometrics – Collective terms for roadway physical features such as alignment, curves, etc.

Injury – Any bodily harm received by a person from a traffic crash.

Intersection – The area embraced within the prolongation or connection of the internal curb lines, or, if the internal boundary lines of the roadways or two roadways that join one another at, or approximately at, right angles, or the area within which vehicles traveling on different roadways that join at any other angle might come into conflict. The junction of an alley or driveway with a roadway is not generally considered to be an intersection.

Intersection-Related Crash – A crash that occurs as a result of the traffic operation of an intersection.

Jurisdiction - A Federal, State, regional, local or tribal government having legal authority.

Location Analysis – A procedure involving study and analysis of a high crash location to determine appropriate countermeasures to reduce crash experience at that location.

Low-Volume Road or Street – Generally a facility with a traffic volume less than 400 vehicles per day.

Metropolitan Planning Organization - A planning agency responsible for an urbanized area with a population of 50,000 or more.

Mid-Block Crash – A crash that is not related to any operations or events occurring at an intersection.

Non-Correctible Crash – Crashes of a random nature that are not usually amenable to correction by a countermeasure.

Opportunity Cost – The other choices that must be given up when selecting one alternative over others (or what could have been done instead).

Pace (10 mph Pace) – The 10 mph range of traffic speeds containing the largest number of vehicle observations during a spot speed study.

Platoon – A group of vehicles or pedestrians traveling together as a group, either voluntarily or involuntarily, because of traffic signal controls, geometrics, or other factors.

Property Damage Only (PDO) Crash – A crash involving damage to one or more vehicles or other property, but no injuries or fatalities.

Recoverable Slope – A slope adjacent to the roadway that is flatter than 4:1, which would permit an errant vehicle driver to regain control.

Regional Planning Affiliation - A planning agency responsible for a mostly rural area, composed of several counties and the smaller cities within that area.

Retroreflective – A property of material that reflects light roughly back to the source rather than an equal but opposite angle.

Road Safety Audit – A formal examination of an existing road or planned project by an independent team of trained specialists. The procedure includes a safety assessment and written report to identify existing or potential safety concerns.

Road User – A vehicle operator, bicyclist, or pedestrian within the highway, including persons with disabilities.

Roadside Hazard – Conditions or objects, generally within the clear zone of a roadway that would present a danger to vehicles leaving the travel way, such as fixed objects or steep slopes.

Salvage Value – Estimated residual worth or value of a project, program, or component at the end of the expected service life.

Service Life – The number of years during which the components of a project or the entire project can be expected to satisfactorily perform an intended function.

Speed – Speed is defined based on the following classifications:

Advisory Speed – a recommended speed for all vehicles operating on a section of highway based on design, operating characteristics, and conditions.

Average Speed – the summation of the instantaneous or spot measured speeds at a specific location divided by the number of vehicles observed.

Design Speed – a selected speed used to determine the various geometric design features of a roadway.

85th Percentile Speed – the speed at or below which 85 percent of the motor vehicles travel.

Operating Speed – a speed at which a typical vehicle or the overall traffic operates. Operating speed might be defined with speed values such as the average, pace, or 85th percentile speeds.

Pace Speed – the highest speed within a specific range of speeds that represents more vehicles than in any other like range of speed. The range of speeds typically used is 10 mph.

Posted Speed – the speed limit determined by law and shown on Speed Limit signs.

Statutory Speed - a speed limit established by legislative action that typically is applicable for highways with specified design, functional, jurisdictional and/or location characteristic and is not necessarily shown on Speed Limit signs.

Spot Speed Study – The measurement of a sample of vehicular speeds at a specific location. Spot speed studies are conducted to determine the speed distribution of all vehicles passing a particular location under the conditions prevailing at the time of the study.

Stopping Sight Distance – The safe sight distance required for a vehicle to stop along a roadway upon the driver sighting an object that will necessitate that action.

Superelevation – Cross sectional banking or slope of roadway surface in a curve.

Tort Liability – A wrongful act resulting in injury to a person or property for which the injured party is entitled to compensation

Traffic – Pedestrians, bicyclists, ridden or herded animals, vehicles, streetcars, and other conveyances either singularly or together while using any roadway for purpose of travel.

