

Concept of Operations

Intersection Warning System

Minnesota Department of Transportation
Innovative Ideas Program, Stage II

SEH No. AMNDOT0731.00

January 8, 2008

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Concept of Operations

Intersection Warning System

Prepared for the Minnesota Department of Transportation

1.0 Project Description

The Intersection Warning System (IWS) project will develop, field deploy, and operationally test a system designed to provide active, real-time supplemental warning to drivers approaching an (define intersection) intersection and alert them to look for oncoming traffic. The intent of the IWS project is to develop a safe and effective low-cost system that can be readily deployed in rural areas and is easy to operate and maintain.

The project will follow traditional systems engineering principles to provide for stakeholder input, requirements definition, detailed system design, laboratory testing and field operational testing phases. A multi-organizational project team will provide input throughout the project. The project will be delivered over an 18 month time frame from November 2007 to April 2009. A six month field operational test from late August 2008 to March 2009 will attempt to assess the system through a variety of seasonal weather extremes. An independent project evaluation will also be conducted to capture data on the effectiveness of the IWS.

Bottom line, our goal is to develop a low-cost, readily deployable, low maintenance system that can be used by transportation agencies to reduce crashes and fatalities at low-volume, non-signalized rural intersections.

2.0 Problem Statement

- **Driver distraction or inattention coupled with failure to yield is the primary cause of many fatal crashes. Many of these fatal crashes can be avoided if the driver becomes aware of a potentially dangerous situation and takes the necessary precautions.**

According to the Minnesota Motor Vehicle Crash Facts for the year 2006, there were 494 people killed on Minnesota roads, another 35,025 were injured. A total of 198,027 people were involved. Rural areas account for about 68% (308) of the total fatalities in Minnesota. About 65% (323) of all fatal crashes occur on trunk or county state aid highways and about 73% (237) of those were in rural areas. Non-signalized intersection and

intersection related crashes alone accounted for xxx (xx%) fatalities and another xxx (xx%) injuries. Traffic crashes are estimated to cost Minnesota almost \$1.6 billion each and every year.

Also, it has been found that most crashes occur in good driving conditions. Over half (53%) of all fatal crashes and 65% of nonfatal crashes occurred during daylight hours. In addition, the Minnesota Motor Vehicle Crash Facts notes that a majority of crashes occur in good weather conditions. 61% of fatal crashes and 58% of nonfatal crashes occurred during “clear” weather. It is also noted that road surface conditions were usually good. 76% of fatal crashes were on dry roads, 11% on wet roads and 9% on snowy or icy roads. Of the nonfatal crashes, 72% were on dry roads, 13% on wet roads and 12% on snowy or icy roads.

What this tells us is that many of the 78,745 crashes in 2006 may have been avoidable, specifically, intersection and intersection-related crashes that account for about xx% of all fatalities that year. Driver distraction or inattention coupled with failure to yield is the primary cause of many fatal crashes. Many of these fatal crashes can be avoided if the driver becomes aware of a potentially dangerous situation and takes the necessary precautions.

- **The current options of installing signalized intersections, or geometric design enhancements such as roundabouts, are not feasible for most rural or low volume intersections. The challenge is finding a solution using state-of-the-science technology to prevent or reduce the number of people killed and injured at low-volume non-signalized intersections in rural Minnesota.**

Minnesota’s Strategic Highway Safety Plan (SHSP) identifies the problem of intersection crashes as a “Critical Emphasis Area” and specifically recognizes the problem associated with non-signalized intersections. Minnesota’s ITS Safety Plan also recognizes the problem and listed the “Use of Rural Intersection Collision Warning Systems” as ITS Critical Strategy #5. Program strategy #11 of the recently completed Minnesota Guidestar Program: Deployment Assessment was one of 13 ITS-related strategies proposed. In addition, “Implement collision warning systems at rural highway intersections” was one of 14 specific projects recommended in the Deployment Assessment. The SHSP focused primarily on non-technology oriented solutions but the ITS Safety Plan and the Deployment Assessment focused on using ITS-related technologies to help solve the problem.

