Intersection Conflict Warning Systems

Informational Booklet

Introduction

Crashes that occur at unsignalized intersections account for numerous fatal and serious injury crashes. Many Strategic Highway Safety Plans call for improved design and operation of unsignalized intersections. In addition to intersection lighting, signing and geometric improvements, transportation agencies have turned to Intelligent Transportation Systems (ITS) as another tool for improving safety. A variety of dynamic intersection conflict warning systems (ICWS) have been developed and tested over the past decade. No specific guidance has been available for these systems in regard to design or evaluation and this has resulted in a broad range of approaches.

Photo: Minnesota Department of Transportation

In 2011, ENTERPRISE engaged state and local transportation agencies that have developed and deployed ICWS to discuss how to best encourage consistency in further deployment and evaluation and to support standards consideration. ENTERPRISE compiled a summary of ICWS deployments and their characteristics along with design, procurement, operational, and evaluation materials from individual projects. Based on this information, ENTERPRISE developed a design and evaluation guidance document to offer technical insight on current practices for deploying ICWS. The guidance also served as preliminary input for the National Committee on Uniform Traffic Control Devices (NCUTCD) recommendation of standards language for ICWS in the 2017 Manual on Uniform Traffic Control Devices (MUTCD). ENTERPRISE further developed model systems engineering materials and planning guidance to support agencies' consideration of ICWS as a safety solution.

This informational booklet summarizes key ICWS resources that have been directly prepared by ENTERPRISE or prepared by others. The resources highlighted in this booklet were selected to provide a technical introduction to ICWS. The booklet is intended to help the reader decide which resources they may want to explore more deeply as they continue to learn about ICWS.

Nature of Intersection Crashes

According to the most recent data available in the Fatality Analysis Reporting System (FARS), in 2013, there were 6,947 fatal crashes associated with intersections throughout the United States. This represents 23% of the 30,057 total fatal crashes in 2013 (FARS Data, US). FARS also reports similar percentages for several preceding years. This national figure was obtained using the following parameters which are provided to allow for repeat data comparisons and to generate similar statistics for individual states.

- Access FARS at http://www-fars.nhtsa.dot.gov/QueryTool/QuerySection/SelectYear.aspx.
- Select "Query FARS Data."
- Under Query – Step 1: Choose a Year, select and submit "2013."
- Under Query – Step 2: Choose the Tables to Query, select and submit "Option 1 (Crashes/Person (Includes Occupants and Non Occupants))."
- Under Query – Step 3: Choose Variables to Use, select and submit "Relation to Junction (Specific Location)."
- Under Query – Step 4: Choose Condition Criteria, select "All" under State and select "All" under Relation to Junction (Specific Location), and then select "Cross Tab."
- Under Query – Step 5: Choose Report Format Options, select "Relation to Junction (Specific Location)" under Column, select "State" under Row, select "Number of Crashes" under Select Data to Count, and then submit.
- Under Report, totals for "Intersection" and "Intersection-Related" may be added together for a total number of fatal crashes associated with intersections throughout the United States. Similar figures are also included the report for individual states.

Additional insight on the nature of intersection crashes is available through the study, *Crash Factors in Intersection-Related Crashes: An On-Scene Perspective*, published by the National Highway Traffic Safety Administration in 2010. The study examines the general characteristics of motor vehicle traffic crashes at intersections by analyzing the critical reasons with several crash factors such as driver's sex and age, traffic control device, critical pre-crash event, and atmospheric condition. Of the intersection-related crashes examined in the study, about 96% had critical reasons attributed to drivers, while the vehicle- or environment-attributed critical reasons were assigned in less than 3% of the crashes. The critical reasons that were attributed to drivers included 55.7% with recognition error (inattention, internal and external distractions, inadequate surveillance, etc.) and 29.2% with decision errors (too fast for conditions or aggressive driving, false assumption of other's actions, illegal maneuver, and misjudgment of gap or other's speed). The study is available online at http://www-nrd.nhtsa.dot.gov/Pubs/811366.pdf.

