CHAPTER 16

Improving the Design and Operation of Roadway Intersections

KEY TOPICS

- access management
- conflict points
- data analysis tools
- design improvements
- rural intersections
- urban intersections

GOALS

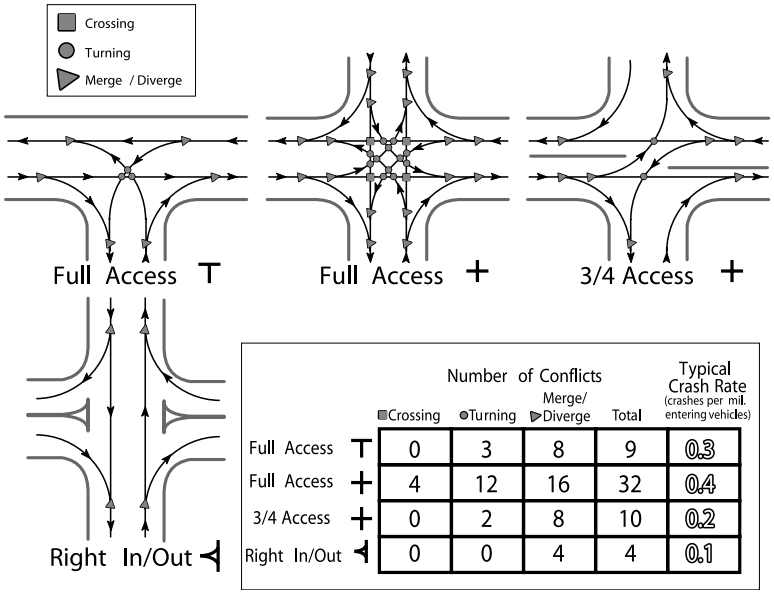
- Reduce the crash rate and the severity of crashes occurring at Iowa intersections.
- Increase consideration for older drivers and pedestrians in the design of intersection improvements.
- Increase funding for the Iowa Traffic Safety Fund (TSF) program.
- Provide additional traffic safety training for state, county, and city engineering staff.

BACKGROUND

From a safety viewpoint, intersections are the most critical element of the road network. By their very nature, at-grade intersections are risky because different road users (vehicles, pedestrians, cyclists) are required to use the same *space*, and a collision is only avoided if they are separated by *time*.

K.W. Ogden, *Safer Roads*

Intersection Conflicts*



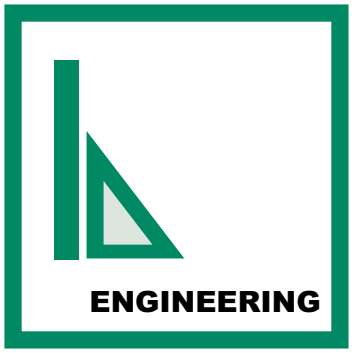
	Number of Conflicts: Crossing	Turning	Merge/Diverge	Total	Typical Crash Rate (crashes per mil. entering vehicles)
Full Access T	0	3	8	9	0.3
Full Access +	4	12	16	32	0.4
3/4 Access +	0	2	8	10	0.2
Right In/Out	0	0	4	4	0.1

*From Minnesota Department of Transportation, *Traffic Safety Fundamentals Handbook*.

Entering or crossing a high-speed multilane highway can be a very complicated maneuver, particularly for young drivers and older drivers. See the figure for the conflict points at different types of intersections.

Intersections constitute a very small part of rural and urban street/highway systems, yet they are implicated in a notable portion of all major motor vehicles accidents. Data from national (Transportation Research Board [TRB], *National Cooperative Highway Research Program [NCHRP] Report 440*) statis-

tics show that the percentage of total motor vehicle accidents classified as intersectional has risen in the past 20 years.