Over the past 10 years, many quality research projects have studied this problem. This operational test project takes the next step to develop a system based on previous research. Because there are literally thousands of low-volume, non-signalized rural intersections in this country, there is a need for a relatively low-cost solution. Many transportation agencies are looking for such a system that can be used to reduce the number and, potentially, the severity of intersection crashes.

A sample of the report findings from two example research projects from around the country are listed here.

The Maine Department of Transportation embarked on a pilot project in 2001 to develop a dynamic, traffic-actuated warning system, primarily to warn minor leg traffic of approaching traffic. The project Final Technical Report published November of 2006 states:

Review of the Norridgewock Intersection Collision Avoidance Warning System demonstrates that the system appears to effectively reduce the number of potential crashes at the intersection of River Road, Sophie May Lane and Route 201A. Results show a 35 – 40% reduction in traffic conflicts using FHWA and Swedish Method Traffic Conflict Analysis, respectively. Driver attitudes about the System are mostly positive, according to a survey that was conducted by the University of Maine. The system is relatively inexpensive to install and operate, and has not experienced significant maintenance issues.

The Pennsylvania Department of Transportation –Crash Avoidance System (CAS), deployed to improve the safety of two intersections on State Route 38, uses sensors to identify the presence of vehicles to motorists approaching the intersection. Special crossroad warning signs display a "Traffic Ahead" message and an LED picture of a car on the right and/or left side of the sign, to let motorists know where the car is approaching from. The CAS has been effective in both reducing accidents and lowering the approach speeds of motorists. Study conclusion from this effort state:

Results demonstrated favorable CAS effects, e.g., reduction of the top 15 percentile speeds approaching on the mainline of the intersections. The data analysis demonstrated that the CAS has a greater impact on driver behavior while the signs of approaching vehicles are illuminated. Specific findings were as follows:

- *Lower vehicle speeds approaching on the main leg of intersection while the signs were illuminated.*
- *A reduction of speed for vehicles traveling over 35 M.P.H. through the intersections while illuminated.*
- *A reduction of the 95-percentile speed at intersections while illuminated.*

One negative behavior was also noted. At the two-month study, vehicle speeds through the intersection while the signs were not activated were higher than when studied prior to the installation of the CAS system. However, the fact that this behavior is occurring may show motorists are more comfortable with the intersection and no longer have the threat of vehicles approaching the intersection surprisingly. The data and analysis reported herein support conclusions that safer traffic operations, i.e., lower intersection speeds, resulted from installation and continued operation of the CAS.

3.0 Project Objectives

There is a need for a low-cost, easily deployable and maintainable warning system for rural low-volume intersections where signalization or further geometric improvements are not feasible. The IWS project will provide an active real-time warning to drivers approaching the intersection on the side road (stop sign), to alert them to look for thru-road traffic either left, right, or both. The IWS project is focused on enhancing the driver's ability to successfully negotiate rural intersections where the thru-road traffic is not required to stop. The system will use sensing and communication technology to detect presence of oncoming thru-road traffic so that a message can be displayed to traffic approaching on the side road. The goal of the project is to reduce crashes and fatalities at such intersections.

The objectives of the project are to:

- Affect driver behaviors, reduce crashes, and improve safety.
- Increase driver awareness at intersections.
- Provide active real-time supplemental warning to alert drivers approaching the intersection on the side road to look for thru-road traffic.
- Create a system that is low cost.
- Create a system that is easy to deploy.
- Create a system that is powered by a solar panel, with battery backup.
- Create a system that is easy to maintain.
- Provide a system that is modular and scalable.
- Provide a tool and baseline guidance for transportation agencies that they can use to improve intersection safety.
- Use input from project participants and other stakeholders to develop a system that meets the needs for rural intersection safety, and builds on national efforts to develop intersection warning solutions.
- Identify criteria to evaluate intersections for potential application and delineate those parameters by which a transportation engineer would select an intersection for deployment of an IWS.
- Identify potential test intersections within Hennepin County and select a single intersection to use for an operational test.