Traffic Conflict – A traffic event involving two or more road users, in which one user performs some unusual or unexpected action, such as a change in direction or speed, that places another user in jeopardy of a collision unless an evasive maneuver is undertaken.

Traffic Control Device – A sign, signal, marking, or other device used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, or shared-use path by authority of a public agency having jurisdiction.

Traffic Records System – The personnel, equipment, facilities, information, and procedures necessary to correlate crash data with vehicle, driver, and/or roadway data to identify the causes of traffic crashes and the means of preventing them.

Traffic Study – An investigation to gather information on traffic flow or safety to solve a traffic problem. Studies should be fully documented throughout the process for future reference.

Traveled Way – The portion of the roadway intended for the movement of vehicles, exclusive of the shoulders, berms, sidewalks, and parking lanes.

Traversable Slope – A slope adjacent to the roadway that is steeper than a recoverable slope, but not as steep as a critical slope, generally between 3:1 and 4:1. A vehicle on a traversable slope will likely not overturn but will continue to the bottom of the slope, unable to return to the travel way.

Vehicle Miles – The miles of travel by all types of motor vehicles as determined on the basis of actual traffic counts and/or established estimating procedures.

Warrants – Threshold conditions used to evaluate potential safety and operational benefits of improvements, such as traffic control devices, that are based upon average or normal conditions. Warrants are not a substitute for engineering judgment. The fact that a warrant for a particular traffic control device is met is not conclusive justification for the installation of that device.

Acronyms and Abbreviations

3R	Resurfacing, Restoration, Rehabilitation
100M VMT	100 Million Vehicle Miles Traveled
ABATE	A Brotherhood Aimed Towards Education
ADT	Average Daily Traffic
AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
AMA	American Motorcyclist Association
ATSSA	American Traffic Safety Services Association
B/C	Benefit/Cost
CHSP	Comprehensive Highway Safety Plan
C.I.O.T.	Click It Or Ticket
CIRF	Compliant Incident Report Form
CMAT	Crash Mapping Analysis Tool
CMF	Crash Modification Factor
CTRE	Center for Transportation Research and Education
DEV	Daily Entering Vehicles
DOT	Department of Transportation
EB	Empirical Bayes
ECCO	Electronic Citation COmponent
EPDO	Equivalent Property Damage Only
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
GIMS	Geographic Information Management System
GIS	Geographic Information Systems
GTSB	Governor's Traffic Safety Bureau
GWRRA	Goldwing Road Riders Association
HM VMT	Hundred Million Vehicle Miles Traveled
HSM	Highway Safety Manuel
IHSDM	Interactive Highway Safety Design Model
ILT	Incident Location Tool
IMAT	Incident Mapping and Analysis Tool
InTrans	Institute for Transportation
ISP	Iowa State Patrol
ISU	Iowa State University
ITE	Institute for Transportation Engineers
ITSA	Iowa Traffic Safety Alliance
ITSDS	Iowa Traffic Safety Data Service
LED	Light-Emitting Diode
MARS	Mobile Accident Reporting System
M DEV	Million Daily Entering Vehicles

MDST	Multi-Disciplinary Safety Team
MEV	Million Entering Vehicles
MOWI	Mobile Operating While Intoxicated
MUTCD	Manual on Uniform Traffic Control Devices
MVD	Motor Vehicle Division
M VMT	Million Vehicle Miles Traveled
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NOAA	National Oceanic and Atmospheric Administration
NSC	National Safety Council
ODS	Office of Driver Services
OWI	Operating While Intoxicated
RTOR	Right Turn on Red
ROR	Run Off Road
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act
SAVER	Safety, Analysis, Visualization and Exploration Resource
SEMCOG	Southeast Michigan Council of Governments
SICL	Safety Improvement Candidate Location
SMARTER	Skilled Motorcyclist Association-Responsible, Trained and Educated Riders, Inc.
SMSCC	Safety Management System Coordinating Committee
SPF	Safety Performance Factors
sTEP	special Traffic Enforcement Program
TAS	Traffic and Safety
TEAP	Traffic Engineering Assistance Program
TraCS	Traffic and Criminal Software
TransData	Transportation Data
TRB	Transportation Research Board
TSF	Traffic Safety Funds
TSIP	Traffic Safety Improvement Program
U.S. DOT	US Department of Transportation
vpd	vehicles per day
VSIS	Vehicle Services Inspection System