



FINAL
EVALUATION REPORT
INTERSECTION WARNING SYSTEM

JUNE 30, 2009

MINNESOTA DEPARTMENT OF TRANSPORTATION
1500 WEST COUNTY ROAD B2
ROSEVILLE, MN 55113

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TABLE OF CONTENTS

Executive Summary	1
1. Introduction.....	3
1.1. Project Background.....	3
1.2. Evaluation Overview.....	4
1.3. Evaluation Team	4
2. Evaluation Methodology.....	5
2.1. Evaluation Strategies.....	5
2.2. Evaluation Test Plan.....	5
2.3. Evaluation Report.....	6
2.4. Evaluation Schedule.....	7
3. Results.....	7
3.1. Test Plan 1 – Evaluate Safety Impacts of the System	7
3.1.1. Overview.....	7
3.1.2. Data Collection and Analysis.....	8
3.1.3. Findings.....	9
3.2. Test Plan 2 – Evaluate Owner Satisfaction	10
3.2.1 Overview.....	10
3.2.2 Data Collection and Analysis.....	11
3.2.3 Findings.....	11
3.3. Test Plan 3 – Evaluate User Perception of the System	13
3.3.1 Overview.....	13
3.3.2 Data Collection and Analysis.....	13
3.3.3 Findings.....	14
3.4. Test Plan 4 – Evaluate System Performance.....	20
3.4.1 Overview.....	20
3.4.2 Data Collection and Analysis.....	23
3.4.3 Findings.....	23
4. Conclusion	27

Executive Summary

Project Overview

The number of traffic-related fatalities at rural intersections has become a major concern for Minnesota motorists as well as officials from local, state and national transportation agencies. Among the 494 traffic fatalities in Minnesota in 2006, one out of every three occurred at intersections. Furthermore, one out of three of these intersection fatalities occurred at rural intersections with thru-stop control.

In response to this issue, the Minnesota Department of Transportation (Mn/DOT) sponsored the development and evaluation of the Intersection Warning System (IWS). This project, as part of the Department's Innovate Ideas Program, developed an active roadside warning system to detect mainline traffic and alert cross-street drivers to look for an acceptable gap in traffic.

The IWS project features a low-cost system that utilizes innovative methods of vehicle detection, data processing, wireless communications, signing and solar/battery power systems. In order to meet these goals the project progressed through a number of phases including: design, laboratory deployment, acceptance testing and a six-month field operational test.

For the purposes of evaluation, four test plans were developed to enable a qualitative assessment of the system's performance as well as a quantitative analysis to compare the before and after data from the field operational test of the system. The test plans were developed in consultation with project team members and aimed to evaluate a number of factors related to the system itself and to the public and owners' perception of the system. These test plans are listed below.

- Evaluate safety impacts of the system
- Evaluate owner satisfaction
- Evaluate owner perception of the system
- Evaluate system performance

The location of the six-month field operational test field test was chosen to be the intersection of Hennepin County Road 47 and Lawndale Lane, located in a rural area of Hennepin County, Minnesota.

Findings

Comparison of the "before" and "after" conditions at the field operational test site reveals that the number of traffic conflicts (sudden braking, sudden acceleration or swerving) was reduced by 54 percent. In the "before" condition a conflict rate of 3.9 conflicts per 1,000 vehicles was observed compared to a conflict rate of 1.8 conflicts per 1,000 vehicles in the "after" condition.

Upon interviewing the system owners it was determined that the Intersection Warning System is very reliable and effective at warning drivers of approaching cross-street traffic. The system was

also noted to be easy to maintain and install, having a relatively fixed low cost and transferability to similar intersections.

From surveys that were distributed to the general public, it became clear that drivers were aware of the sign and understood its meaning, despite some minor confusion over what conditions caused the sign to activate. Half of the survey respondents indicated that they would pay more attention at the intersection when seeing the sign flash. Overall, as indicated by a 55 percent return rate and many comments included in the surveys, the general public appreciates the sign and has a desire to increase road safety.

The system operated with a 98.6 percent uptime, experiencing only three failures during the six-month field operational test. In all weather conditions during the field operational test, the sign continued to operate, notifying drivers of oncoming cross-street traffic.

The data indicates that the Intersection Warning System is an effective method to increase safety at rural intersections. The system was accepted by motorists, performed reliably and increased safety at the field operational test site.

1. Introduction

The Minnesota Department of Transportation (Mn/DOT) sponsored the development and evaluation of the Intersection Warning System (IWS) as part of the Department's Innovative Ideas Program. The IWS project developed a low-cost, active roadside warning system to detect vehicles and prompt drivers to look for cross traffic at intersections controlled by stop signs. The IWS project is a cooperative effort being implemented by Mn/DOT, the Federal Highway Administration (FHWA), Hennepin County, and two private sector partners, Short Elliott Hendrickson Inc. (SEH) and Network Transportation Technologies (NTT).

1.1. Project Background

Approximately 500 people are killed on Minnesota roads each year. In 2006, one out of every three fatalities occurred at intersections. Of these intersection fatalities, one out of three was located at rural intersections with thru-stop control. With the majority of these crashes occurring during daylight hours and under good driving conditions, driver distraction and inattention have been identified as significant causes.

The IWS project developed a low-cost active warning system for motorists approaching rural through-stop intersections. The system warns motorists on the stop-controlled approach to the intersection of vehicles approaching on the uncontrolled intersecting roadway. The IWS utilizes innovative methods of vehicle detection, data processing, wireless communication, signing and solar/battery power systems. The project's Concept of Operations document provides additional detail of the system.

This project consisted of design, field deployment, acceptance testing (laboratory and field), and a six-month field operational test of the warning system. The operational field test location was the intersection of Hennepin County Road 47 and Lawndale Lane, located in a rural area of Hennepin County, Minnesota. Figure 1 shows the test site.



Figure 1 – Test Site

1.2. Evaluation Overview

The approach that was used to evaluate the IWS system is based on the ITS Evaluation Resource Guide¹ published by the USDOT. As defined in this guide, “evaluation is the reasoned consideration of how well project goals and objectives are being achieved”. The guide recommends that an evaluation focus on identifying performance characteristics that will result in system revisions and, ultimately, a more successful deployment.

The evaluation approach proposed for this project consisted of both a qualitative assessment of the system’s performance and of a quantitative analysis to compare and contrast before and after evidence from the field operational test of the system.

1.3. Evaluation Team

The involvement of all project partners was key to the success of this evaluation. Given the need for pre-system deployment data collection and the range of evaluation objectives, it was essential that project team members actively participate in the evaluation. Project team members are listed below:

- Mr. Matt Gjersvik, Mn/DOT, Project Manager
- Ms. Ginny Crowson, Mn/DOT, former Project Manager
- Mr. Mike Weiss, Mn/DOT
- Mr. Steve Misgen, Mn/DOT
- Mr. Dave Kopacz, FHWA
- Mr. Eric Drager, Hennepin County
- Sgt. Mike Benson, Hennepin County Sheriff
- Mr. Curt Bolles, Olmsted County
- Mr. Andy Terry, SEH, Project Manager
- Mr. Tom Sohrweide, SEH
- Mr. Dennis Foderberg, SEH
- Mr. Mark Ray, SEH
- Mr. Gordon Melby, NTT
- Mr. Brian Scott, SRF
- Mr. Erik Minge, SRF
- Mr. Jacob Folkeringa, SRF

¹ http://www.its.dot.gov/evaluation/eguide_resource.htm

2. Evaluation Methodology

Evaluation is an integral part of the project development process and was given consideration in each phase of the project. The following evaluation process loosely follows the six-step process recommended by the USDOT ITS Evaluation Resource Guide. Note that this approach deviates from the US DOT Guide which recommends separate documents: an Evaluation Plan and one or more Test Plans. These documents were combined into a single Evaluation Test Plan to better match the scale of the evaluation being conducted.

2.1. Evaluation Strategies

The first step in the project evaluation was to establish the evaluation priorities. Input from the project team was solicited and other resources were reviewed to identify specific areas for potential evaluation under the categories of safety and customer satisfaction. These were then assessed and prioritized according to the project's high level Requirements, System Design, and further input from the project team. The prioritization process resulted in the selection of the following evaluation strategies. These strategies formed the basis for developing the Evaluation Test Plan.

- Evaluate safety impacts of the system
- Evaluate owner/user satisfaction and human factors/user perception of the system
- Evaluate system performance

2.2. Evaluation Test Plan

Building on the identified evaluation strategies, the Evaluation Test Plan presented the approach by formulating hypotheses, the "if-then statements that reflect the expected outcomes of the project"². Hypotheses were developed for each area of evaluation according to the priorities established in the Evaluation Strategies. The plan identified all such hypotheses and then outlined the different tests that were needed to assess them. Tests and the measures associated with them are both quantitative and/or qualitative in nature.

In addition to the technical factors that influenced project performance, non-technical factors, such as user and owner perceptions, were considered. Of particular interest was how these perception factors relate to system impact.

The Evaluation Test Plan included details of how the tests were conducted, and identified the equipment, supplies, procedures, personnel and schedule required to complete the tests. Additionally, objective/hypotheses tables with Measures of Effectiveness (MOEs) were developed for Test Plan 1 (Evaluate Safety Impacts of the System) and Test Plan 4 (Evaluate System Performance) and are shown below.

² http://www.its.dot.gov/evaluation/eguide_resource.htm

Table 1**Test Plan 1: Objective 1-1 Hypotheses, MOEs and Data Sources**

Evaluation Objectives	Hypotheses	MOEs	Data Sources
1-1 Assess safety impacts during mid-day period	The system will reduce TCR (Traffic Conflict Rate)	TCR	Video observation
	The system will reduce TCS (Traffic Conflict Severity)	TCS	Video observation

Table 2**Test Plan 4: Objective 1-1 Hypotheses, MOEs and Data Sources**

Evaluation Objectives	Hypotheses	MOEs	Data Sources	
1-1 Assess the system's performance	The system will meet all stated functional requirements	Varies	Field acceptance tests, surveys	
	The system will meet all stated performance requirements	Varies	Field acceptance tests, system data, project team input	
	The system will meet all stated operational modes	Varies	Field acceptance tests	
	The system will meet all stated interface and subsystem requirements	Varies	Field acceptance tests, system data, project team input	
	The system will meet all stated data requirements	Varies	Field acceptance tests	
	The system will meet all stated enabling requirements	Varies	Field acceptance tests, system data, project team input	
	The system shall perform reliably	Mean time between failures		System data
		False positive rate		System data, video images
		False negative rate		System data, video images
The system will have a false detection rate of less than 0.5 percent	Volume		Road tube, video images, or radar sensor (provided by evaluator)	

2.3. Evaluation Report

The Test Plans were executed and the resulting data analyzed in this phase of the evaluation. Once all of the data and test findings were analyzed, the Evaluation Report (this document) was prepared. This report documents the evaluation strategy, plans, results, conclusions and recommendations.

2.4. Evaluation Schedule

The evaluation schedule for the project is provided below.

- Draft Evaluation Test Plan – 4/10/08
- Evaluation Test Plan – 7/30/08
- Collect “Before” Data – 7/28/08 – 7/31/08
- Collect “After” Data – 10/1/08 – 3/31/09
- Draft Evaluation Report – 5/28/09
- Final Evaluation Report – 6/30/09

3. Results

Results are presented for each of the four test plans identified earlier. This section also describes the steps that were followed to capture and analyze the data.

3.1. Test Plan 1 – Evaluate Safety Impacts of the System

3.1.1. Overview

In order to determine the safety impacts of the IWS, the traffic conditions before the installation of the system (the “before” condition) were compared to the traffic conditions after the IWS was installed (the “after” condition). For a given application, factors such as changes in crash rates, crash severity or crash types are typically used to describe the safety impacts. However, given the short duration of the field operational test (six months), it was not feasible to get statistically significant crash data. Instead, a traffic conflict analysis was used as a surrogate measure for crash rates. The following two Measures of Effectiveness (MOEs) were used to characterize the traffic in the before and after conditions:

- **Traffic Conflict Rate (TCR)** – the TCR is a measure of the rate of traffic conflicts (per 1,000 vehicles) at an intersection. Observation of one of the following three driving behaviors constitutes a traffic conflict: sudden braking, sudden accelerating or swerving.
- **Traffic Conflict Severity (TCS)** – the TCS is a measure of the severity of a traffic conflict. Two parameters will be examined to determine the severity of each observed conflict, the “time to collision” and the “risk of collision”. Higher severity scores are assigned to traffic conflicts with a low time to collision and a high risk of collision.

In order to collect traffic conflict data, a number of methods were considered. Typically, traffic conflict studies are done with data collection in the field. However, due to the low traffic volumes at the site, especially during off-peak periods, an automated data collection process with video recording was chosen.

To further improve the process, the four year crash history at the intersection was reviewed. This revealed that most of the incidents involved southbound left-turning vehicles on Lawndale and westbound through vehicles on Country Road 47³. This review also indicated that all incidents were on clear or cloudy days with dry pavement. With this information a decision was made to focus the evaluation resources on examining the westbound approach to the intersection and to analyze traffic during daylight hours and dry pavement conditions.

According to the original test evaluation plan, the impacts of the system on safety were going to be analyzed during the peak and non-peak periods separately. However, upon observing the data during the peak period (7:00 to 8:00 a.m. and 5:00 to 6:00 p.m.), it was noticed that a queue was consistent on Lawndale Avenue due to heavy traffic on County Road 47. This caused the IWS to be more-or-less continuously on, lessening the system's expected benefit. In order to make the study more effective, the original objective of analyzing the peak and non-peak periods was modified to measure only the period between the morning and afternoon peaks (8:00 a.m. to 4:00 p.m.).

3.1.2. Data Collection and Analysis

Data was collected using a trailer-mounted CCTV placed in the southeast quadrant of the intersection. The trailer was deployed in July 2008 and recorded the "before" condition from July 28th to July 31st. The IWS was activated on October 1, 2008, and the trailer remained on site to collect data for the "after" condition from October 18th to October 26th.

ViSec, a software application, was used to monitor the CCTV video images in real time and capture (record) video whenever movement was detected at the intersection. The video analysis process was more efficient since time periods without traffic were not recorded. The trailer's digital video recorder (DVR) was also used as a backup source of video data. SRF personnel recharged the system's batteries as needed throughout the data collection period.

Other data was also collected including the following:

- System data (activation events, faults, etc.)
- Pavement conditions (wet, dry, etc.)
- Daylight/night conditions
- Other environmental conditions (fog, construction activities, etc.)

Upon collecting all of the video data, the "before" condition and "after" condition were observed to determine the Traffic Conflict Rate (TCR) and Traffic Conflict Severity (TCS) for both conditions. To maintain consistency and reduce bias, one observer viewed all of the data. Video data from the ViSec software was first used as it expedited the observation process. However, when data was not available from the software, the backup DVR data was used. On certain days, the video revealed traffic was impacted by a road resurfacing project that was being done on County Road 47. Video from these time periods was not used in the analysis.