In a major review of road safety measures, TRB reviewed the factors affecting safety at intersections. The main factors include

- Number of legs
- Angle of intersection
- Sight distance
- Alignment
- Auxiliary lanes
- Channelization
- Pavement friction
- Turning radii
- Lighting
- Lane and shoulder widths
- Driveway location
- Type of traffic control
- Approach speed

NATIONWIDE

National Facts

- 55% of all urban vehicle crashes occur at intersections.
- 32% of all rural vehicle crashes occur at intersections.
- Over the past two decades, *urban* intersectional vehicle crashes have increased 14%, while *rural* intersectional vehicle crashes have increased 5%.
- 23% of urban fatal crashes occur at intersections.
- 16% of rural fatal crashes occur at intersections.

National Public Opinion

A 1999 Louis Harris Poll conducted for the Advocates for Highway and Auto Safety reported that 85% of those polled want more attention paid to intersection safety problems.

IOWA

Iowa Facts

In Iowa, about one-third of the fatal crashes, and over half the injury crashes, occur at intersections. Traffic violations at intersections such as failure to yield the right-of-way and running stop signs or signals are among the most predominate crash-related driver errors.

Iowa has one of the highest percentages of older drivers in the country, and the number of older drivers will significantly increase as the baby boomer generation ages. Older drivers as a group have a particularly difficult time entering and crossing intersections.

Iowa's Traffic Safety Programs

Iowa has two specific traffic safety programs that are primarily used to improve safety at high-crash locations. The Hazard Elimination Program (HEP) is a federally funded program that targets intersections ranked among the top 200 high-crash locations in the state. The Iowa Traffic Safety Fund program provides funding to Iowa cities and counties to improve traffic safety. The TSF program is funded from an "off the top" one-half percent of the state road use tax fund.

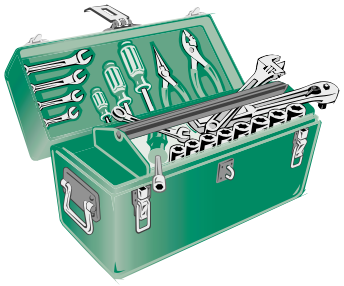
Safety projects funded by these two programs have had a mean crash reduction of 23% and a mean benefit/crash ratio of 6.3% (as found by the *Effectiveness of Roadway Safety Improvements* study conducted by the Center for Transportation Research and Education [CTRE] at Iowa State University).

Iowa Public Opinion

Iowa SMS Public Opinion Survey
The 1999 Iowa Safety Management System (Iowa SMS) *Iowa Strategic Highway Safety Plan* included a number of potential strategies for dealing with these safety issues. The SMS public opinion survey asked over 1,000 Iowans whether they would support these strategies.

- More than half (61%) selected improving the design and operations of intersections for high emphasis over the next five years.

POTENTIAL STRATEGIES



Legislation, Policy, and Enforcement

- Increase the Iowa Traffic Safety Fund program from 1.5% to 1% of the road use tax fund.
- Develop programs to help local communities improve traffic signal equipment and signal timing.
- Provide more traffic safety engineering assistance to local governments through the Iowa Traffic Engineering Assistance Program (TEAP).
- Target more funds on intersections that have the most severe crashes.
- Increase intersection safety studies.

Education and Public Awareness

- Work with local news media to publicize crash-prone intersections and/or locations and predominant driver errors that cause crashes to better inform and draw public attention.
- Develop a resource for local officials and others to use in answering basic highway safety questions (see Successes and Strategies Implemented section in this chapter).
- Conduct local safety campaigns targeting red light running to call attention to this problem and initiate countermeasures to impact the problem.

Design and Technology

- Perform studies for the possible relationship between crash rates and various traffic control designs.
- Evaluate intersection safety improvement countermeasures at new and existing intersections to determine whether new designs and countermeasures are working, and provide Iowa crash data in the determination of crash reduction factors.
- Reduce the number of "fixed objects" (poles, trees, etc.) near and at intersections.
- Improve access control near intersections.
- Optimize signalized intersection timing to smooth traffic flow.
- Construct offset right-turn lanes and/or offset left-turn lanes at selected intersections.
- Identify candidate urban four-lane to three-lane roadway conversion projects.