In addition to these project objectives there is a list of project boundaries identified in Appendix #1 of this document and a listing of project Risks and Mitigation Strategies identified in Appendix #2 of this document. These appendices are given to aid in managing the project scope and deliverables and also to help assure that project objectives are met.

4.0 Stakeholder Description

Over the course of the IWS project a number of stakeholders will be involved. Involvement will vary depending on the stakeholder roles and responsibilities. In addition to the stakeholders that have direct involvement in delivering the project, there are a number of stakeholders that have an interest in the development and outcome of the IWS. Generic stakeholder descriptions are:

Drivers: This group will include those project participants, and potentially Hennepin County Employees at the Medina facility, who observe and react to the IWS system during the Laboratory Test and the Field Operational Test portions of the IWS project. This group also includes the general public who will directly observe and react to the IWS system throughout the field operational test. The drivers will be categorized as either thru-road drivers or side road drivers. The side road drivers will have the most direct exposure to the IWS system.

Transportation Engineers / Planners: In their role in improving intersection safety and determining appropriate intersection signage this group will evaluate the need for and potential placement of IWS equipment. This group may also direct funding for IWS, interact with or direct operations and maintenance of IWS, and monitor performance of the IWS. This group could use data collected by the IWS, such as number of radar triggers or number of sign activations. The interaction could also include responding to inquiries from the driver group or other interested parties. This group will be concerned with IWS conformance to signing guidelines and standards, as well as ultimate performance of the IWS in improving safety and reducing crashes.

Operations Staff (Technician/Maintenance Worker): This group may have direct interaction with the IWS through the installation, operations and maintenance of the IWS. This work may be done directly by operations staff or contracted through the consultant and vendor group. The interaction could also include responding to inquiries from the driver group or other interested parties.

Consultant and Equipment Supplier Community: This group will serve a service provider role to the transportation engineer and operations staff. This group will assist in development of the IWS, evaluation and recommendation of IWS deployments, and installation and operations support. This group may assist in educating and informing stakeholders on the IWS products, applications, benefits, and costs.

Other Interested Parties: This group may include the media, professional associations, industry experts, local law enforcement, educational institutions and various governmental agencies. These groups may have an interest in the IWS project, the technology, the evaluation or the project results. These groups will not have direct involvement in the IWS project. However, through various means these groups may become aware of the IWS and request information from the other stakeholder groups listed above.

The table below lists the specific project participant stakeholders and interested parties for the IWS project and the anticipated involvement in the project and beyond.

Entity	Key Staff	Project Role	Operational and/or Long Term Role
General Public		Road Driver – Affected Party	Observe and react to the System
MN/DOT		Project Champion	Standards, Policy, Funding, Safety, Deployment, Operations
	Ginny Crowson	Project Manager	Oversight, Safety, Standards, Signage, Schedule, Policy, Funding, Deployment, Operations, coordination and communications with other stakeholders
	Mike Weiss	Team Member	Signage, Standards, Safety
	Amr Jabr	Metro Traffic	Signage, Safety, Deployment, Operations
	Skip Misgen	Metro Traffic	Signage, Safety, Deployment, Operations
FHWA		Project Sponsor	Signage, Standards, Safety, Usage, Policy, Funding
	Dave Kopacz	Team Member	Signage, Standards, Safety, Usage, Policy, Funding, coordination and communications with other stakeholders
Hennepin Co.		Project Sponsor	Standards, Usage, Policy, Funding, Deployment, Operations
	Eric Drager	Team Member	Signage, Standards, Safety, Policy Deployment, Operations, coordination and communications with other stakeholders
	Marthand Nookala	Administration	Policy, Funding, coordination and communications with other stakeholders
SEH		Project Consultant	Standards, Safety, Development, Deployment, Marketing
	Andy Terry	Project Manager	Oversight, Safety, Standards, Signage, Schedule, Policy, Development, Deployment, coordination and communications with other stakeholders
	Tom Sohrweide	Team Member	Signage, Standards, Safety, Development
	Dennis Foderberg	Team Member	Signage, Standards, Safety, Development, coordination and communications with other stakeholders
	Mark Ray	Project Resource	Signage, Standards, Safety, Development
NTT		Project Subcontractor	Standards, Safety, Development, Deployment, Marketing Operations.