Stop-Controlled Intersection Safety: Through Route Activated Warning Systems

Photo: North Carolina Department of Transportation

The Federal Highway Administration (FHWA) published *Stop-Controlled Intersection Safety: Through Route Activated Warning Systems* in early 2011 to provide information on low cost, infrastructure-based ITS technologies that may be applied to stop-controlled intersections to improve safety. The document describes the nature of intersection crashes as well as traditional low cost infrastructure countermeasures commonly used to address these crashes. The document then focuses on infrastructure-based ITS solutions including ICWS, why ITS solutions are needed, and their key design attributes. The document is available online at http://safety.fhwa.dot.gov/intersection/resources/fhwasa11015/.

Planning Guidance for ICWS

ENTERPRISE has developed planning guidance for several ITS devices, including ICWS, to assist agencies in the decision process of deploying, as well as to validate the locations of previously deployed devices. The AASHTO Subcommittee on Traffic Engineering (SCOTE) has also reviewed and provided comments on the planning guidance. ICWS is defined in the planning guidance as a traffic control device placed on major, minor, or both roads of an intersection to provide drivers with a real-time dynamic warning of vehicles approaching or waiting to enter the intersection. It is acknowledged that ICWS are typically installed to address crash factors associated with limited sight distance and poor gap selection at stop-controlled intersections. Two guidelines capture the most common uses of ICWS to influence driver behavior at stop-controlled intersections. Complete information is available online at http://www.enterprise.prog.org/itswarrants/icws.html.

ICWS Guideline – 1:

Intersections with High Crash Frequencies or Rates (Reactive Approach)

Purpose: To influence driver behavior at stop-controlled intersections (typically 45 mph or greater posted speed on major road) where right-angle crashes are the predominant crash type.

ICWS Guideline – 2:

Intersection Characteristics (Proactive Approach)

Purpose: To influence driver behavior at stop-controlled intersections (typically 45 mph or greater posted speed on major road) where conditions are such that the intersection could be susceptible to right-angle crashes.

ICWS Crash Modification Factor

The Evaluation of Low Cost Safety Improvements Pooled Fund Study completed a national safety effectiveness evaluation of ICWS. Systems studied were grouped into two overarching categories based on placement of the warning signs: post-mounted signs consisted of a static sign (usually) paired with yellow flashing beacons and overhead signs included a static sign bordered by two yellow flashing beacons suspended above the roadway. Data was analyzed from deployment sites in three states and further separated by two-lane at two-lane (2L2L) intersections and four-lane at two-lane (4L2L) intersections. Using the Empirical Bayes methodology, crashes from the deployment sites were observed and compared to similar reference sites to determine the crash modification factor (CMF). The CMF for total crashes at 2L2L deployments was 0.73, a 27% reduction in crashes. The CMF for total crashes at 4L2L deployments was 0.83 or a crash reduction of 17%. Of the post-mounted and overhead-mounted signs located on major roadways at 2L2L intersections, the post-mounted sign realized the greatest crash reduction (48%) likely due to the signs being located further in advance of an intersection. Treatments on major roadways were generally more effective than those on minor roadways. After considering installation, maintenance and operation costs, system lifespans, and crash costs, the benefit-cost ratio for 2L2L intersections was 35:1, and the 4L2L benefit-cost ratio was 13:1. The complete study will be available at http://www.fhwa.dot.gov/research/tfhrc/projects/safety/comprehensive/elcsi/pubs.cfm.

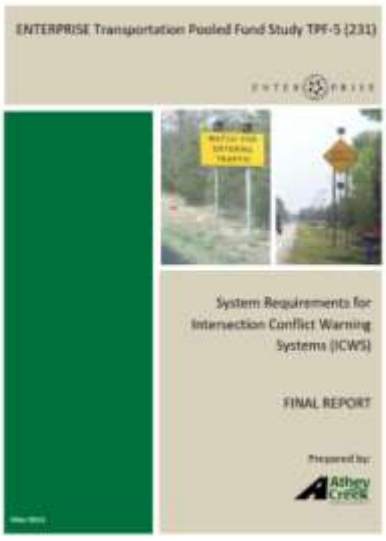
Design and Evaluation Guidance for ICWS

Bringing together organizations that have developed and deployed all types of ICWS, ENTERPRISE sponsored a project to develop a consistent approach for more uniform deployment and further evaluation of ICWS and to recommend preliminary guidance for MUTCD consideration. Based on the information assembled, an initial version of design and evaluation guidance was developed to support future deployment of ICWS. The guidance offers technical insight and recommended practice for designing and evaluating ICWS. It does not mandate the deployment of such systems, nor does it limit the engineering or policy discretion of the transportation agencies who may consider deploying these systems. The guidance provides an overview of typical system components, a glossary of related terms, recommended layouts, and evaluation guidance. The guidance document is available online at http://www.enterprise.prog.org/Projects/2010_Present/developingconsistencyIWS/iws_relateddocuments.html.