³ Hennepin County Collision Diagram, Data from 1/1/2002 to 12/31/2005, compiled 2/1/2008.

3.1.3. Findings

Thirteen hours of the “before” condition data were determined to be suitable for analysis. Upon observing this data, 12 conflicts were observed, ranging from low to moderate severity. Table 3 summarizes each of these conflicts.

Table 3
“Before” Condition Conflict Data

Date and Analysis Period	Time of Conflict	Driving Behavior	Time to Collision Severity	Risk to Collision Severity
7/28/08 3:30 p.m. – 4:00 p.m.	3:40 p.m.	Sudden Braking	Low	Low
	3:42 p.m.	Sudden Braking	Low	Low
	3:43 p.m.	Sudden Braking	Moderate	Low
7/29/08 8:00 a.m. – 4:00 p.m.	8:23 a.m.	Sudden Braking	Low	Low
	8:47 a.m.	Sudden Braking	Low	Low
	11:05 a.m.	Sudden Braking	Low	Low
	1:04 p.m.	Sudden Braking and Swerving	Moderate	Moderate
	3:52 p.m.	Sudden Braking	Moderate	Low
7/30/08 8:00 a.m. – 4:00 p.m.	8:03 p.m.	Sudden Braking	Low	Low
	2:13 p.m.	Sudden Braking	Low	Low
7/31/08 8:00 a.m. – 3:45 p.m.	9:00 a.m.	Sudden Braking	Low	Low
	9:51 a.m.	Sudden Braking	Low	Low

Eighteen hours of data were analyzed for the “after” condition and four conflicts were observed, as summarized in the following table.

Table 4
“After” Condition Conflict Data

Date and Analysis Period	Time of Conflict	Driving Behavior	Time to Collision Severity	Risk of Collision Severity
11/18/08 1:00 p.m. – 4:00 p.m.	1:53 p.m.	Sudden Braking	Moderate	High
11/19/08 8:00 a.m. – 1:45 p.m.	8:33 a.m.	Sudden Braking	Low	Low
	8:49 a.m.	Sudden Braking	Low	Low
11/20/08 8:30 a.m. – 10:00 a.m.	<i>No Conflicts Were Observed During This Time Period</i>			
11/24/08 12:30 p.m. – 4:00 p.m.	<i>No Conflicts Were Observed During This Time Period</i>			
11/25/08 8:00 a.m. – 12:00 p.m.	8:31a.m.	Sudden Braking	Low	Low

By comparing the number of conflicts to the historical volume during the sampling period, the overall Traffic Conflict Rate for the “before” condition was determined to be approximately 3.9 conflicts per 1,000 vehicles. For the “after” condition, the Traffic Conflict Rate was determined to be approximately 1.8 conflicts per 1,000 vehicles. This equates to a 54 percent reduction in traffic conflicts. The Time to Collision Severity and the Risk of Collision Severity did not seem to change between the “before” and “after” condition. For more details on the observed conflicts, see Appendix A.

3.2. Test Plan 2 – Evaluate Owner Satisfaction

3.2.1 Overview

After the IWS system completed the operational field test, the owners were surveyed by e-mail to capture their perception of the value and effectiveness of the system. An Owner Satisfaction Survey was developed following standard survey development practices. The following personnel are considered system owners and received a copy of the survey:

- a. Mn/DOT project team members
 - o Matt Gjersvik
- b. Hennepin County operators and maintainers
 - o Eric Drager
- c. Hennepin County Sheriff Department personnel
 - o Sgt. Mike Benson
- d. Other project participants
 - o Curt Bolles, Olmsted County

The survey examined the following aspects of owner satisfaction:

- a. Is the system reliable?
- b. Is the system effective?
- c. Is the system data useful?
- d. Is the system easy to install and program?
- e. Is the system easy to operate?
- f. Is the system easy to maintain?
- g. Is the system transferable to other intersections?
- h. Were the requirements in the System Requirements Test Log met? (Some of the requirements are qualitative and require input from project team members.)

3.2.2 Data Collection and Analysis

The survey was distributed by e-mail and the results tabulated. At a team conference call on April 30, 2009, the survey results were reviewed and additional input from the project team members was solicited.

3.2.3 Findings

Upon reviewing all of the survey responses the following observations were made regarding each question:

- a. Is the system reliable?

The majority of the respondents indicated that the system is very reliable and has had very few technical difficulties. It was also stated that the system is not overly complex, which helps with reliability. This issue is explored further in the Evaluate User Perception of the System portion of the report.

- b. Is the system effective?

According to the system owners, the system does what it is designed to do. One respondent also indicated that the meaning of the sign is not obvious to all drivers, as determined by the motorist survey.

- c. Is the system data useful?

The respondents did not indicate that the system data was particularly useful. This is because the owners of the system do not have much use for the data besides troubleshooting. It was noted that other engineers may be able to make use of the data.

- d. Is the system easy to install and program?

Overall, the owners agreed that the system is easy to install. Some lessons were learned throughout the process, but in the end it was deemed to be simple enough for typical public works staff to install the system with the right equipment.

- e. Is the system easy to operate?

The responses indicated that the system is very easy to operate as little work is required except for occasional maintenance issues.

- f. Is the system easy to maintain?

Respondents indicated that the system is not too complex, making it easy to maintain. However, it was also brought up that a typical public works staff may not be able to repair the electrical components of the system. Due to this, it was suggested that a warranty or customer service contract be included to cover maintenance of the electrical components. It was also noted that it would be desirable to have a notification system that could notify maintenance personnel remotely of issues with the system.

- g. Is the system transferable to other intersections?

Consensus is that the system is very modular and could be set up and utilized at other intersections. It was mentioned that the system may not improve safety at any random intersection. Rather, intersections should be chosen where the system could actually make an impact. For example, intersections with obscured sight lines would be ideal candidates for the installation of the Intersection Warning System.

- h. Were the requirements in the System Requirements Test Log met? (Some of the requirements are qualitative and require input from project team members.)

3.3.0 – The intersection warning system shall not obscure or detract from any in place signing.

The respondents agreed that the system did not cause any problems.

3.7.0 – The failed system shall not present a more dangerous situation than if the system was not present at the intersection.

It was clear from the responses that the “failed” system was still acceptable and safe.

7.2.1 – Detailed design process and the final test results shall be used to identify the maximum AADT that a roadway may have and still allow the IWS to operate.

Consensus of the group is that the deployment at Lawndale Lane and County Road 47 is near the upper limit of AADT. Any higher and the system would be on continuously during much of the peak period, reducing its effectiveness.

7.6.0 – The system shall be considered low cost

The respondents indicated that this system is much cheaper than other systems such as a traffic signal or modifying the layout of the intersection.

7.6.1 – System cost for basic detection and communications is relatively fixed, the variable cost items are related to solar panel and battery installation.

It was agreed that the power system costs will vary depending on the location.

3.3. Test Plan 3 – Evaluate User Perception of the System

3.3.1 Overview

In addition to directly observing the impact to driver behavior, this evaluation seeks to explore the human factors side of the Intersection Warning System's impact. This impact was measured by conducting surveys during both the laboratory phase and field deployment phase of the project. The survey assessed a number of human factors involved with the intersection warning system, including:

- Do drivers understand the message being conveyed by the sign?
- Does the warning system improve driver awareness of traffic approaching the intersection?
- Do drivers rely on the sign to warn them of approaching traffic rather than watching for themselves?
- What actions do drivers take when they see the sign flash?
- Based on drivers' understanding of the warning sign, does it activate as they expect it to?

3.3.2 Data Collection and Analysis

Two surveys were developed. The first survey measured the Hennepin County employee's perception of the laboratory deployment of the system at the Medina Public Works Facility (see Appendix B). The survey was e-mailed to all public works employees and a total of 105 surveys were returned.

A second survey was created for the general public to measure their perception of the system deployed at County Road 47 and Lawndale Lane for the six month field operational test of the warning system (see Appendix C). This "post card" version of the survey was distributed to

the general public by field personnel on Tuesday, November 18, 2008, after the system had been in place for approximately seven weeks. A survey was handed out to each motorist at the Lawndale approach to the intersection. Each survey was pre-stamped and included a complimentary Minnesota State Highway Map to encourage the public to fill out and mail in the survey. From 7:00 a.m. to 1:00 p.m., 649 surveys were distributed. Of the 649 surveys, 360 were returned (a 55 percent return rate).

3.3.3 Findings

This section lists each of the survey questions followed by a summary and analysis of the findings. In cases where the question wording differed between the general public and County employee versions of the survey, the County version is shown in italics. Note that some of the questions have no County employee response. This is because the question was omitted on the County employee version of the survey.

Many respondents left written comments liberally throughout the survey, whether comments were solicited or not. These written comments are summarized here and the full comment text is provided in Appendix D.

1. How many times have you driven south on Lawndale Lane through this intersection in the last 30 days?
(How many times have you driven past the warning sign?)

Response	County Employees		General Public	
	Count	% of Total	Count	% of Total
0 Trips	2	1.9%	0	0.0%
One to Two	1	1.0%	12	3.3%
Three to Five	6	5.7%	16	4.4%
Five or more	94	89.5%	332	92.2%
Blank	2	1.9%	0	0.0%
Total	105		360	

2. What time of day do you typically drive south on Lawndale through this intersection?

Response	General Public	
	Count	% of Total
4-6 p.m.	10	2.8%
4-6 p.m.; Other	1	0.3%
7-9 a.m.	136	37.8%
7-9 a.m.; 4-6 p.m.	125	34.7%
7-9 a.m., 4-6 p.m.; Other	39	10.8%
7-9 a.m.; Other	21	5.8%
Blank	3	0.8%
Other	25	6.9%
Total	360	

3. Has there been traffic approaching on County Road 47 when you have driven through this intersection in the last 30 days?
(Has there been approaching traffic present when you have driven past the warning sign?)

Response	County Employees		General Public	
	Count	% of Total	Count	% of Total
No	18	17.5%	7	1.9%
Yes	79	76.7%	353	98.1%
Sometimes	1	1.0%	0	0.0%
Yes/No	5	4.9%	0	0.0%
Blank	2	1.9%	0	0.0%
Total	105		360	

County employees had frequent exposure to the laboratory test sign, with 89.5 percent indicating that they had driven past the sign more than five times at the time they were surveyed. Of those times, 76.7 percent reported the presence of traffic on the cross street (Prairie Center Drive), a high percentage for such a low volume road.

The general public respondents had frequent exposure to the field test sign, with 92.2 percent passing the sign more than five times in the 30 days prior to receiving the survey. Of those times, 98.1 percent reported the presence of traffic on County Road 47.

4. If yes, did you see the warning sign flash?
(If yes, did the warning sign activate?)

Response	County Employees		General Public	
	Count	% of Total	Count	% of Total
Blank	22	21.0%	6	1.6%
No	9	8.6%	10	2.8%
Yes	69	65.7%	340	94.4%
Yes/No	5	4.8%	4	1.1%
Total	105		360	

65.7 percent of County employees reported seeing the sign flash. While this may reflect a lower number reporting that they had seen traffic on Prairie Center Drive, there were also a relatively high number of County employee respondents (21 percent) who left this question blank.

A much higher portion of the general public (94.4 percent) saw the sign flash.

County employee comments: six comments indicated that they did not notice flashing, or noted what appeared to be failures of the system.

General public comments: ten indicated that they perceived intermittent operation and/or visibility issues with the sign.

5. If you have seen the sign flash, please indicate if this was:

Response	General Public	
	Count	% of Total
After Receiving Survey	15	4.2%
Blank	7	1.9%
Both	182	50.6%
Prior to Receiving Survey	156	43.3%
Total	360	

This question was asked in order to determine if the survey itself had brought driver awareness to the sign's operation. A small portion of respondents (4.2 percent) reported seeing the sign flash only after receiving the survey.

General public comments: One respondent indicated a desire to have the sign also face County Road 47. The other two comments related to when they first noticed the sign.

6. A flashing sign means to look for approaching cross street traffic. Is this clear?
(A flashing sign means to look for cross street traffic. Is this meaning clear?)

Response	County Employees		General Public	
	Count	% of Total	Count	% of Total
Blank	6	5.7%	1	0.3%
No	18	17.1%	37	10.3%
Yes	80	76.2%	319	88.6%
Yes/No	1	1.0%	3	0.8%
Total	105		360	

A majority of the County employees (76.2 percent) responded that the meaning of the flashing sign (to look for cross-street traffic) was clear. When asked if the sign improved their awareness of approaching traffic, the County employees were split; with 49.5 percent replying that it had not improved awareness and 46.7 percent indicating that it had.

A large majority of the general public (88.6 percent) responded that the meaning of the flashing sign (to look for cross street traffic) was clear to them. When asked if the sign improved their awareness of approaching traffic, the general public strongly indicated that it had, with 79.2 percent answering "yes".

County employee comments: three comments expressed confusion, seven remarked on the appearance of the sign, seven stated they watch for traffic regardless of the presence of the sign.

General public comments: A large number of comments (51) were received. Of these, 33 indicated some confusion prior to receiving the survey over the meaning of the sign. Several others expressed a desire for a larger/more visible sign. 88.6 percent responded that the meaning of the sign was clear, but for some portion of them, it may not have been so until they had read the survey.

7. Does the warning sign improve your awareness of approaching traffic?
(Does the warning sign improve your awareness of traffic approaching the intersection?)

Response	County Employees		General Public	
	Count	% of Total	Count	% of Total
Blank	4	3.8%	7	1.9%
No	52	49.5%	65	18.1%
Yes	49	46.7%	285	79.2%
Yes/No	0	0.0%	3	0.8%
Total	105		360	

County employee comments: Four people said that the improvement in awareness was slight; that the sign was unnecessary; or wondered what would happen if the system failed.

General public comments: 12 of the 17 comments stated that the sign did improve their awareness of the intersection, or would now that the respondent understood how the sign operates. The others stated that they watched for traffic anyway, or that visibility at the intersection was still bad.

8. Do you rely on this sign to warn you of approaching traffic rather than watching for yourself?

Response	County Employees		General Public	
	Count	Count	Count	% of Total
Blank	2	1.9%	4	1.1%
No	99	94.3%	331	91.9%
Yes	3	2.9%	24	6.7%
Yes/No	1	1.0%	1	0.3%
Total	105		360	

The County employees predominantly indicated (94.3 percent) that they would not rely on the sign alone rather than watching for traffic themselves. Only 2.9 percent of County employees indicated they would rely on the sign alone rather than watch for traffic themselves.