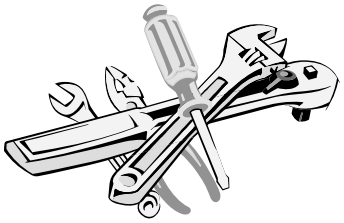
- Develop a program to identify and remove unwarranted signals.
- Increase sign lettering size for street names, directional signing, and advance intersection signing.
- Install traffic signal back plates.
- Install more traffic signals above traffic lanes.
- Complete a study of the most common deficiencies at existing signals.
- Compile before-and-after studies of safety projects to identify benefits of various intersection improvements (see Successes and Strategies Implemented section in this chapter).
- Provide more protected left-turn signal phases.
- Provide dashed pavement lining to guide left-turning vehicles through selected intersections.
- Install roundabouts and traffic circles at appropriate intersections.
- Build more "T" intersections along high-volume expressways.
- Build 100-foot medians at non-full-access-controlled bypass intersections.
- Accommodate full deceleration in turn lanes, especially on expressways.
- Construct more right-turn lanes.
- Install median stop sign, stop bar, and median centerlines in selected expressway medians.
- Increase use of destination lighting at intersections.
- Provide paved shoulders near rural intersections.
- Encourage 90-degree intersection at paved side roads.
- Install larger stop signs with high-intensity reflectivity sheeting.
- Install rumble strips in advance of rural stop signs consistent with driver expectations (see Successes and Strategies Implemented section in this chapter).
- Enhance sight distance at uncontrolled intersections including removal of tall cornrows.
- Provide advance warning of signal changes at rural signalized intersections.
- Study improved signing for expressway median intersections, including use of large arrow pavement markings for lane assignments.
- Remove unwarranted stop signs and signals.
- Decrease signing near and at intersection.
- Improve the quality of pavement markings near and within intersections.

Access Management

Access management is the process of carefully managing motorists' access to properties along highways, roads, and streets that serve as major traffic routes. Access management can have a profound impact on the operation of adjacent intersections. These strategies were included in *Iowa Access Management and Awareness Project Report* (see also Successes and Strategies Implemented section in this chapter):

- Consolidate or close selected driveways to reduce conflicts with turning and entering traffic.
- Move driveways away from corners at major intersections
- Add continuous left-turning lanes to separate turning traffic and through traffic completely.
- Add raised medians near major intersections.
- Add raised medians along selected high-volume urban roadways.
- Restrict more driveways near intersections to right turn in or out only.
- Allow left turns "in" but prohibit left turns "out" at selected access points.

SUCCESSES AND STRATEGIES IMPLEMENTED



- Improved crash data and analysis tools are available or under development. Data and analysis tools including Intersection Magic have been developed and made available to local governments. Intersection Magic is a graphic display and data summary package designed for use in traffic accident analysis of intersections, corridors, and mid-block locations. It is interactive and includes collision diagrams, geographic information systems (GIS) table output, data retrieval, accident summaries, statistical output, and user-specified graphic displays. (See Chapter 25, Improving Information and Decision Support Systems.)
- The Iowa Department of Transportation (Iowa DOT) sponsored a study of traffic safety improvement projects. The *Effectiveness of Roadway Safety Improvements* study (conducted by CTRE) of 94 traffic safety projects concluded that there was a mean crash reduction rate of 23% on these hazard elimination and safety improvement fund projects.
- The *Traffic and Safety Informational Series* is sponsored by the Iowa Department of Transportation Office of Traffic and Safety. The goal of this project was to make available clear, concise, and consistent answers to 25 traffic and safety questions, commonly asked by local officials and the public. The information may be altered, distributed, and used as

seen fit by area officials and/or transportation professionals. It is available in print, on disk, and on the web.