	Gordon Melby	Team Member	Oversight, Safety, Standards, Signage, Schedule, Policy, Development, Deployment, coordination and communications with other stakeholders
	Dmitry Gringauz	Team Member	Safety, Signage, Development, Deployment, Operations
Hennepin Co Sheriff	Sgt. Mike Benson	Team Member	Safety, Signage, Operations, coordination and communications with other stakeholders
SRF	Erik Minge	Project Evaluation Consultant	Safety, Evaluation, Design, Operations
MCEA		Interested Party	Potential Future Users - Standards, Policy, Funding, Deployment, Operations
U of M - CTS		Interested Party	Standards, Policy, coordination and communication with other stakeholders
Mn. Guidestar		Interested Party	Policy, Funding, coordination and communication with other stakeholders
ITS Mn.		Interested Party	Policy, Funding, coordination and communication with other stakeholders
Media		Interested Party	Observe and react to the System. Communication with the Public.

5.0 Concept of Operations - General Operational Description

This general operational description is provided to aid the development of the IWS system requirements, detailed system design, and field operational test. The Concept of Operations is focused on providing the project team clarity in how the IWS will be used for this field operational test project. Various scenarios are presented to describe how the IWS will be used and will be described from various stakeholder viewpoints. The scenarios described in this section assume the IWS is deployed and operational.

Deployment of the IWS at a low-volume, non-signalized intersection.

Insert various intersection pictures and configuration examples: (Example – Hennepin Intersection #1- Possible Google Capture)

5.1 Description from the viewpoint of the driver, after intersection warning system is installed and operational.

Drivers on the thru-road, approaching or departing the intersection, will experience the intersection in the same manner as prior to the IWS deployment. In place signs will not be relocated or replaced during the evaluation period since the intent of the IWS is to supplement the in place signing. The signage that was present prior to deployment will remain the same. An observant driver may be aware of the addition of the IWS detector nodes on the signs adjacent to the thru-road as drivers approach the intersection. They may also observe additional equipment such as a solar panel or an advisory sign that is displayed to the side road traffic. However, the thru-road traffic will have the same signage displayed to them as the pre-IWS conditions and should experience approaching and proceeding through this intersection in the same manner as any intersection not instrumented with an IWS.

Drivers on the side road(s) of the intersection will have an additional advisory sign displayed to them at the intersection. As they approach the stop line, they should notice an intersection warning sign across the intersection that displays an advisory message. The warning sign will be advisory and drivers will still be required to obey the original intersection signage. The advisory message and sign format will be determined in the design phase of this project. The message sign will be dynamic. If no thru-road traffic is approaching the intersection, no indication will be given to the driver. If thru-road traffic is present, approaching the intersection from either direction within the set parameters of the IWS detectors, an indication will be given to the driver. The IWS will provide a predictable, easily understood indication to the driver. The type of indication, sign configuration, and fail safe parameters of the indication will be determined during the design phase of this project.

5.2 Description from the viewpoint of the transportation engineer.

In general the transportation engineer will identify intersections in need of safety improvements through traditional means such as crash data, public comment, intersection safety audits, and professional judgment. The transportation engineer will evaluate the viability of an IWS by reviewing the

current intersection signage and evaluating cost and performance criteria. Section 7 of this Concept of Operations presents additional detail on intersection selection criteria.

In cases where the transportation engineer determines that use of an IWS is needed a plan set should be developed to identify location of IWS detector nodes, warning signs, solar panels and battery systems, and other intersection specific information. Prior to installation of the IWS, in place signs should be inventoried.