Similarly, the majority of the general public indicated that they would not rely on the sign alone rather than watching for traffic themselves (91.9 percent). However, 6.7 percent of the general public indicated they would rely on the sign alone rather than watch for traffic themselves. Motorists becoming dependent on the sign is an item to consider, as identified at the onset of the project. Any number of motorists that indicate they are dependent on the sign could become an issue. However, as this is a public survey, some respondents may have indicated they were dependent on the sign in order to compliment the system.

County employee comments: One comment expressed concern that people could become dependent on the sign.

General public comments: Of the 21 comments received, nearly all said that they would not rely on the sign. Three comments said that they would rely on the sign “somewhat” or “sometimes” and one speculated that “but I may begin to”.

9. What actions do you take when you see the sign flash?

Response	County Employees		General Public	
	Count	Count	Count	% of Total
Blank	4	3.8%	4	1.1%
Pay Less Attention	3	2.9%	3	0.8%
Pay More Attention	45	42.9%	185	51.4%
More, No Change	0	0.0%	5	1.4%
More, No Change, Other	0	0.0%	1	0.3%
More, Other	0	0.0%	8	2.2%
Less Attention/Other	1	1.0%	0	0.0%
No Change	43	41.0%	146	40.6%
Other	9	8.6%	8	2.2%
Total	105		360	

As a result of seeing the sign flash, the most common County employee response is to pay more attention to the intersection (42.9 percent). Nearly as common, however, was the response that “no change” in action would be taken (41.0 percent). A minority indicated they would pay less attention (3 percent).

As a result of seeing the sign flash a slight majority (51.4 percent) of the general public said they would pay more attention to the intersection. 40.6 percent said no change in their action would be taken. A minority of respondents (0.8 percent) said they would pay less attention. Furthermore, when asked if they were more likely to stop at the intersection, 65.3 percent of the general public indicated they would. However, many respondents also indicated they would stop simply because of the stop sign.

County employee comments: Two of the five comments indicated that drivers may pay less attention to traffic because of the distraction of the sign.

General public comments: When asked what actions were taken as a result of the sign, several motorists commented that they always paid attention anyway or commented that the intersection was dangerous. One person said that the sign was a distraction from watching for traffic.

10. Are you more likely to stop when you see the sign flash?

Response	County Employees		General Public	
	Count	Count	Count	% of Total
Blank	7	6.7%	10	2.8%
No	43	41.0%	114	31.7%
Yes	52	49.5%	235	65.3%
Yes/No	1	1.0%	1	0.3%
Yes/Not Sure	1	1.0%	0	0.0%
Not Sure	1	1.0%	0	0.0%
Total	105		360	

Similarly, when asked if they were more likely to stop at the intersection when the sign was flashing, 49.5 percent answered “yes” and 41 percent answered “no”. Those who answered “no” often left a comment stating they would stop anyway because of the stop sign. See comment discussion below.

County employee comments: All 11 comments indicated that they stop regardless of the presence of the sign.

General public comments: All of the 35 comments indicated that they stop regardless of the presence of the sign.

11. Based on your understanding of the warning sign, does it flash as you expect it to?
(Based on your understanding of the warning sign, does it activate as you expect it to?)

Response	County Employees		General Public	
	Count	Count	Count	% of Total
Blank	14	13.3%	24	6.7%
No	20	19.0%	36	10.0%
Yes	71	67.6%	298	82.8%
Yes/No	0	0.0%	2	0.6%
Total	105		360	

In terms of comprehending the purpose of the sign and its operation, 67.6 percent of County employees indicated that the sign worked as they understood it was intended to, with 19.0 percent saying it did not.

82.8 percent of all the general public respondents indicated that based on their understanding of the sign, it flashed as they expected it too. However, many people thought the sign was always supposed to flash, see comments below.

County employee comments: Twenty-six total comments were received, of which 11 indicated that the system did not operate as they had expected. Another four stated that the respondent didn’t know what to expect and three said that they had never seen the

sign activated. The remaining comments indicated that they hadn't seen the sign or did not pay attention to it.

General public comments: Comments were again received indicating confusion about the meaning of the sign. Of the 47 comments, 17 reported some confusion over the sign's message. The remaining comments recommended different sizes or operational changes to the sign. One person indicated that they paid no attention to the sign.

12. Other comments

County employee comments: a total of 50 comments were received for question 12. They generally fell into the following categories:

- Concerned with the money being spent on the system.
- Wondered if the sign might provide an incentive to drivers to pay less attention to the actual roadway.
- Had not seen the sign flash.
- Expressed concern that the sign and its attendant devices represent a distraction.
- Thought another location may be more appropriate.

Two individual comments of note were that the sign appeared to activate in heavy rain without any vehicles present and that the use of yellow LED arrows seemed to conflict with the red stop sign.

General public comments: a total of 225 comments were received for question 12. They generally fell into the following categories:

- 36 comments reported confusion about the sign's meaning.
- 25 indicated that they thought an intersection stop light or 4-way stop would be a better solution to the safety issues in the area.
- Other comments expressed support for the system, were related to geometric changes that the respondent thought were appropriate, or were opposed to the project on financial grounds. For example, nine respondents indicated that it was a poor use of taxpayer resources.

3.4. Test Plan 4 – Evaluate System Performance

3.4.1 Overview

System performance is an important aspect of the system evaluation. Elements such as reliability and accuracy directly impact the effectiveness of the warning system. In order to determine if the system performed adequately a number of objectives were developed. These objectives are largely based on the various system requirements. These objectives include:

- The system will meet all stated functional requirements
- The system will meet all stated performance requirements
- The system will meet all stated operational modes
- The system will meet all stated interface and subsystem requirements
- The system will meet all stated data requirements
- The system will meet all stated enabling requirements
- The system will meet all test and evaluation requirements
- The system shall perform reliably
- The system will have a false detection rate of less than 0.5 percent

The majority of the data for this test plan came from field acceptance test results provided by the project contractors. Some additional field data collection was used to supplement the provided data, including observation of video images.

The majority of the system requirements were verified through acceptance testing that was conducted separately from the evaluation. However, there were 15 requirements that required input from the evaluation process to determine if they should be classified as PASS or FAIL. These are listed in Table 5.

**Table 5
System Requirements Measured by Evaluation**

Requirement Category	Requirement	Data Source
Functional	2.3.1 - Sign meaning is intuitive to driver	Surveys
Performance	3.3.0 - Safety: the intersection warning system shall not obscure or detract from any in place signing	Project team and surveys
	3.4.0 - Reliability: The system shall reliably detect approaching mainline traffic and predict arrival at the intersection	System data
	3.5.0 - Availability: The system is intended for 24 hour per day, 7 day per week continuous operation	System data
	3.5.1 - The system shall function with a 99 percent up time	System data
	3.7.0 - Failsafe mode: The failed system shall not present a more dangerous situation than if the system was not present at the intersection	Project team
Operational Requirements/ Operational Modes	4.1.4 - The indication will be displayed for a duration that corresponds to the calculated time needed for the approaching vehicle(s) to proceed to the intersection.	System data
Interface and Subsystem Requirements	5.1.2 - Detectors shall have a false indication rate of less than 5 false indications per 1,000 vehicles detected (0.5 percent)	System data
	5.3.2 - The warning message or indication given to the driver shall be intuitively obvious to understand	Surveys
	5.5.0 - Environmental Requirements: The system shall function to defined requirements in typical Minnesota weather conditions. The operating temperature range shall be: -34 to +74 degrees C	System data and weather data
	5.6.2 - Wireless connection shall perform in heavy rain and snow conditions up to and including 3 inches per hour (includes wireless communication equipment and traffic sensors)	System data and weather data
Enabling Requirements	7.2.1 - Detailed design process and the final test results shall be used to identify the maximum AADT that a roadway may have and still allow the IWS to operate	System data and project team
	7.6.0 - System Costs: The system shall be considered low cost	Project team
	7.6.1 - System cost for basic detection and communications is relatively fixed, the variable cost items are related to solar panel and battery installation	Project team
Test and Evaluation Requirements	8.3.0 - System data shall be retained for 7 days	System data

3.4.2 Data Collection and Analysis

As listed in Table 5, a variety of data sources were used to evaluate the system requirements. This included a large amount of data that was recorded at the site. This information was downloaded every seven days from the site for analysis. This data provided information regarding all components of the system. By analyzing this data, it was determined if the system met the stated objectives.

3.4.3 Findings

This section lists each test objective with a summary and interpretation of the relevant data. From this, it can be determined if the various objectives were met.

- The system will meet all stated functional requirements.

- 2.3.1 – Sign meaning is intuitive to driver.

As seen in the survey results, 76.2 percent and 88.5 percent of the County employees and general public, respectively, indicated that it is clear that a flashing sign means to look for cross-street traffic. Furthermore, 67.6 percent of County employees and 83.3 percent of the general public responded that the sign flashes as they expect it to. By looking at the survey responses, it does appear that the sign meaning is intuitive to the majority of drivers. However, there is also a portion of drivers (9.3 percent) that initially though the sign flashed continuously, and was not operating correctly when it was not in operation. They only understood its operation through the process of completing the survey.

- The system will meet all stated performance requirements.

- 3.3.0 – Safety: The intersection warning system shall not obscure or detract from any in place signing.

There were no comments received in the general public survey results that indicated that the sign conflicted with any in place signing. Furthermore, the owner satisfaction survey also indicated that the sign did not create any sight problems or in any other way distract from in place signing.

- 3.4.0 – Reliability: The system shall reliably detect approaching mainline traffic and predict arrival at the intersection.

System data regarding the detection of vehicles and activation of the sign was analyzed to quantify reliability. Observation of the system in operation, combined with a review of the system data, indicates that this requirement is met.

- 3.5.0 – Availability: The system is intended for 24 hours per day, seven days per week continuous operation.

As shown by the system data, there were three subsystem failures during the six-month field operational test. In each of these three failures one of the subsystems of the IWS failed while the other subsystems continued to operate. For example, two of the failures were power failures at one of the detection nodes, which caused the system to go into failsafe mode. These failures totaled approximately 62 hours of down-time during a total of a 4,320 hour test. This yields a system up-time of 98.6 percent. Note that the 62 hours of downtime is mostly made of time it took to notice that the system was down, not time to actually execute the necessary repairs.

- 3.5.1 – Availability: The system shall function with a 99 percent up-time.

As previously calculated, the system had an up-time of 98.6 percent.

- 3.7.0 – Failsafe mode: The failed system shall not present a more dangerous situation than if the system was not present at the intersection.

Upon receiving responses regarding this issue from the owner satisfaction survey, it was agreed upon by the system owners that the system in a failed state did not present a more dangerous system than if the system was not present.

- The system will meet all stated operational modes.

- 4.1.4 – The indication will be displayed for a duration that corresponds to the calculated time needed for the approaching vehicle(s) to proceed to the intersection.

As determined in memorandums dated July 2, 2008 and September 23, 2008, the system indicated approaching cross-traffic at the appropriate time. For details of these memorandums, please see Appendix E.

- The system will meet all stated interface and subsystem requirements.

- 5.1.2 – Detectors shall have a false indication rate of less than five false indications per 1,000 vehicles detected (0.5 percent).

A Wavetronix 105 radar traffic detector was used to generate traffic counts for County Road 47 westbound traffic for a 24-hour period. Upon comparing these results to a count by the IWS, it was determined that the system count varied by 4 percent. However, a Wavetronix 105 detector typically has a 5 percent error. Therefore, the only statement that can be made is that the detection error is within the 5% accuracy limits of the baseline. It should also be noted that the vendor indicated that he observed miscounting occur when vehicles traveling in the opposite direction crossed over the centerline.

- 5.3.2 – The warning message or indication given to the driver shall be intuitively obvious to understand.

See response to 2.3.1.

- 5.5.0 - Environmental Requirements: The system shall function to defined requirements in typical Minnesota weather conditions. The operating temperature range shall be: -34 to +74 degrees C.

The system experienced three failures over the six month field operational test. As previously indicated, these were not system failures, but rather failures of individual subsystems. One failure was due to water intruding into the battery box. This was not due to temperature effects, but due to the location of the battery box. As the battery box was mounted on the ground, water entered the box as the area flooded and caused the failure. The box was subsequently moved to an area that would not flood as easily. Therefore, the system is considered functional.

- 5.6.2 – Wireless connection shall perform in heavy rain and snow conditions up to and including 3 inches per hour (includes wireless communication equipment and traffic sensors).

There were no failures directly due to rain or snow conditions. However, snow on the solar panels did cause the battery to recharge much more slowly. The two comments received in the survey that indicated the sign activated due to rain were investigated. No evidence was found in the data that suggested the sign activated due to heavy rain or snow fall.

- The system will meet all stated enabling requirements.

- 7.2.1 – Detailed design process and the final test results shall be used to identify the maximum AADT that a roadway may have and still allow the IWS to operate.

While it is inherently difficult to determine a definitive “maximum AADT” that would still provide an effective IWS deployment, an estimate can be made from the field operational test. At this field operational test, occasional queues were noticed on Lawndale Lane. If queues were present more often, the sign would lose its effect, as drivers would already be expecting cross-traffic. Furthermore, during peak periods, the traffic on County Road 47 appeared to activate the sign quite frequently. If any additional traffic had been present, the sign would have always flashed, reducing its effect on drivers. Therefore, the AADT on County Road 47 of approximately 3,000 vehicles, is proposed to be the maximum allowable for the system to be effective.

- 7.6.0 – System Costs: The system shall be considered low cost.

As determined by the owner satisfaction survey, the system is considered to be low cost. Other alternatives to improve safety at the intersection would involve installation of traffic signals or a modification to the road geometry. Both of these options would be much more costly than the implemented system.

- 7.6.1 – System cost for basic detection and communications is relatively fixed, the variable cost items are related to solar panel and battery installation.

The respondents of the owner satisfaction survey confirmed that the price of the basic detection and communication is fixed. Furthermore, it was asserted the costs of the solar panels and batteries may vary. However, a few respondents indicated that the costs of the solar panels and batteries are more or less fixed relative to the overall system cost.

- The system will meet all test and evaluation requirements.

- 8.3.0 – System data shall be retained for seven days.

Throughout the field operational test, data was obtained from the site every seven days. Upon every visit to the site, the last seven days of data were available (except for the noted subsystem failures).

- The system shall perform reliably.

- Mean time between failures.

As previously indicated, there were three subsystem failures during the field operational test. The field test lasted six months. Therefore, the mean time between failures is approximately 60 days, or 1,440 hours. All project team members said this is of exceptional quality for a prototype level test.

- False positive rate.

Due to a lack of data obtained during the field operational test system, the false positive rate could not be determined.

- False negative rate.

Due to a lack of data obtained during the field operational test system, the false negative rate could not be determined.

- The system will have a false detection rate of less than 0.5 percent.

See response to 5.1.2.