Model Concept of Operations for ICWS

The model concept of operations for ICWS articulates the basic needs and operational concept for the systems. It reflects stakeholder needs based on known national practices and should be adapted as necessary to reflect any unique or additional needs driven by individual deployment conditions. The document presents the needs of the noted stakeholder groups, describes an operational concept from the stakeholders' perspectives, outlines systems components, and presents common operational scenarios for ICWS that provide both major and minor road alerts. The concept of operations does not mandate the deployment of ICWS, nor does it limit the engineering or policy discretion of the transportation agencies who may consider deploying them. The document is available online at http://www.enterprise.prog.org/Projects/2010_Present/developingconsistencyIWS/iws_relateddocuments.html.

Model System Requirements



Building on the needs identified in the concept of operations, the model system requirements describe what ICWS must do and set the basis for system design, procurement, installation, and operation. System requirements are verifiable details that define what a system will do, how well it will perform, or what conditions it must perform under. The requirements are associated with detection, alerts, placement, operations, and maintenance. The document also explains how ICWS fit within the National ITS Architecture as a part of the Intersection Collision Avoidance User Service. The system requirements illustrate the basic requirements associated with the needs for ICWS and serve as model documents that may be adapted to meet individual deployments. The materials do not mandate the deployment of such systems, nor do they limit the engineering judgment or policy discretion of the transportation agencies who may consider deploying ICWS. The document is available online at http://www.enterprise.prog.org/Projects/2010_Present/developingconsistencyIWS/iws_relateddocuments.html.

Design, Construction, and Maintenance Cost Considerations

The cost of any ITS deployment in the early stages of development can vary significantly until components are uniformly produced and widely available. ICWS is no exception. Depending on the design, placement, equipment selection and a variety of other factors, the systems may be considered relatively low-cost, particularly in contrast to more extensive alternatives such as those requiring geometric modifications. Maintenance and operations are additional factors to consider in relation to cost. Understanding the anticipated performance of system components, having adequately trained and available staff, and the availability of replacement parts are just a few of the more critical aspects of maintenance and operational costs for ICWS. All of these factors must be considered when selecting ICWS, developing requirements, and finalizing design.

Public Outreach

The Wisconsin Department of Transportation (WisDOT) was one of 19 transportation agencies awarded a Rural Safety Innovation Program grant from FHWA in 2008. Their proposal included installation and evaluation of a Rural Intersection Collision Avoidance System (RICAS). The primary goal of the project was to demonstrate technology that improves the safety of a rural stop-controlled intersection by providing drivers information to promote safer gap selection. WisDOT developed a series of outreach materials to make the public aware of the project and educate them about the system being installed. Materials included a brochure, fact sheet, and overview presentation available online at: http://www.enterprise.prog.org/Projects/2010_Present/developingconsistencyIWS/iws_relateddocuments.html.

ICWS Language Proposed for MUTCD

The NCUTCD Regulatory and Warning Sign Technical Committee (RWSTC) established a task force in 2012 to review ICWS work to-date and suggest a course for further action. In June 2014, the task force suggested specific ICWS language to be added to the MUTCD. The RWSTC reviewed, modified, and approved suggested language that was then presented to and approved by the NCUTCD Council. The language has been sent to FHWA for further review and consideration for the 2017 MUTCD. A Notice of Proposed Amendment for this and other changes to the next MUTCD is expected later this fall. The document is available online at http://www.enterprise.prog.org/Projects/2010_Present/developingconsistencyIWS/iws_relateddocuments.html.

Conclusion

Intersection safety has improved with the implementation of ICWS. As vehicle automation continues to evolve, ICWS may also advance so that alerts or even automated assistance are provided to drivers directly in their vehicles. Until then, roadside deployments of ICWS offer transportation agencies an effective tool to address safety issues at stop-controlled intersections.

For information about the information presented in this booklet, please contact Cory Johnson, ENTERPRISE Project Champion, from the Minnesota Department of Transportation at 651-234-7062 or at coryj.johnson@state.mn.us, or visit enterprise.prog.org.