There should be no need for additional public education or notice in order for the IWS to be deployed and operate effectively. However, the transportation engineer may choose to provide some form of public notice of the change in traffic signage, and provide some level of public education to establish expectations and guide driver behavior through announcement at public meetings, such as county board meeting and city council meetings in order to provide some public relations. The installation of the IWS may serve as an opportunity to provide general traffic safety educational messages to the public. Articles or announcements in local newspapers or circulars may also be appropriate.

As with any change in traffic control, the transportation engineer may expect questions or comments from the public, media, or elected officials. The transportation engineer should be prepared to address questions by understanding the objectives and intended operation of the IWS.

The implementation of an IWS will not constitute an addition of an enforceable traffic control sign. The IWS is advisory. However, the transportation engineer may choose to advise local law enforcement of the addition of the IWS so they are also able to respond to questions or concerns raised to them by the public.

The transportation engineer may direct installation of the IWS. The engineer may also be responsible to direct maintenance staff to perform initial system diagnostics and ongoing adjustment and calibration on a scheduled basis.

The transportation engineer should conduct periodic review of intersections to evaluate and adjustment traffic control as needed.

5.3 Description from the viewpoint of the traffic technician, maintenance worker, or field support staff.

The IWS installation for this project will be performed by the consultant team with participation and assistance from Hennepin County. In general, a transportation agency may choose to contract a turn key procurement and installation of an IWS, or they may purchase a system to be installed by its own staff. In either case the transportation agency field support staff should assure the following tasks are preformed, inspected or planned for the future.

The installation will include:

- Attachment of detector device and solar array to existing sign structure when available and in the proper placement to the roadside intersection advance warning sign.
- Check that batteries used in system are charged before installation.
- Verify that solar charging system is working correctly.
- Attach active warning sign (indication) to accessible location across the thru-road from stop sign/stop line. Insure warning sign (indication) is visible to approaching side road traffic.
- Conduct installation radio communications quality check.
- Conduct overall system check in diagnostic mode and insure all components are working. This process will create log of installation parameters and system performance. Observe that approaching vehicles are properly detected and warning sign (indicator) activates and remains activated for the prescribed time. Verify system does not detect thru-road traffic moving away from intersection.

Ongoing system maintenance may include items such as:

- Scheduled drive by observation of the IWS.
- Scheduled system diagnostic readings.
- Scheduled battery replacements.
- Scheduled solar panel and sign replacement.

5.4 Description from the viewpoint of local Law Enforcement.

The implementation of an IWS will not constitute the addition of an enforceable traffic control sign. The IWS is an advisory traffic sign. However, local law enforcement may become aware of the placement of the IWS via notification from the transportation agency or from inquiries by the public.

In general local law enforcement should have no additional responsibilities or traffic enforcement activity as a result of the IWS deployment. Similar to the statements on public awareness in section 5.2, local law enforcement should become familiar with the objectives of the IWS, and may choose to use the installation of the IWS as an opportunity to provide general traffic safety educational messages to the public.

6.0 Intersection Evaluation and Selection.

This section will identify the intersection evaluation and selection process to be used for this project to select the candidate intersection for operationally field testing the intersection warning system. This project is intended to improve safety at intersections. The concept was originally developed to address intersections which have inadequate sight distance. Therefore we believe that the intersections evaluated should have a safety problem and restricted sight distance.

Another factor to consider is that of a locally recognized bad intersection. There are times when an intersection with bad sight distance is measurably safe, due to drivers taking extra caution. Conversely there are intersections with good sight distance that are having vehicle crash problems. Ultimately, if proven successful, this system could also be deployed in these situations.

The measure of intersection safety is the intersection crash rate. Mn/DOT has calculated an average crash rate for “Thru Stop” intersections of 0.4 crashes per million entering vehicles. While the crash rate is a good measure, the critical crash rate is a more accurate measure of an unsafe intersection. The critical crash rate, as defined in Mn/DOT’s Traffic Safety Fundamentals Handbook, is calculated by adjusting the system wide categorical average based on the amount of exposure and a statistical constant indicating level of confidence.