4. Conclusion

A number of conclusions can be drawn by looking at the various test plans incorporated into this Evaluation Report. Some of these conclusions apply only to specific elements of the test, but others can be used to indicate the overall performance of the system.

Test Plan 1 – Evaluate Safety Impacts of the Systems

From the comparison of the “before” and “after” conditions at the field operational test site, the following conclusions regarding the safety impacts of the system can be made.

- The Traffic Conflict Rate was greatly reduced after the installation of the Intersection Warning System. This can be seen by the 54 percent reduction in the number of traffic conflicts from the “before” to “after” condition.
- The change in Traffic Conflict Severity seems to be negligible. In both the “before” and “after” conditions various severity conflicts were encountered. Interestingly, the most severe conflict actually occurred after the installation of the Intersection Warning System.
- Weather and lighting conditions were not correlated with traffic conflict rates since the data was collected in well lit and dry pavement conditions.

Overall, the IWS had a positive safety impact on the intersection as shown by the decrease in TCR. The change in TCS was not large.

Test Plan 2 – Evaluate Owner Satisfaction

Upon reviewing the responses received from the Owner Satisfaction Survey, the following thoughts regarding the system are agreed upon by the system owners:

- The system is very reliable and effective at warning drivers of approaching cross street traffic.
- The installation, operation and maintenance of the system is fairly simple and straightforward. With appropriate training regarding the components of the system, public works personnel will be able to take care of the system.
- The system is designed to be modular and could be deployed at a variety of other intersections. The key is for the operating agency to determine locations where the system will be most effective.
- The test log requirements were all met by the system. This indicates that the system did not obstruct other signage in the area and that the system did not create a greater hazard to drivers if it failed. Additionally, the system has a relatively fixed, low cost.

Test Plan 3 – Evaluate User Perception of the System

Before making any final conclusions based on the findings on the survey results, it is important to remember the differences between the laboratory and field test systems. The laboratory test was installed for County employees leaving the Medina Public Works building parking lot. There is no history of traffic safety issues at this location. Conversely, the field test system was located at an intersection with sight line issues and a high crash rate. This intersection of Lawndale Lane and County Road 47 was described to be an extremely dangerous intersection by many comments from the general public survey, and has a high crash rate based on historical records. Considering this distinction, the results of the motorist survey were expected to be more positive. User perception conclusions include:

- Overall, both groups (County employees and the general public) indicated that they were aware of the sign and generally understood its meaning.
- Approximately half of those surveyed indicated that they would pay more attention at the intersection as a result of seeing the sign flash. The general public responses tended to be more uniform and positive about the system and its operation.
- From the general public's comments, approximately 10 percent did not understand the intent of the flashing sign without further explanation. Some believed it was meant to flash continuously, or activated when they approached it as opposed to cross-traffic approaching. In any case, some sort of publication information should be provided to educate drivers.
- The high survey response rate (55 percent) along with the high number of written comments (208 surveys with comments out of 360 returned surveys) indicates that the general public has a strong interest in this intersection and public safety in general. The detailed observations regarding the sign and its effects on motorists further convey the idea that the general public is very concerned in regards to traveler safety.

Test Plan 4 – Evaluate System Performance

By comparing the system requirements to how the system actually performed, the overall system performance can be evaluated. Conclusions below are based on requirements verified through acceptance testing and through the evaluation process.

- The system met all functional requirements as the sign was intuitive to drivers. This was determined based on survey responses from the general public and County employees.
- The system was determined to be reliable and safe by achieving a 98.6 percent uptime as it failed three times during the six-month field operational test. Furthermore, the system did not obstruct any in place signing nor did it become an increase hazard when it entered the fail-safe mode.

- In general, the system was able to operate throughout all weather conditions. Water in the battery box did cause a failure, but this was due to battery box placement.
- The system detectors were determined to have a false detection rate that was within the limits of the evaluation methods (5%).
- Beyond the system performance evaluated in this test plan, the system also was required to go through acceptance testing. Through this process the system met additional objectives related to the system's performance. For the System Requirements Test Log, see Appendix F (the appendix includes an uncompleted version of the log).

As seen by these test plan findings, the Intersection Warning System offers an effective method to increase safety at rural intersections. The system meets the systems requirements, is received well by the public, and is shown to reduce conflicts at the test intersection. Based on these results, Hennepin County has extended the maintenance contract on the system for one year.

Appendix A

Traffic Conflict Data

“Before” Condition Conflict Data

Date/Weather	Time	Time to Collision Severity	Risk of Collision Severity	Conflict Description	Construction
7/28/08 1530-1600 (Sunny)	15:40 15:42 15:43	Low Low Moderate	Low Low Low	Slight Braking Only Slight Braking Only Moderate Braking	Occasional construction
7/29/08 0800-1600 (Sunny)	8:23:30 8:47:16 9:10-10:00 11:05:03 12:00-12:45 13:04:18 13:30-14:15 15:51:43	Low Low ----- <i>Reconstruction of Shoulder with Flagmen</i> ----- Low Moderate Moderate Moderate	Low Low ----- Low Moderate Moderate Low	Slight Braking Only Slight Braking Only ----- Slight Braking Only ----- <i>Construction with Flagmen</i> ----- Braking and Minor Swerve ----- <i>Construction at Intersection</i> ----- Moderate Braking	Occasional construction
7/30/2008 0800-1600 (Sunny)	8:00-16:00 8:02:40 14:13:12	----- <i>Construction All Day</i> ----- Low Low	----- Low Low	----- Slight Braking Only Slight Braking Only	Construction all day (these two conflicts were the only ones counted because they did not seem to be a direct result of the ongoing construction)
7/31/2008 0800-1545 (Raining)	9:00:52 9:51:05 11:30-14:45	Low Low ----- <i>Tree Pruning with Bucket Trucks and Flagmen</i> -----	Low Low -----	Slight Braking Only Slight Braking Only -----	Construction 2nd half of day

“After” Condition Conflict Data

Date/Weather	Time	Time to Collision Severity	Risk of Collision Severity	Conflict Description	Construction
11/18/08 1300-1600 Overcast	13:52:33	Moderate	High	Very Strong Braking	None
11/19/08 800-1345 Overcast	8:32:50 8:48:41	Low Low	Low Low	Slight Braking Only Slight Braking Only	None
11/20/08 830-1000 Partly Cloudy	<i>No Events Occurred During this Time Period</i>				None
11/24/08 1230-1600 Partly Cloudy	<i>No Events Occurred During this Time Period</i>				None
11/25/08 800-1200 Sunny	8:30:53	Low	Low	Slight Braking Only	None

Appendix B

Hennepin County Sample Survey

Intersection Warning System Driver Survey

Hennepin County and its project partners are testing an active warning system to alert drivers approaching an intersection to look for oncoming traffic. This system is being tested at the main entrance to the Medina Public Works facility. The test will run from July 9th to July 30, 2008. Please help us evaluate the system by answering the questions below. Return completed surveys to Eric Drager, Hennepin County Public Works, by Wednesday, August 6th. Contact Eric at (612) 596-0309 or Greg Chock at (612) 596-0758 with any questions about this study.



- 1) How many times have you driven past the warning sign?
_____ (none) _____ (1-2) _____ (3-5) _____ (5 or more)
- 2) Has there been approaching traffic present when you have driven past the warning sign? _____ (Yes) _____ (No)
- 3) If yes, did the warning sign activate? _____ (Yes) _____ (No)
- 4) A flashing sign means to look for cross street traffic. Is this meaning clear?
_____ (Yes) _____ (No) If no, please explain: _____

- 5) Does the warning sign improve your awareness of traffic approaching the intersection?
_____ (Yes) _____ (No)
- 6) Do you rely on this sign to warn you of approaching traffic rather than watching for yourself?
_____ (Yes) _____ (No)
- 7) What actions do you take when you see the sign flash?
_____ Pay more attention to approaching traffic _____ Pay less attention to approaching traffic
_____ No change in my driving pattern _____ Other (explain below)
- 8) Are you more likely to stop when you see the sign flash? _____ (Yes) _____ (No)
- 9) Based on your understanding of the warning sign, does it activate as you expect it to?
_____ (Yes) _____ (No) If no, please explain: _____

Appendix C

General Public Sample Survey



Traffic Approaching Warning Sign Driver Survey

Hennepin County is testing a "LOOK FOR TRAFFIC" flashing warning sign that alerts drivers of cross street traffic. The sign is being tested at the 'T' intersection of Lawndale Lane and County Road 47 in Plymouth (sign is visible to motorists driving south on Lawndale Lane).

Please help us evaluate this sign by answering the following questions and returning the survey to Eric Drager, Hennepin County Public Works, by Friday, December 5th. Contact Mr. Drager at eric.drager@co.hennepin.mn.us or (612) 596-0309 with any questions about this study.



1. How many times have you driven south on Lawndale Lane through this intersection in the last 30 days? none 1-2 3-5 5 or more
2. What time of day do you typically drive south on Lawndale through this intersection? Check all that apply.
 7-9 am 4-6 pm Other time: _____
3. Has there been traffic approaching on County Road 47 when you have driven through this intersection in the last 30 days? Yes No
4. If yes, did you see the warning sign flash? Yes No
5. If you have seen the sign flash, please indicate if this was:
 Before receiving this survey After receiving this survey Both
6. A flashing sign means to look for approaching cross street traffic. Is this clear? Yes No
If no, please explain: _____
7. Does the warning sign improve your awareness of approaching traffic? Yes No
8. Do you rely on this sign to warn you of approaching traffic rather than watching for yourself?
 Yes No
9. What actions do you take when you see the sign flash? Pay more attention to approaching traffic
 Pay less attention to approaching traffic No change in my driving
 Other (please explain) _____
10. Are you more likely to stop when you see the sign flash? Yes No
11. Based on your understanding of the warning sign, does it flash as you expect it to? Yes No
If no, please explain: _____
12. Other comments? _____

Appendix D

Comment Text (Both Surveys)

County Employee Comments

- 1) How many times have you driven past the warning sign?
 - 1) Don't you mean "face the sign?"
- 2) Has there been approaching traffic present when you have driven past the warning sign?
 - 1) Don't you mean "face the sign?"
- 3) If yes, did the warning sign activate?
 - 1) Don't recall.
 - 2) But too late
 - 3) The system failed early in the test period. What guarantee is there that the system won't fail in the future?
 - 4) Most of the time.
 - 5) Did not notice?
 - 6) Only appears to be working for eastbound approaching traffic.
- 4) A flashing sign means to look for cross street traffic. Is this meaning clear? If no, please explain
 - 1) "I always look for traffic, maybe ""approaching traffic"" would be clearer."
 - 2) Should say which way the traffic is coming from instead of general.
 - 3) Not always.
 - 4) You need to look and see is it clear before going.
 - 5) I look anyway, it's just flashing arrows.
 - 6) It's clear but the yellow arrows are really small and if I had not been looking for something to happen to the sign I would have missed the flashing arrows.
 - 7) Shouldn't you always look for traffic even if there is no flashing sign?
 - 8) If the sun hits the sign in a certain manner, it's not evident or clear that there's any flashing going on.
 - 9) LIGHTS COLOR SAME AS SIGN.
 - 10) This could be misleading. You should always look for traffic. And of course this is a stop condition.
 - 11) THE SIGN IS NOT VERY VISABLE, ESPECIALLY FOR TURNS, AS YOU ARE USUALLY BUSY LOOKING FOR TRAFFIC, NOT SIGNS. THEY WORK BETTER FOR THROUGH TRAFFIC, IN PREPARATION FOR UPCOMING STOP LIGHT CHANGE.
 - 12) I thought it has activated when there was no approaching traffic. I thought it was to serve as a reminder. I did not understand that it was responding to oncoming traffic. What really tells us that?
 - 13) A flashing sign means pay attention.
 - 14) I don't know if all would understand it w/o explanation. Plus, I am looking down and sideways vs. up and in front (where sign is).
 - 15) But the flashing is distracting for a moment.
 - 16) Paid little attention to sign (we are over stimulated already).
 - 17) DISTRACT ATTENTION.
 - 18) Not sure. I know because I work here and I saw the sign being installed.
 - 19) I always look for traffic, so why a sign?
 - 20) Flashing or not you see look for cross traffic.
 - 21) Sometimes it is still flashing when trucks are past the intersection, unless the also set off the sensors when they pass the sensor for the opposite approaching lane.
 - 22) Flashing is almost invisible. Flashing lights are lost in the field of too much yellow warning sign.
 - 23) Still have to look.
- 5) Does the warning sign improve your awareness of traffic approaching the intersection?
 - 1) What if the system fails?
 - 2) Slightly.
 - 3) I can think for myself. It is a stop condition.
 - 4) I wonder how many times it was flashing and I didn't see it.
- 6) Do you rely on this sign to warn you of approaching traffic rather than watching for yourself?
 - 1) But this sign could get people dependent on just the sign alone.
 - 2) See above.
- 7) What actions do you take when you see the sign flash? Pay more attention to approaching traffic/Pay less attention to approaching traffic/No change in my driving pattern/Other (explain below)
 - 1) Because I'm looking at the flashing sign.
 - 2) I look to figure out why it's flashing.

- 3) Pause for a longer time than usual to observe the sign (add'l delay?).
- 4) I stop anyway - it is a stop sign.
- 5) I pay attention to traffic, but look anyway. The sign gives me more warning and does help me to look more and stop instead of a rolling stop.

8) Are you more likely to stop when you see the sign flash?

- 1) Should stop anyway.
- 2) I stop because there is a stop sign.
- 3) It's a stop condition. I always stop at stop signs.
- 4) I HAVEN NEVER RECOGNIZED THE FLASHING LIGHT, EVEN THOUGH TRAFFIC HAS BEEN APPROACHING.
- 5) I always stop anyway.
- 6) My experience is that I am more aware or likely to double check for oncoming traffic.
- 7) I will stop always, it's the law.
- 8) I stop at the stop sign.
- 9) I stop anyhow.
- 10) I'm already stopped!
- 11) A complete stop instead of a rolling stop.

9) Based on your understanding of the warning sign, does it activate as you expect it to? If no, please explain:

- 1) Haven't paid that much attention as to whether or when it activates. I stop and look both ways because there is a stop sign there.
- 2) Slow cars are already there when it flashes.
- 3) Doesn't activate until you pass by the center sign.
- 4) I look on my own, so I haven't thought about it.
- 5) I do not know.
- 6) Don't know.
- 7) Lights up too late.
- 8) I think the timer is off because the traffic is at or past the intersection before it starts flashing.
- 9) Not usable.
- 10) I think there were problems with it in the beginning which caused me to change my expectations of the system.
- 11) I am unsure how far away a vehicle should be before it is activated. I've been approaching the intersection and it isn't going but I see the traffic coming.
- 12) Never saw it activate, could not see it well due to the sun. I saw approaching traffic but never saw it flash.
- 13) IT IS NOT VISIBLE ENOUGH.
- 14) I thought it was to serve as a reminder to stop and watch for traffic only.
- 15) During the test period I had no preconceived idea as to what to expect for operation. I experienced curiosity. 1 observation is not enough to draw any conclusion.
- 16) I have never seen the sign activate, so I do not even know that it works.
- 17) Seems it didn't always flash when traffic approached.
- 18) I try to ignore the flashing lights.
- 19) Sometimes there is no activation but there is traffic.
- 20) It did not always activate for approaching traffic.
- 21) As noted above, sometime it is flashing and trucks are already past the intersection.
- 22) I have not seen the warning sign activate as designed.
- 23) I don't always pay attention to the flashing arrows or the whole sign in particular, because I habitually look left then right anyways at intersections.
- 24) The detector for westbound traffic appears to be inoperable or very intermittent.
- 25) What is it that it is expected to do?
- 26) Never have seen it on.