- The Iowa DOT Office of Traffic and Safety is developing the "TAS" manual for highway safety practitioners and engineers at the state and local levels (to be available in print and on the Office of Traffic and Safety web site in 2002).
- The Iowa DOT Office of Traffic and Safety sponsors the annual Traffic and Safety Forum each fall to help city, county, state, and consulting highway safety engineers stay up-to-date on recent developments in highway safety technology and practice.
- The Iowa Traffic Safety Fund program provides funds for cities and counties to improve intersections.
- The Iowa DOT has increased funding for TEAP.
- The Iowa DOT provides cities and counties with a list of candidate safety improvement intersections in their communities.
- The Iowa DOT has identified the expressway intersections that have the highest crash rates and severity and has initiated safety improvements at selected intersections.
- The Iowa DOT is participating in the American Association of State Highway and Transportation Officials (AASHTO) intersection safety improvement pilot studies.
- The Iowa DOT has completed the Iowa Access Management Awareness Project. This is an extensive study of access management policies, practices, and results. The findings, the *Access Management Toolkit* for answering frequently asked questions, and the *Access Management Handbook* for roadway designers provide excellent public awareness and education tools for Iowa engineers.
- High-accident, four-lane, undivided, urban corridors have been identified, and safety studies have been initiated.
- The Iowa DOT chartered the Rural Expressway At-Grade Intersections Team to study design and safety elements and present conditions. Goals included accommodation for increasing truck traffic and older drivers.
- The Iowa DOT has completed a study of paved shoulder benefits and costs on rural freeways, expressways, and Super 2 highway corridors in Iowa.
- The Iowa DOT's rumble strip use policy is under review and appropriate installations are currently planned.

NOTE

The potential strategies in this chapter do not represent specific recommendations of the Iowa SMS Coordination Committee or any agency, group, or individual represented in Iowa SMS. The strategies represent a range of alternatives for legislators, department or agency directors, local governments, and citizen groups to consider when they elect to address a specific highway safety concern.

This toolbox is a living document that will continue to provide information, direction, and ideas for highway safety decision makers. Any strategies selected for implementation by Iowa SMS or any other entity will require further development through identifying potential partners, entities impacted, potential funding, steps for implementation, evaluation, and other pertinent tasks.

RESOURCES

Information in this chapter is drawn from many individuals and sources. Known sources are listed here. **Contributors:** Tom Welch (primary), Steve Gent, Becky Hiatt, Dave Little, Andy Loonan, Tom McDonald, John Nervig, Jaime Reyes, Randy Schlei, and Don Tebben.

American Association of State Highway and Transportation Officials
Strategic Highway Safety Plan (Sept. 1997):
A comprehensive plan to substantially reduce vehicle-related fatalities and injuries on the nation's highways.
safetyplan.tamu.edu/plan/toc.asp

Center for Transportation Research and Education, Iowa State University
www.ctre.iastate.edu/index.html
Effectiveness of Roadway Safety Improvements:
www.ctre.iastate.edu/Research/detail.cfm?projectID=386
Guidelines for the Conversion of Urban Four-Lane Undivided Roadways to Three-Lane Two-Way Left-Turn Lane Facilities:
http://www.ctre.iastate.edu/reports/4to3lane.pdf

Iowa Department of Transportation Office of Traffic and Safety
www.dot.state.ia.us/traffic_safety/index.htm
Traffic and Safety Informational Series:
www.ctre.iastate.edu/pubs/tsinfo/index.htm
Iowa Access Management Awareness Project:
Iowa Access Management and Awareness Project Report; Access Management Toolkit; Access Management Handbook:
www.ctre.iastate.edu/Research/access/index.htm
Intersection Magic Analysis Tool Manual:
www.dot.state.ia.us/alas/imw_manual/imw_main.htm
Traffic and Safety ("TAS") Manual (Jan. 2002)

Iowa Safety Management System
www.IowaSMS.org
Iowa Strategic Highway Safety Plan (Aug. 1999):
www.iowasms.org/pdfs/ishsp.pdf
Iowa Strategic Highway Safety Plan Goals and Strategies: Statewide Survey of Adults (Oct. 2000):
www.iowasms.org/pdfs/publicopinionsurveyexecsumm.pdf

Minnesota Department of Transportation
Traffic Safety Fundamentals Handbook (2001)
http://www.dot.state.mn.us/trafficeng/otepubl/fundamentals/safetyfundamentals.pdf

Safer Roads—A Guide to Road Safety Engineering
By K.W. Ogden, Avebury Technical, Aldershot England (1996).

Transportation Research Board
NCHRP Report 440—Accident Mitigation Guide for Congested Rural Two-Lane Highways:
www.nationalacademies.org/trb/bookstore