To select the intersection for this project we will use following the process:

- a. Seek input from Hennepin County as to “bad” intersections to consider. Hennepin County has a process for categorizing and prioritizing intersections within their jurisdiction. This process includes
 - i. Prioritizing intersections based on crash rate.
 - ii. Prioritizing intersections based on crash severity.
 - iii. Creating an aggregate non-signalized intersection ranking based on the two criteria above.
 - iv. Prioritized ranking is typically updated annually.
- b. Discuss the prioritized intersection ranking with Hennepin County and inquire as to other parameters that will help identify candidate intersections for deployment of the IWS.
 - i. Current status of Stop Sign Warrant evaluation for candidate intersections.
 - ii. Site distance characteristics of candidate intersections.
 - iii. Traffic volumes of Thru-Road and Side Road for candidate intersections.

- iv. Public perceptions and expectations for candidate intersections.
 - v. Hennepin County judgment for selection of candidate intersections.
- c. The process described above provided two candidate intersections for further evaluation. The two intersections are:
- i. 116th Street and 150th street.
 - ii. CR 47 and Londale Ave.

These candidate intersections investigated in more detail as candidate intersections through the System Requirement and Detailed System Design phase of the project. These candidate intersections will be documented with the following parameters:

- physical location; roadway attributes; existing traffic control; and crash history (crash volume, type, time of day, conditions)
- measure sight distance at the intersection and calculate the critical crash rates.

One candidate intersection will be selected for deployment of the intersection warning system for field operational testing.

APPENDIX #1

System Boundaries: Identify items within and outside the system. This provides for focus of the project on items of primary concern to the development of the Intersection Warning System and also identifies items not included in the work to be performed as a part of this project.

Boundary Item	Description
Existing Regulatory Signs	
Advisory IWS Signs	
Detector Nodes	
Solar Power Supplies/Batteries	
Vehicles	
Drivers	
Data Collection and Processing	
Infrastructure Elements	

Graphic

APPENDIX #2

Project Risks and Mitigations Strategies

Project Risk	Description	Mitigation Strategy
Coordination with other projects	Other projects with similar or complimentary goals and scopes exist. Lack of coordination and communication with other similar projects may jeopardize the validity, success, or acceptance of the results and outcomes of this IWS project.	1. Status and summary information for this project should be made widely available to stakeholder groups and interested parties. 2. Reports to the Guidestar Board will be given as requested. 3. The MN/DOT project manager serves on the project team for the CICAS project and can actively share information between the two project teams.
Interest of Rural Partners	There has been interested expressed by a number of counties in Minnesota for an IWS product. Desire to more broadly deploy the IWS could impact the current operational test.	Mn/DOT is evaluating options to expand the project or introduce a new project to provide for broader deployment of IWS's.

Obtaining experimental waiver	If needed, an experimental waiver may introduce additional complexity or project delay into the project.	1. The project has several experts with experience in the experimental waiver process. 2. The project schedule and tasks anticipate this item in the program plan. 3. Early discussion of this topic have taken place to position the team to address issue in this area as they arise.
Functionality of system	The performance of the IWS is one critical factor in meeting the objectives of the project.	1. Standard market accepted technology and off the shelf products are being used in the system design where practical. 2. The project is using standard systems engineering methodology throughout the development of the IWS.
Safety of traveling public	Introduction of a new advisory sign may not have the anticipated safety benefits anticipated. The public may be distracted or confused by the additional signage, causing additional safety concerns for the candidate intersection.	1. The project team includes a number of participants focused on safety aspects of the intersection and the sign. 2. The project will initially deploy the signage in a test environment prior to deployment in live field operations. 3. There will be an independent evaluation of the effectiveness of the sign. 4. There will be numerous key project members with the ability to terminate or suspend the project due to a safety concern.
Public Interest	Early media attention to the project and interest from the public may influence the project outcomes.	1. The project team has provided open communication with the media from the beginning of the project to aid in providing positive messages about the project, the need for IWS's, and traffic safety. 2. The project team has

		discussed the need for common and consistent messages about the project. 3. The project team has an informational one pager with IWS project facts use as speaking points if needed.