10) Other comments?

- 1) Waste of money and time.
- 2) I have not had the opportunity to see it in action, however I am aware that it is there.
- 3) Good idea - when it works right.
- 4) Never noticed flashing lights.
- 5) How much did it cost and whose budget did it come out of.
- 6) The lights don't stand out in the daylight.
- 7) I thought it was more of a distraction than anything else. Part of this should be attributed to my sense that I don't think oncoming traffic is a problem at this intersection While this system might become more of a warning device as its novelty wears off, it didn't really help me become more aware of oncoming traffic in this particular application.
- 8) It is a stop condition at this intersection That means STOP. A sign like this only encourages drivers to roll through the intersection. What happens when drivers become dependent on the sign and it fails. Would the County be liable? I think this is a bad idea and should be discontinued.
- 9) We really need something like this at crosswalks that are on bike trails etc that are in the middle of a road (I know Vicksburg comes to mind, even though it isn't a county road) and you see the crossing lines on the road going 35-40 mph and you realize you need to watch for pedestrians and it's almost too late. Something like this that could activate and warn traffic that people are approaching would be WONDERFUL.

- 10) It is my practice to stop and look both ways at a stop sign. This warning sign was across the road, which in my mind was a bad place to begin with. I look side to side not forward to watch a sign. If anything, this sign deters the idea of Stop and Look both ways.
- 11) On days when the sun was bright and shining onto the sign, I did not think the flashing lights were all that bright or distinguishable. I'm sure they work fine at night.
- 12) NEED FOR LAW ENFORCEMENT FOR NON-STOPPERS.
- 13) "My feeling is that this system will create a false sense of security and that drivers will rely on the sign rather than looking before proceeding. If this is a "sight distance problem," fix the "sight distance" problem. "
- 14) During hard rain it activated with no cars approaching.
- 15) I think this system is a clear waste of taxpayer's money. It's one more sign in the millions of signs out there that people don't read. Isn't the essence of a stop sign that you should look both ways and come to a complete stop? So when people become complacent to this system, are there going to be other systems to try and fix stupid people and their driving? Is a stop sign that confusing to not understand? Stupid people are always going to be stupid and people that are aware of their driving don't need this system. Maybe if everyone read and understood English people would be better drivers. What's next? A stop sign in every language spoken in the US?
- 16) "What a complete waste of money. A joke. How can the County afford stupid things like this in these "tight" times?"
- 17) Stupid idea. What then does a stop sign mean?
- 18) If this sign were at a yield sign or other intersection control than a stop sign I would be more likely to stop.
- 19) "This particular sign is a waste of resources. There is already a stop sign at a "T" intersection. What more is really needed?! If the device fails to operate is there additional liability for the installer of the device. Additional maintenance costs? Security of solar device and battery cost? Are crossing guards next? Common sense and good driving habits may be less common these days. I don't think this sign will change that."
- 20) I believe that this sign would make people less apt to stop at the stop sign if they notice the arrows not flashing.
- 21) Only observed the sign operation once as no traffic was approaching during the other days as I drove past the sign. It should also be noted that during the one time I observed the sign in operation, a large dump truck was the approaching vehicle. As it approached the intersection, I knew about it before the sign turned on the flashing lights. If this is to be an early warning system it should pick up the vehicle sooner. If it is just to create additional awareness, it probably does that OK.
- 22) Lights should be brighter or red flashing. Can't see as well during the day.
- 23) "The solar collector on the top of the sign is obviously necessary, but unfortunately it is a distraction (people do not expect "things" to be mounted on traffic signs)."
- 24) On one occasion when the sign was flashing as I approached it from the driveway there was no cross traffic travelling on the city street. This only occurred once, not sure if it was a malfunction, if the settings had been changed, or if the cross traffic had just recently disappeared around a corner out of my line of sight. The fact that the sign was flashing caused me to take a double look in each direction for traffic as I suspect I have become conditioned to believe the sign.
- 25) Ideally, I think the sign should be brighter. Maybe it's the current direction it faces (against the sun), but more LED would have been helpful, having the sign face north on Lawndale should be better.
- 26) The lights tend to be hard to see in sunlight, such as when leaving the County facility in the afternoon with the sun shining directly on the sign. When the sign is flashing, it tends to distract one's attention from the road, and for those of us with a limited attention span, we (I) tend to focus more attention on the sign rather than the traffic. Perhaps over time this would improve, but as something new, I find it more of a distraction than a help. Part of the reason is that, when leaving the County facility, the only direction of real importance is from the left, since I would not be conflicting with traffic from the right. Perhaps in differing situations, it would be of more help.
- 27) "The only issue I had is when the sun is on the sign, it's hard to see the yellow flashing arrows. I think people associate "yellow" with slow down. Maybe red would indicate you should stop. "
- 28) I always stop and look before I pull out; I found the arrows to be a distraction. I'm not sure if it was the color of the arrows or what, but I was more prone to stare at the flashing rather than oncoming traffic.
- 29) "These are more of a distraction than anything. "the lit speed limit sign" do they mean to say I really mean it as to say the no-lit signs are only a suggestion?"
- 30) Relieves driver responsibility/adds another distraction beyond kids, cell phones, make up, shaving, eating, drinking, napping, etc.
- 31) FALSE SENSE OF SECURITY VERY HIGH RISK OF PEDESTRIAN FATALITY FLASHING YELLOW WITH BACKGROUND YELLOW - POOR COMBINATION RECOMMENDATION TO REMOVE UNNECESSARY TOO MANY SIGNS/FLASHING UNIT.
- 32) Waste of time and energy and scarce resources.
- 33) "1) Fix the intersection, road or sightline problem. 2) Install a non-lighted sign that says "Blind Intersection - Watch for Traffic" etc. 3) Drivers may become dependent on the sign."
- 34) This sign will be viewed as another device to relieve the driver of their responsibility of making sure they have safe entry at an intersection. Shortly, motorists will no longer have to stop for the stop sign if the sign indicates no traffic is coming. If the sign fails, what happens when the public relies on the sign rather than visually making sure the intersection is safe? In bright yellow sunlight the yellow arrows and the color of the sign become somewhat muted. There are already more signs than necessary.
- 35) I think the arrows should be bigger.
- 36) Seems as though this installation location is not appropriate.
- 37) I think it would have more impact and be more helpful at a less familiar intersection.
- 38) I have not had an opportunity to see the sign work yet. And, honestly, I would ignore it anyway because I'd be looking to the left while stopping and preparing to make a right turn at the intersection. Not to mention putting on my seatbelt, changing the radio station and turning on the air conditioning while pulling up to the intersection.
- 39) I could see it being more helpful on blind intersections at higher speeds, etc. But wouldn't trust it to determine if it is safe to pull out.
- 40) It's a stop condition, no other signage should be necessary. If there is a preexisting geometric(?) problem fix that. More signs are confusing and a lot of people don't pay attention. What are the liability issues? Who instigated this and what was the cost?
- 41) Add a flasher to the stop sign or place a warning sign below the stop sign which functions through the intersection warning system. Don't take the driver's eye away from the stop sign after all their main responsibility is to stop at ALL times.
- 42) My concern is that the daily commuters will rely on the warning flashers and assume all is clear when they don't flash.

- 43) "In the evening there is a glare caused by the sign. This sign might be effective if the background was all black and the message was more clear. Like just plain ""Traffic"" on a black background with lots more LEDs and more LEDs in the arrows - maybe double rows. Good Idea - bad sign design."
- 44) I do need to have more cross traffic to see how well it works! I have only had cross traffic once or twice. I still need to have cross traffic more when I approach the warning sign to get a better feel for the program!
- 45) This would work perfect for blind intersections (hands down). Great for T intersections. ?? Reverse radial curves (car approaching ?? from behind your view). Will it work on hill crowns? (Drawings included.)
- 46) We have tested the westbound detector by driving in the shoulder- this closer proximity seems to work. (Bob Byers on July 23, 2008)
- 47) I don't need a sign to tell me to look both ways before pulling out! Save Precious Tax Dollars! Have a Nice Day!
- 48) I tried to fill out the survey, but its difficult when I haven't seen the flasher work. Generally my eyes are looking to the left for approaching conflicts. My opinion is that the location is poor for the test.
- 49) No cars have been coming when I am there.
- 50) To be honest I don't even pay attention to the sign. There's no point in having it.

General Public Comments

1. How many times have you driven south on Lawndale Lane through this intersection in the last 30 days?

1. 1c
2. 2x a day
3. Everyday 2-3x's
4. 1 time each day in the last 5 years
5. 2-3x/day
6. 25-35
7. 60 times
8. Everyday!
9. Every workday M-F
10. Every work day > 20 times/month

2. What time of day do you typically drive south on Lawndale through this intersection?

	6-7pm	I leave 3 houses North on 47
Mid day on Weekends. 7pm on Wednesday	6-10	all the time
throughout the day	weekends more than weekdays	multiple times per day (day and night)
6am-7am	occasional afternoons	5-7pm
after 6pm on weekends	lots of different times 4am-10pm	7-8p
All day I leave 2 driveways N of intersection	5:30am-9:00am	any time during the day
6-8pm	9-10am at weekend	3-4pm
8-9am	9am-3pm	11:30am
11am-4pm	11:30am-1pm	mid day & evening
11:00am-1pm	noon	Random
9am-4pm	throughout the day on weekends	during the day
12am	mid-day	varies by day but throughout almost every day
6-10pm	10-11am	3-4pm
all day	2-3x daily	more 9:15am
all times of the day	all times	11:15, 11:45, 3:00, 3:30
9:30am and 4:30 pm	9pm	10am
noon	all times	different times all day long
8pm	anytime	10am-3pm
9-11?	all day	usually at rush hours
evening	2:30am, 8 pm	10:45am/12:15pm
9am to 4pm	7am-3pm	6:00-7:00
12-1pm 7-8pm	all day	off and on everyday-thru out the day
after 10am, after 6pm	2-3pm	all times
8am-2pm	all day	between 8am and 3:30pm
at night	8-10pm	6:30am
12-1pm	1-3pm	3-3:30pm
also at 5:15am M-F	maybe 4-6 to go eat or shopping	11:15, 11:45, 8:15, 8:40-daily and multiple other random times
2:45-3:15	3pm	2-3 pm
11:30am, 1-2pm	weekends	11am-1pm
all the time I live 4 houses away from the intersection	7:30am	all day
weekends, & frequent off peak times	all times of the day	varies - work out of my house

3. Has there been traffic approaching on County Road 47 when you have driven through this intersection in the last 30 days?

1. Always.
2. Not at weekend.
3. Always.

4. If yes, did you see the warning sign flash?

1. Sometimes.
2. Sometimes.
3. It didn't flash during low traffic times - from what I see.

4. But sun in the way!
 5. Inconsistent.
 6. (Sometimes)
 7. Sometimes early in the morning before sunrise it has not lit.
 8. Very difficult to see during the day.
 9. "Yellow arrows were 'on', but I don't recall flashing".
5. If you have seen the sign flash, please indicate if this was:
1. The sign should also face traffic on 47 to at least go the speed limit - people on CR 47 accelerate so Lawndale traffic doesn't pull out in front of them.
 2. Just received the survey today.
 3. I noticed the sign when it was covered.
6. A flashing sign means to look for approaching cross street traffic. Is this clear?
1. We were unaware that the signs were based on detecting vehicles.
 2. Also look if it's not blinking.
 3. Wondered why it is flashing sometimes and not others.
 4. I thought the light was always flashing.
 5. I didn't really notice/relate the sign to approaching traffic. I thought it was a result of reflecting off my car headlights.
 6. But I didn't get that it only flashed when cars approach.
 7. It is now after I received this. I had no idea that is what the purpose of it was.
 8. If it said look for traffic when flashing that would be easier. It took me time to understand.
 9. I never figured out why it would flash or not flash.
 10. The sign doesn't always flash. You could assume if it's not flashing, there is no approaching traffic most always here.
 11. The sign is too small.
 12. The flashing is a distraction, the sign without the flashing is self-explanatory!
 13. More so for people unfamiliar with the area.
 14. The sign does not always flash - most times only notice it flashing during dusk or night.
 15. Until I received this I did not know the flashing meant approaching cars.
 16. Because there are so many cars ahead of me during rush hours.
 17. People shouldn't rely on this-it gives false sense of traffic clear.
 18. Wasn't sure if it flashed always as a warning or only if traffic present.
 19. Not sure about flashing--warning or traffic approaching or both.
 20. My 15-year-old son figured that out before I did. I didn't pick up on its flashing.
 21. It seems like it's just saying to look, not that there is cross traffic.
 22. At first I thought it flashed all the time until my fiancée told me it was hooked up to the sensors.
 23. I thought it flashed at night. My wife thought it flashed all the time.
 24. Maybe could state that when flashing cars are approaching.
 25. I did not understand initially.
 26. Sign only flashes when there is traffic.
 27. I just figured out there was a trigger mechanism.
 28. It would be better to just have a stop light.
 29. I thought it was for construction first!
 30. But I won't trust it.
 31. I did not realize that it only flashed when there were cars approaching. I thought it always flashed to be more visible.
 32. I thought it's just a warning sign only. It doesn't really mean there's actually traffic coming in.
 33. I guess I just didn't realize it only flashed when traffic was approaching.
 34. No clue why it was flashing.
 35. I didn't know that's how it worked until now!
 36. I preferred a bigger one.
 37. At first it was inconsistent. We discussed with others in our neighborhood, as to its purpose.
 38. Did not associate flashing arrows w/traffic. Thought it was simply to warn of the possibility.
 39. Didn't know sign was dynamic. Thought it just always flashed.
 40. It took a few times to figure this out.
 41. It is not clear that flashing means a car is approaching from either direction. See below Q. 12 (other comments).
 42. The sign is not always flashing and you don't really note the sign.
 43. When it wasn't blinking I thought it was broke.
 44. Negative condition; since drivers always should look.
 45. But shouldn't people look anyway?
 46. "It just wasn't clear. The sign should say "cars approaching when flashing".
 47. Does not intuitively imply actual traffic is approaching.
7. Does the warning sign improve your awareness of approaching traffic?
1. Most definitely!
 2. I was aware of the approaching traffic before the sign was there.
 3. More on dark mornings than when it is lighter out.

4. Now it does.
5. Very much.
6. Somewhat.
7. (Now that I know why it flashes).
8. I ALWAYS look for traffic.
9. Maybe, but still hard to see approaching traffic from east.
10. I will still look.
11. Now that I know it only flashes with approaching traffic.
12. But it is still hard to see the traffic approaching due to the steepness of the road.
13. Overall, yes.
14. Only if I remember to look.
15. Now I will know that I know what it is telling me!
16. Now that I know it does.

8. Do you rely on this sign to warn you of approaching traffic rather than watching for yourself?

1. "But it keeps me alert that traffic "happens".
2. Now I do use it as a support. I always look!
3. Sometimes.
4. I also check approaching traffic for myself.
5. Did not trust at first!
6. I am an observant driver anyway.
7. Both.
8. Just because we've lived there long enough to know to look several times. The problem is the blind spot when someone is turning onto Lawndale.
9. But it really helps. That intersection is bad!
10. Somewhat.
11. Still a dangerous intersection (see #12 comments).
12. But I may begin to...
13. (I do both).
14. Also I pay more attention when flashing.
15. Don't trust sign to be accurate all the time. Fear people will trust it all the time and become lazy drivers.
16. (It's a bad intersection!)
17. SCARY!! I don't always trust the sign!
18. Kind of, but I wouldn't 100% trust it.
19. I will now, but not before this card.

9. What actions do you take when you see the sign flash?

1. It reassures my decision.
2. The stop signs means look both ways anyway.
3. Look, but quicker reaction time to either go our stop; you're expecting one of those before you look.
4. I trust my eyes, not explicitly a sign.
5. I have always paid attention to approaching traffic.
6. I'm alerted that there is traffic before I get to the stop sign.
7. I expect traffic in the morning so I'm used to looking both ways.
8. I have always been extremely cautious and wary at this intersection.
9. More aware of it when still dark in morning - No change in driving when lighter outside.
10. Also, drivers on 47 are also turning right/left onto Lawndale - Lawndale drivers are turning right/left onto 47.
11. Continue driving precautiously as usual.
12. It is a dangerous intersection, I am always careful with or without a flashing sign.
13. At first paid more attention.
14. I rely on watching for myself.
15. It reminds me to be a little more cautious as that intersection has a blind approach.
16. I already look for traffic--this is a distraction.
17. I have almost been hit, so I am very aware of traffic or very careful now!
18. I always look carefully.
19. I will still check.
20. Always stop and look if a bad intersection.
21. This intersection requires lots of attention--I find it difficult to turn left from 47 to Lawndale every day--hard to see approaching traffic until they are often too close.
22. I think at first it causes drivers to check--but it has been inconsistent, so over time, people will not trust it and coast through the stop sign.
23. Helps with blind spot in base of hill.
24. The sign just enforces my observations of traffic.
25. I look multiple times to be sure its safe to proceed - hard to see traffic intersection.
26. I am always careful at this intersection because I know there have been many accidents here.
27. I didn't know what it was telling me - I always double check both directions.
28. I always wondered why it only flashed sometimes. If I understand, it only flashes when it senses oncoming traffic?

10. Are you more likely to stop when you see the sign flash?

1. I always stop anyway. It's a stop sign.
2. It's a stop sign controlled intersection.
3. Not anymore than I did.
4. There is a stop sign.
5. But I would stop for the stop sign even if the sign weren't flashing!
6. I will stop every time.
7. I always stop.
8. I stop because there is a stop sign.
9. If I was traveling on a road I was not familiar with.
10. Would stop either way!
11. I stop for the stop sign.
12. I always stop. There's a stop sign.
13. There is a stop sign, duh.
14. There is a stop sign--I stop anyway.
15. I always stop (this is a stop sign!)
16. I would stop anyway.
17. (I always stop).
18. I always stop at STOP signs.
19. Would stop anyway.
20. Always stop there.
21. Stop because of sign.
22. I would stop either way but it does increase awareness.
23. Stop sign forces me to stop.
24. ALWAYS STOP!!
25. (Now).
26. It's a stop sign. I stop.
27. See #12.
28. I always stop and look.
29. I always stop there is a stop sign at this intersection.
30. I always stop.
31. Because I always stop.
32. I always stop.

11. Based on your understanding of the warning sign, does it flash as you expect it to?

1. Don't see a need for a sign.
2. I was not aware that the sign only flashed when traffic was approaching.
3. Not sure, I'll be more aware of it.
4. Had no expectation.
5. I have approached this intersection early in the morning before sun up. There is cross traffic and the sign is not flashing.
6. Not sure.
7. I had no idea what the flash meant before I got this.
8. See above.
9. I don't understand what makes it flash. Does it based on time of day, heaviness of traffic, or just as cars are approaching?
10. I have noticed traffic approaching when the sign is NOT blinking.
11. It always flashes. I assumed it was just always on.
12. I have been at the intersection when it isn't flashing and there is still approaching traffic.
13. Wasn't aware it flashed when cars were approaching. Thought it was a constant flash.
14. I've been trying to figure it out but it doesn't always seem to flash when vehicles are coming. Therefore, I don't pay much attention to it anymore. Maybe it flashes too long after cars already pass by? Definitely good ideal. Just improve timing.
15. Could be brighter (the flashing).
16. Only arrow on side of approaching traffic should blink.
17. I pay no attention to the sign.
18. It should flash all the time.
19. I was not aware the sign only flashed when there was traffic--I thought it flashed all the time.
20. I thought it would flash on one side if cars were approaching--actually both sides flash at the same time, sometimes there are no cars approaching.
21. Sometimes it seems to stop before traffic passes.
22. Not bright/big enough--I would think it needs to be higher or same as stoplights. As you wait in line to go, you don't see sign until you are last car ready to go.
23. See below.
24. Did not use sign to indicate no for no traffic.
25. Kind of get complacent.
26. I'll pay more attention now.
27. See other comments.
28. If it works, yes. Still very dangerous intersection!
29. I will check and see if it works as intended now.

30. I rarely see it flashing--maybe once or twice.
31. Wasn't aware the function of sign. It's a new sign I've never seen. Now that I know the function, it will be helpful.
32. My understanding is that it flashes all the time, not just when traffic is approaching still unclear. But it is helpful!
33. Not clear why the sign is there.
34. I expect it to flash as soon as I am at the intersection. Sometimes it does not flash until I am almost through the intersection.
35. Although before receiving this survey I did not realize why it only flashed sometimes and not every time I approached that corner.
36. "Sometimes seems to be "out".
37. It should flash sooner.
38. Now it does.
39. See above - didn't know it senses. Thought it was inconsistent.
40. Don't know. I cannot rely on /verify proper functioning of sign.
41. Haven't experienced it since receiving this card.
42. I expect it to be on continuously, rather than when some sort of sensor senses traffic.

12. Other comments?

1. Initially we didn't realize it was detecting traffic, just thought it was always flashing. Please keep Parade of Home signs, open house signs, etc. out of sight triangles. Also, in the summer months the grass gets tall blocking the sight triangles.
2. Seems like a dangerous place for a school bus stop - the kids are usually sitting right by the sign and not very visible to traffic on 47 approaching from either direction.
3. Nice, but with all the building in Maple Grove, seems like we'll soon need a traffic light.
4. Although it's a nice reminder, I feel its unnecessary as licensed drivers should be responsible enough to look both ways before proceeding at a stop sign.
5. It is hard to see the flashing lights when it is dark out or raining.
6. While this is a step in the right direction of making this intersection safer, the visibility is still poor at this intersection and drivers who may rely only on the flashing sign could create a very dangerous situation.
7. Great idea for this intersection. It is very difficult to see cars over the hills and when the grass gets tall in the summer.
8. "There is a stop sign at this intersection already - doesn't that mean to ""look for traffic?"" It's redundant to have another sign there."
9. In the morning the sign blinks a lot. Drivers may not pay attention as it is amber color. Blue and red are more eye-catching.
10. Awesome pro-active change!
11. I was unaware that it only flashes when traffic is coming. Today, when given the survey, there was traffic coming down 47 but the sign was NOT flashing. Not sure when it flashes and when it doesn't.
12. I wasn't aware that traffic trigger the light. Now that I know, it will be more useful to me. Thank you.
13. Before this survey I just thought it flashed all the time. Now if I understand correctly, it flashes only when traffic is approaching on HWY 47.
14. #10 above - even if the sign is not flashing, or doesn't even exist, you should stop anyway because there is a stop sign at that intersection and even more importantly it is difficult to see traffic in either direction.
15. "Now that I know ""how"" the sign is supposed to work I will incorporate it into the process. But what I may be comfortable with and what the sign may record/flash in terms of approaching traffic may not correspond. Weather conditions play with this."
16. I think the sign is an aid but it doesn't replace my personal responsibility as a safe driver and definitely not to the point that I rely on it rather than myself.
17. This is a very tough intersection and going south you have to pull out so far in order to see traffic going east. Very dangerous especially with more and more traffic with all of the developing.
18. I did not know that it only flashed when traffic is approaching. I thought it did all the time to remind a person to look carefully. I like the sign!!
19. This is a great effort to make intersection safer, but grade and obstructions need improvement too! It does not alleviate congestion and long waits during peak times. There is one lane going south on Lawndale. People in line turning right crowd 1st guy in line by coming up on side and blocking view for 1st guy. Police should ticket.
20. I do not think the sign is needed at all - everybody stops approaching the intersection anyways. Stop sign or stop light would be much better at this intersection. The sign, and the survey is a waste of money and time.
21. "I love this! This is a dangerous intersection. I didn't ""get"" that it only flashed when cars were approaching. My hubby pointed it out. Great for my new teen driver to confirm his confidence. Not a replacement for looking. A support!"
22. I think more thoughts should be put into making this intersection more easy to merge onto the road; such as clearing trees/brushes, taking the hill out completely.
23. Works great!! There are many intersections that could use this.
24. I might use the sign more in heave fog or snow. Otherwise, it is only a pretty, shiny flashy distraction.
25. A gigantic mirror, four way stop or stoplight seems more appropriate.
26. I think that all signs should flash so people can be more aware of them.
27. Heading east of 47 and making left is even more dangerous, especially at night.
28. I like it, I think it helps people pay more attention.
29. For #10, you need to stop there is a stop sign!
30. There needs to be a traffic signal at this intersection. No stop signs.
31. Again, I travel south on Lawndale daily. There have been times when the sign not flashing, yet cross traffic on 47 is present. This may cause some motorists to be less cautious. My recommendation: the sign should always flash.

32. They use these signs on the toll ways in Ohio to also warn if there are animals on the roadways in high deer/car collision area. Very good use of County money!
33. Great Idea!
34. This intersection needs a stop light (dangerous).
35. I like the sign. This is an intersection where cars approach fast and can easily be misjudged. I have 2 young drivers and I think this creates more awareness.
36. We've lived off of Lawndale for 5 years and have been aware from the beginning that it's a dangerous intersection. We've almost been hit 2x. It's difficult to see cars coming west on 47 when sitting at the stop sign on Lawndale. We don't think the sign is enough. It needs to be a 3-way stop sign instead. Thanks for surveying us.
37. The sign could be a little bigger. It doesn't stand out very well in bright sunlight. Trim the bushes/trees so it's easier to see the traffic on 47.
38. Clearing brush from both sides of Lawndale would be helpful.
39. This sign has worked very well every morning on my way to work and cars use to be backed up before this sign was put up. It would be beneficial to place a right turn lane - especially since nobody lives in that house on the corner.
40. If the sign bigger and with red color for the arrow with by much better.
41. The bushes and weeds on both sides of Lawndale (on the corners at end of street) should be cut back. They are a large reason that we cannot see traffic coming.
42. Lawndale has a stop sign at 47, 47 does not. 47 therefore has the right of way. Stop wasting tax payer dollars on more bells and whistles and flashing lights and remove the IDIOT sign. Also see the attached piece of paper.
43. This intersection needs either a stoplight or a stop sign (all three ways).
44. It seems this flash sign doesn't improve traffic a lot in the morning. It has always been a long waiting line.
45. I am actually surprised at how well it reads traffic. I drive this route every morning and I think the sign also helps traffic move faster through the intersection. Is there anything we can do to the timing of the left turn light as you go south on Vicksburg and take left on 36th? It doesn't turn green if someone isn't waiting for it but most times the line to go straight is so long that the person waiting to go left is stuck behind the curb. When the light does turn green, it is very short. Typically there is very little traffic going North on Vicksburg in the morning 7-9am. So it would make more sense to allow people to turn left. Thanks!
46. No more home builder signs or any type of signs. Make traffic on 47 more aware of the intersection, maybe have them slow down 10 miles an hour past the road. Last resort add a stop light, but with all the new construction you might need to.
47. You should really put in a street light at the intersection. It is the most dangerous part of my entire commute. It is especially bad in the winter when you can't get any traction and the line-up of cars stretches for what seems like a mile. I just worry that someone will get seriously hurt or killed, and a simple light could have prevented it.
48. Thank you for making this intersection safer!
49. Why doesn't Plymouth put a stop light at that intersection - there is a tremendous amount of traffic going south.
50. There is some danger in drivers becoming too dependent on the sign and if it ever fails they may pull out in front of oncoming traffic. This is no more of a concern though as a RR crossing, but I wonder if it is reliable.
51. I feel drivers should not rely upon a sign to increase their awareness of cross traffic. I do not see the sign as a needed resource and also feel it could result in people relying upon the sign and therefore paying less attention to cross traffic on their own.
52. It does not change my driving.
53. I think a stop light would actually more effective at this intersection. It can get pretty backed up in the morning when trying to turn left on CR-47. Sometimes takes 5-6 minutes just to make a left turn.
54. "There is no right turn lane from Lawndale to 47 as there shouldn't be. However, people who want to go right block the view of those going left, and this causes a dangerous situation. It's the "who will get out on 47 first". Also, the realtor signs -for sale-garage sale block the view and you have to pull out too far to view oncoming traffic".
55. I think the sign should just flash constantly to alert drivers to always be aware of oncoming traffic.
56. Overkill. Already have a stop sign. Better solution would be a 4 way stop.
57. Put a stop light in and be done with it. Traffic sucks here!
58. It never occurred to me that the sign flashed only when traffic was detected - if this was the point I think its unclear. I always stop and look left-right-left at this turn.
59. I am not clear on whether or not the sign flashes in both directions even if traffic is only coming from one direction. I am also not clear how near an approaching vehicle must be to activate the sign.
60. I think people are aware to look - the issue is the turn lane onto Lawndale. If someone is turning onto Lawndale you can't tell if there is a car behind them that is still heading West on 47. Thank you!
61. This sign is definitely a plus - the intersection can be tricky and any help for people to pay closer attention is welcome.
62. The flash sign is a little small.
63. About #7 and 10, only because I take the route daily and known to look for traffic. I think it's good to have for people who are unfamiliar with the area.
64. I was under the impression that it flashed as the southbound cars approached, not as cross traffic did. I assumed it was a reminder to check for cars. This new knowledge is great - thanks!
65. Again, now that I know what the sign is meant to do, I will use it to help identify oncoming traffic. It really is an unsafe intersection, so any help is welcomed.
66. I like it! The sign helps to keep traffic moving through the intersection. I use it as my gauge to go if a car is approaching.
67. Why not add signal lights at this intersection?
68. We need a stop light more than just a warning sign.
69. Milling high spots, killing low would cure sight lines--More \$ but permanent--What if sign fails to blink and some moron blames the County after getting drilled? Nice kid giving surveys 11/18. Thanks for map.
70. We feel all blind intersections like Lawndale & Cty Rd 47 should have these signs.
71. I assumed it flashed as my car approached the intersection.

72. I just don't want people to think they don't have to stop at the stop sign if they see no lights flashing for traffic. (Don't only rely on the sign.)
73. There is a lot of traffic at this intersection. Should have a stop sign for all directions. Then you wouldn't need a fancy flashing sign that I pay for anyway. 2 extra stop signs is cheaper than a flashing sign.
74. Great sign! I love it!
75. I think this intersection would be perfect for a roundabout.
76. I drive through this intersection every day & I noticed the sign right away but however I never realized that it flashes when traffic is approaching. I always stop & carefully look both ways.
77. "Intersection really needs a light. It has some blind areas & you need to creep into the intersection to fully see. Plus the ""housing"" signs block your view farther. Now that I understand the warning sign, it is helpful but still would prefer a light."
78. Sometimes I forget to check for traffic myself due to the sign.
79. Good idea--will be interesting if data shows reduced accidents.
80. It is a very dangerous corner. You must be almost into the intersection in order to see oncoming traffic. There should be a stop sign or traffic lights for fast moving cross traffic.
81. I would like to think Hennepin County could find a better use of tax payer money. Brad Brummer 612-272-9849.
82. It helps me know if there is traffic coming. I do rely on it to confirm what I see. I wonder how young drivers will use it? Please keep it there.
83. "There is already a stop sign in place. It is a "T" intersection so traffic is not likely to be going straight across (traveling on Lawndale). There is a road there but it's a gravel/private road. I am wondering if this test is a result of accidents at that site."
84. I guess the sign is difficult to understand. I really thought it just meant look for traffic whether flashing or not.
85. I feel this is a terrible intersection with many blind spots and increased traffic. I strongly suggest stoplights. Why isn't this sign also not used for traffic traveling east and west on Cty. Rd. 47?
86. This is a very good addition to this intersection.
87. I wasn't sure at first that it only flashed when traffic was approaching--I thought it flashed all the time--but then I realized it was only when traffic is coming--which is nice--an added safety feature to make sure you look clearly.
88. When it first went up it wasn't clear that it would flash only when traffic was coming. I think it's helpful--problem is seeing around cars turning left, seeing traffic coming behind them. Also, Lawndale can get very icy at that intersection and there is increased risk of sliding through the stop sign. Slower traffic on 47 near that intersection might help, too.
89. I didn't know oncoming traffic made it flash. This is a dangerous intersection and should have stoplights.
90. I like the sign, I think it will help reduce crashes.
91. Flashing signal is hard to see during day. Good at night. After living in area and traveling Lawndale to 47 exit for 3+ years, I recommend 3-way stop.
92. Would like to see an extra lane made on both Lawndale and Cty 47 to help w/increased traffic.
93. Good sign to have!!!
94. Re-design the intersection! My fear is issues with question #8, #6, and #10. Bottom line this is a good addition but MN drivers are clueless so this might actually create a sense of false trust.
95. I think the distance should be a little longer than it is now from the time it senses approaching traffic. A very dangerous intersection, hope this will help cut down on accidents.
96. I think it's great, it helps some of the people out.
97. The warning sign helps. But it is still an unsafe intersection. I was hit by a car when I was traveling west--they couldn't see me at dusk--it's the big hill there that's part of the problem--westbound traffic coming up the hill and also that big mound that belongs to the property owner. You just can't see around it.
98. I think it is great and a much needed change to a somewhat dangerous intersection.
99. Dangerous intersection due to slight hill. Better to have a stoplight. I don't think this new sign is a safer alternative.
100. Cute guy handing this survey out!!! Nice--
101. It's great!
102. I don't remember seeing any flashing sign, but I've only driven through there twice.
103. This corner needs more than a stop sign and flashing sign. The corner needs grading to be able to see approaching traffic. It's very difficult to see cars unless you inch your way out into the intersection. Signs for advertisements should never be displayed near this corner.
104. Would help if right turn lane on 47 would begin earlier so would know if turning sooner and also able to see cars behind them better. Even leveling out the intersection so it's not so elevated would make safer with improved sight.
105. Now that I've figured out the lights flash when there is traffic coming E or W on 47 it really helps. I have seen my share of bad accidents at this location. I appreciate your efforts to make it safer.
106. **See attached diagram** This is a dangerous intersection. The problem is that you have to pull so far forward to even see over the hill. The cars back up at certain times, people become impatient and don't look carefully. Some cars will try to pass on the outside of the car that is waiting to turn. **See attached diagram: If this car is turning left, they have to pull up so far to be able to see over hill. If a car is turning north onto Lawndale you can't see the line of cars coming behind on 47--that is a dangerous blind spot. Cars try to edge on the shoulder to turn west on 47 and they could cause accident.. Also when cars try turning left onto Lawndale, I've seen cars try to pass on shoulder--very dangerous. This corner needs a stoplight--this blinking light doesn't solve problem.
107. Quit wasting my tax dollars on stupid things like this survey and your flashing sign project. A responsible driver should know to look before proceeding through an intersection that requires them to stop.
108. I normally stop because trees at the corner obstruct the view on 47 in both directions.
109. Dangerous intersection--any warning/caution signs would likely help increase awareness.
110. I think that the sign helps. This is a very difficult intersection to see if traffic is approaching from the East.
111. The sign provides an extra measure of safety.
112. Cars from the east in the right turn lane to go north on Lawndale block your vision of cars going through the intersection!

113. Because it is not a traffic light I do not trust the indication. The intersection is awful and therefore I pay attention always. I can't tell if this helps. The intersection needs a redesign not wasting time and money on this study.
114. It is helpful to have, especially when the sun is really bright.
115. Sign has made me a little less vigilant in watching myself since it only flashes when there is traffic.
116. I think this is a very good location for this sign.
117. I have to stop at stop sign anyway. I assume traffic is coming at all times. Sign doesn't help because I can't see left and right until I get out and look both ways. Visibility left and right is the problem.
118. It may be helpful to have it flashing all the time to avoid people to rely on the sign for traffic control.
119. Doesn't really change my driving habits since I always stop and look both ways. But I do use it as a confirmation of my visual check and I think it's great at dusk and bad weather when approaching traffic may not have their lights on.
120. I just figured out that there must be a trigger embedded in the road. I thought that the sign blinked all the time. I am not sure that it is needed. Isn't a stop sign enough? Seems like a waste of money to me.
121. I thought the sign flashes every time a car on Lawndale approaches the intersection. Does it only flash if there is traffic approaching on Co. Rd. 47? I will have to pay closer attention. If it only flashes if there is approaching traffic on Co. Rd. 47, then it is more useful.
122. When I first noticed the new sign, I assumed it would always flash rather than a dynamic response to traffic--nice touch. Note: In the winter when stopped at this intersection to wait--tough to get going again due to ice (slight incline there southbound). Black ice from exhaust--waiting to turn.
123. This is a very, very busy intersection during the morning and afternoon rush hours. Traffic on 47 goes way too fast for the speed limit. The flashing arrow sign does not help with traffic flow or alert drivers any better than before. A better solution would be a traffic light and to lower the speed limit on 47. Traffic on 47 is way too fast.
124. It would be more beneficial to have the oncoming traffic stop. It is still too difficult to see cars when trying to pull out of there. I am well aware of the traffic coming but the sign does not assist me in pulling out safely.
125. A stoplight would be safer!
126. Stop light is better. Horrible intersection. Wasting tax \$ on this is not a good use of our funds unless this was way cheaper.
127. I am glad the new sign is there. It really helps me to pay more attention and not to miss someone coming from the east.
128. This is a terrible intersection due to visibility and amount of traffic. I thought the sign was put up to help remind people to REALLY look both directions before proceeding. I did not know that the flashing was an indicator I thought it was to help at night and for visibility of the sign.
129. Dangerous intersection. Cars approaching from the west on 47 at nearly the same speed with one turning right onto Lawndale--the driver facing south on Lawndale trying to go left onto 47 cannot see the car on 47 going straight. Too many close calls!!
130. There have been too many close calls at this intersection. Car stopped at stop sign--headed south, turns left onto hwy 47. If two cars are approaching from the west at the same time or the vehicle going straight is slightly behind (left side) the car turning right onto Lawndale--it obstructs the vehicle going straight.
131. I would like it to be bigger!
132. A very high traffic area due to new housing in area and very busy with the high school nearby.
133. It helps the awareness bottom line. Otherwise, it's a dangerous intersection.
134. I am always cautious at this intersection, I think the sign is a great addition to improve awareness.
135. It's a good traffic sign that adds awareness to drivers. Winter time is hard because piled snow may block sights, and driver can't trust this sign as much as traffic light.
136. I feel that intersection is very dangerous. I think the only way to solve this is a signal.
137. I was always cautious at this intersection because of the semi-obstructed view. The new sign will be very helpful in warning me that traffic is coming. -But, I now may be more tempted to roll into my right turn when the sign isn't flashing--trusting the sign more than using my own cautious eyesight.
138. That intersection needs to be opened up due to all the construction in that area.
139. This is greatly needed. Also the traffic on 47 needs to slow down.
140. The flashing needs to be brighter--sometimes hard to see during daylight hours.
141. Love having the sign there-sometimes it can be hard to see traffic from the east because of the little hill there, so this has been very nice!
142. I think as more and more houses are being built in this area, there may come the need to do a more drastic measure to insure safety at this intersection--I myself take extra precaution whether turning right off of Lawndale or left from 47 to Lawndale.
143. It's awesome.
144. I still believe a stoplight at this intersection would be more beneficial.
145. Great concept. These signs should be used in more places. If we can save one or more lives, it has paid for itself.
146. If possible it might be additionally helpful if the arrows flashed in relation to which direction the traffic was coming from.
147. I wasn't aware it flashed based on approaching traffic-I just thought it was random until this survey!
148. I would drive defensively whether or not the flashing light was there, but it does increase my awareness and may help in a situation where I otherwise would have made a mistake.
149. I am aware of approaching traffic, but I LOVE the sign to remind other drivers that may not be paying close attention. I would like to see more of these signs around. Thank you!
150. I could see a potential problem if too many people relied on the flashing lights to determine if it was safe to proceed. I was there one morning when the flashing lights were not working.
151. The flashing sign is a great addition to this intersection! Especially if the structure and trees on the west side of Lawndale remain! Thanks!
152. This has been a busy, dangerous intersection. Lots of rush hour traffic and hills and curves. I think it's especially beneficial to those in car whose visibility is decreased. It's a little easier from a truck or SUV that sits higher. It's a welcome improvement!

153. You have to pull out to look on 47 because it is blind until you pull your car out far enough to see. I still look w/ or w/o sign because if it stops working there could be trouble--Good idea.
154. I really think a traffic light is needed there before an accident occurs.
155. Light on Vicksburg is not timed properly. Left turn arrow does not always come on in sequence.
156. My 5-year-old also watches for the flashing lights and lets me know if they are flashing or not! I like that she notices also.
157. Thank you!
158. I appreciate as the warning sign is placed and it gives me more confidence of better driving. Please keep it. Thanks.
159. Great idea!
160. I didn't realize that the sign actually had a sensor and only flashed when there was approaching traffic on Co. Rd. 47. I just thought it flashed all the time. In the few years that I have been using this road, I've never thought of it as a road that was traveled so infrequently that I didn't need to look.
161. I didn't realize the flashing lights were on sensors until I received this survey. I just thought it worked/flashed only at random times! This is a great traffic tool/sign!
162. We think a stop light needs to be installed at this intersection. The sign does help but it's inconsistent and still accidents happen. 47 is too fast and the hill limits visibility.
163. I like the sign and hopefully it will help avoid accidents and close calls.
164. That is a very dangerous intersection that I wish I could avoid more. The flashing sign does help a little but if you are turning east and the person behind you is turning west they sneak around you and block your view anyway so the sign does no good.
165. Big help to warn of upcoming cars. Sometimes very hard to see and Co. Rd. 47 people are driving very fast.
166. It's helpful! Hard to see traffic coming up the hill sometimes, or when blocked by large trucks in front of you.
167. Again, just thought it was there for awareness. It would be nice to have a different configuration at that intersection; it's getting too congested and hard to enter, quite dangerous!
168. It's a neat idea, and will probably be more useful as I get used to it. Mostly, by the time I get to the front of the line in the AM rush hour, I'm already looking to the left before I notice the sign. I see it more in the dark. Barely noticeable during the day.
169. This new warning sign definitely helps. But at this intersection traffic backs up during weekdays. A stop light would be more beneficial to clear traffic fast and also avoid accidents.
170. Like to see more of these around! Happy Holidays!
171. I think at night it helps the most to remind drivers to look both ways.
172. "There is nothing indicating these flashing lights indicate oncoming traffic. Suggestion, put in a sign below saying "Watch for traffic. When lights are flashing." Similar to the flashing lights indicating a street light is about to change."
173. "I am glad that there is a sign indicating an incoming traffic. This intersection was in dire need of it. But until my wife once figured it out--very early morning (at 5:00am) that sign only flashes when there is an incoming traffic. It is not clear from the sign. It is worth to have an explanation in big bright letters like ""Extra Caution when Flashing". Thanks for the improvement."
174. I was not aware that the sign only flashed when traffic was approaching on 47.
175. I think this sign is a great tool for careful drivers but I suspect that some drivers may try to rely on the flashing instead of looking, which concerns me. But I do think it will help to reduce the number of accidents at this intersection, and it is a needed improvement.
176. Really would like to see a light there instead of a flashing sign.
177. I wasn't sure if the flashing sign was intended to alert motorists of traffic approaching. Maybe a sign indicating this flashing sign can be placed as you approach the intersection! Great idea!
178. The sign is not in the correct location. You should have put up a flashing red light or no sign at all.
179. This is a very dangerous intersection and I feel the sign helps a lot.
180. The sign is helpful. However the visibility as this intersection is still poor. People put up signs making it even harder to see oncoming traffic. The sign is a good attempt to improve things, but I think more needs to be done regarding visibility.
181. This sign does not stand out. Something larger or brighter and always flashing should replace it. The sign reminds me of a railroad sign, one does not always pay attention to it.
182. PLEASE lower the grade of the hill - it is impossible to see approaching cars when driving east on Cty Rd 47 and turning left on Lawndale. Cars are easier to see approaching at right because of head lights. Thanks for the sign.
183. At first the LED's were really dim, but after a week or so, the brightness increased in intensity.
184. "Quest 10 is poor. Should be ""are you more likely to look both ways." Your question infers that people do not stop at the stop sign. By the way, this is a VERY DANGEROUS intersection."
185. Need this for kids in neighborhoods so drivers slow down.
186. I think it's a waste of money.
187. Mirror facing east, but visible for those going South on Lawndale would be helpful also. You can't always see traffic when someone is in the turn lane. Also slow down the traffic on 47. Most people are driving 50 through the intersection and if the whole section of road was 45 maybe people would slow down.
188. Regarding #10: Since there is a stop sign there, I always stop before turning. Also, I appreciate the flashing sign for its extra level of safety for what I feel is a dangerous intersection.
189. Great idea! This intersection is hard to see the cars on CR47, especially if cars are turning onto Lawndale from the east in the turning lane.
190. Does it only flash when traffic is approaching? What is the distance of the cross traffic before the sign blinks? Does snow or rain affect the sensitivity of the sign?
191. It is a dangerous intersection. A stop light may save a life or injury. Thanks.
192. "This is a dangerous intersection (I drive it 5 days/week). Is there a way to create better visibility to the west by clearing back vegetation/trees? When people place signs (ex. Parade of Homes, real estate, garage) along the roadway it also obstructs view of oncoming traffic. Regarding the new "Look for traffic sign" - I feel it is a good reminder to frequent users of that intersection and may help anyone new be alerted to the dangerousness/difficulty seeing traffic".

193. I like the additional reminder!
194. This is still a tough intersection.
195. Great addition to a busy intersection.
196. Helpful when it's foggy!
197. That hill was shaved off about 10 years ago and they did not take enough off then to make the intersection safe. I do not feel that Hennepin County is diligent when it comes to spending tax dollars. They are careless and don't care like all government. Should be wider arrows also. Also, wasting taxpayer money building new Plymouth Library - it was fine.
198. Personal responsibility and drivers training is always superior!
199. I have watched cars only look at the sign - not right or left. If this sign breaks/is defective there will be an accident. I strongly encourage you to remove the sign. If traffic is heavy enough to require action, put a stop light in.
200. I tell my kids that drive that this intersection scares me more than any other. And I think you should fine housing developments that put signs up that hinder viewing. I fear that if people know that it flashes only when it senses cars that they will roll and go when it isn't flashing.
201. Would be ideal if it flashed only on the side that the approaching traffic is coming from i.e., flash on left - car approaching from left.
202. I thought the lights flashed continually. It didn't matter if traffic was coming or not.
203. people/drivers should not be taught to rely on these flashing signs. One day the sign does not flash. Driver does not look and claims the accident was due to the sign not operational. Waste of money, energy, and bad habit teaching.
204. Thanks for making our neighborhood more safe!
205. I prefer not to have stoplights. I like the sign.
206. This intersection needs a light that is green/yellow/red during 7-9 and 4-6 M-F and Red flashing for Lawndale/yellow for 47 the rest of the day. Should also tear down home on the corner to improve sign lines. And remove bushes.
207. I have seen near death experiences at this intersection. I strongly recommend making it a 4-way stop. Mark Simonett work# 952-832-4348.
208. Can it detect bicycle or motorcycle going by?

Appendix E

4.1.4 Test Log Requirement Verification Memorandums

7/2/08 Memorandum from Gordon Melby

I have been parsing and processing the data from hc medina.

I think you should call your data guy and have him just get data by the hour.

If we do 5 minutes we will drown in data.

I have included for your viewing an hours worth of data from 070208 10 AM

This sample had 14063 records

26 node 1 speed detections

19 node 1 sign activations

23 node 1 presence detection

32 node 2 cars

22 node 2 sign activations

28 node 2 presence detections

The sign went on a total 37 times

The relevant cols of data are

E node 1 speed readings MPH

G node 2 speed readings MPH

H node 1 presence (when >32000)

J node 2 presence (when >32000)

M sign on (256= node 1, 512= node 2, 768=both)

The example below is from node 1 the eastbound node and I believe it is a vehicle leaving the HC Garage driveway. Looking at slow accel, it maybe is a truck.

I have also attached a slightly doctored plot of the event shown below.

Conditions:

Initiation of the sign ON sequence will begin if we have at least 7 valid speed readings from the last 12. We look at the world 8times a second and report results 4 times a second, which is what you see on the spreadsheet.

If you look at ROW 57 Col E you will see a car picked up @ 18 MPH @ 10:00:14. It remains in view for about 2.5 seconds until 10:00:17 (0 samples @ approx. 4 per second). The speed than drops to) (cosine effect) AT 10:00:19 (Row 76 Col H we get the first presence indication and it lasts for about 1.5 seconds. Now scroll down to Row 89 Col M and you will see a 256 begin, this is when the sign lites up. We are approx. 400 feet from node to sign and we would have used an average speed of the first 7 samples of speed $18+18+20+20+20+22+23=20.14$ MPH average speed. This is approx 30 fps velocity. We want 7.5 seconds of warning so we will multiply $7.5*30=225$ feet from intersection when we turn on sign. We should travel 175 feet past detector before we turn on sign. WE got our on time @ 10:00:16 and we need 5.8 seconds of delay so we should turn sign on at 10:00:22 which we did. Unfortunately the vehicle continued to speed up to >30 MPH so it arrive early at the sign and the sign stayed on for 9 seconds off at 10:00:32.

We have just gone thru a single encounter, but you can see how we use the spreadsheet data.

I working on automation of this analysis.

The other col are hex status data from nodes and master which are not decoded on the spreadsheet.

An interesting side note (not on the spreadsheet data I attached), someone stopped at node 1 the east bound node and sat there from 6:47 until 7:20 AM or at least that's what the presence detection indicated.

We are also picking up pedestrians, especially at node 1 as everybody in the building takes walks past the node and it sees them. They often stand and gawk at it in groups.

9/23/08 Memorandum from Gordon Melby

I have been studying the data from project area and have some concerns.

1. If you look at attached plots, namely the speed distributions you will see many are more than 50-55 mph these vehicles cause the sign to start as soon as they are detected because we have no margin to wait. If the radar sees these at a long range we get the longer sign on times which you can see in the plot of sign on time distributions. Some of these longer on times are actually platoons, which there are a lot of these at the site. However, the bottom line is the sign is on for 10-11 hours per day. 3-4K vehicles. The sign operates at a 50% on - off time so we actually draw power for $\frac{1}{2}$ the time or 5-5.5 hours per day/hours. This may push the solar battery capacity during this winter.

2. The current algorithm for turning on sign is:

A. We measure speed.

B. We compute how much time we can look at the speed before a car would get inside the 7.5 second warning zone if we assume all readings were in front of detector node. When we reach the 7.5 second threshold we activate the sign.

C. If we have fast vehicles, the say 60mph (88 fps) then we would only have 1 second to make the decision on turning on sign. If radar began seeing vehicle at 200 feet from detector then we would wait 1 second, which would put vehicle at 120 feet from detector when we activate sign. Because we continuously compute this we would then have the sign on for 120 feet before we reach detector, plus the 9.5 seconds (7.5 + 2 second overlap) which would yield a total sign on time for this vehicle of approx. 11-11.5 seconds. This is shown in the sign on plots.

D. Because we can't predict radar Doppler range, I think we need the above scheme to insure we catch the car that is seen at 50 ft from detector. However I would like to reduce the sign on time. I suggest we drop the 2 second overlap feature. This would reduce by 20% the above on times. And help our battery life.

E. I am also proposing that we modify the dimming scheme we use for the sign. When we had sign at HC Medina it faced south and needed full brightness to work in direct sun. At Lawndale we at facing north and in the shade of the big tree, so the sign should never need full brightness. I propose we start at 80% as a full setting and dim down from there. This will further aid in battery life.

Appendix F

System Requirements Test Log

System Requirements Test Log

Intersection Warning System

MnDOT Contract No. 91418

DATE:		Test Start Time:	
By:		Test Finish Time:	

		REQUIREMENT	Pass	Fail	Comments
1.0	Background:				
2.0	Functional Requirements:				
	2.1.0	use radar detectors			
	2.1.1	use secondary presence detection devices			
	2.1.2	detect vehicles approaching			
	2.2.0	wirelessly communicate the detection information to a master node			
	2.2.1	activate a dynamic warning sign			
	2.3.0	active real-time warning			
	2.3.1	sign meaning is intuitive to driver			
	2.4.0	warning sign shall alert side road drivers to look for approaching thru-road traffic either left, right, or both			
	2.5.0	warning sign shall conform to MN MUTCD			

3.0	Performance Requirements:				
	3.1.0 Scalability: ...from 1 to 4 dynamic warning signs				
	3.1.1 from 1 to 8 detector nodes				
	3.1.2 able to handle increased volumes of users and/or data.				
	3.2.0 Speed: The end-to-end response time of the system shall be less than 500 milliseconds (system will detect the vehicle, process signals, wirelessly communicate to the warning sign node within 500ms)				
	3.3.0 Safety: The intersection warning system shall not obscure or detract from any in place signing				
	3.3.1 The system shall be able to meet NCHRP 350 certification if needed.				
	3.4.0 Reliability: The system shall reliably detect approaching mainline traffic and predict arrival at the intersection				
	3.4.1 The system shall use a dual fused sensor methodology, which permits one sensor to validate the operation of the other				
	3.4.2 Three consecutive mismatches of sensor detection shall cause the fail-safe mode to initiate.				
	3.5.0 Availability: The system is intended for 24 hour per day, 7 day per week continuous operation				
	3.5.1 The system shall function with a 99 % up-time				
	3.6.0 All system hardware components shall be self-contained modules housed in weather proof, NEMA 4 rated enclosures suitable for outdoor use				
	3.6.1 No internal manual settings or adjustments shall be needed to install or maintain the system				
	3.6.2 Maintenance shall consist of module-level replacement and shall not require circuit board level or component-level adjustment, replacement or repair.				
	3.6.3 Software Set up, Programming and Diagnostics: The system shall be user programmable through the use of a laptop computer				
	3.6.4 shall allow for diagnostics, data download and programming of system parameters				
	3.6.5 system shall allow operations staff to perform diagnostics via a wireless laptop connection without leaving the vehicle				
	3.7.0 Failsafe mode: The failed system shall not present a more dangerous situation than if the system was not present at the intersection				
	3.8.0 Fault detection: The system shall employ a fault detection component for easily determining the proper functioning of the system.				

4.0	Operational Requirements / Operational Modes:						
	4.1.0	Normal Operation: IWS will be actively taking wireless measurements, with two detectors per detection node, to identify and verify the presence of traffic approaching					
	4.1.1	When no vehicles are detected the warning sign shall give indication that the system is functional and active, but no active warning indication shall be given					
	4.1.2	When the presence of a vehicle is detected and verified on the thru road, this information is wirelessly sent to the master node where a signal will be sent to activate the warning sign					
	4.1.3	When a vehicle is detected, approaching from either direction on thru road, or both directions simultaneously, an indication shall be displayed.					
	4.1.4	The indication will be displayed for a duration that corresponds to the calculated time needed for the approaching vehicle(s) to proceed to the intersection.					
	4.2.0	Failsafe Operation: The system will provide a means for determining that the system is not operational					
	4.2.1	When a failure condition occurs, the system shall create an internal failure notification					
	4.2.2	When a failure occurs the system shall provide an indication on the warning sign that is unique from any other operation mode.					
	4.2.3	Failure conditions may include: 1. Loss of radio communication between nodes of the system,					
	4.2.4	2. Malfunction of detection sign nodes (radar/secondary presence detection),					
	4.2.5	3. Failure of warning sign node (indication),					
	4.2.6	4. Low power (battery failure).					
	4.3.0	Diagnostic Operation: The system shall permit operations staff to monitor operation of the system at the master node					
	4.3.1	This monitoring shall be accessible via laptop computer and shall display system status in real time.					
	4.3.2	The monitoring shall be done wirelessly without the operations staff having to leave the vehicle.					

5.0	Interface and Subsystem Requirements:				
5.1.0	Detection nodes: The IWS shall use upstream detection devices to sense the approach and speed of a vehicle				
5.1.1	Detection nodes indicate to the warning sign node when mainline vehicles approach				
5.1.2	Detectors shall have a false indication rate of less than 5 false indications per 1,000 vehicles detected (0.5 percent).				
5.1.3	Placement of detection nodes shall be required at one location in each direction on the thru-road.				
5.2.0	Wireless Gateway: The system shall be based on a wireless implementation that uses a deterministic wireless protocol				
5.2.1	The communications system shall ensure that register information is updated 8-16 times per second.				
5.2.2	A bit shall be set in the register if this update fails.				
5.2.3	The registers shall be read from the Gateway and used by the warning sign node.				
5.3.0	Warning Sign Node: The warning sign(s) shall provide notification to the side road driver of approaching mainline vehicle(s).				
5.3.1	The sign shall be classified as a warning sign per MN MUTCD guidelines				
5.3.2	The warning message or indication given to the driver shall be intuitively obvious to understand				
5.3.3	Placement of the warning sign shall be on the far side of the intersection within the side road driver's cone of vision.				
5.3.4	The size of the warning sign shall be such that can be easily seen by the side road driver(s).				
5.4.0	Power Supply: The system shall be powered by a solar panel, with battery backup.				
5.4.1	The battery system shall function for a minimum of 96 hours in the event of loss of solar charging.				
5.4.2	The system design shall minimize power consumption to allow for the smallest possible panel size.				
5.4.3	When placing solar panel, it must have a clear view of the southern sky.				
5.4.4	Placement in areas with heavy foliage that blocks the panel's openness to the sun will affect how long the system can operate without manual recharge or replacement of the primary battery.				
5.4.5	Traffic volumes at each selected site will affect battery and panel size. Some sites with high traffic volumes or obscured southern view of the sky may require supplemental AC power or frequent battery recharging.				
5.5.0	Environmental Requirements: The system shall function to defined requirements in typical Minnesota weather conditions. The Operating Temperature Range shall be: -34° to +74° C.				
5.6.0	Communications: Wireless communication links shall automatically establish and maintain connection between detection nodes and the warning sign node.				
5.6.1	Communication between the nodes of the system shall occur via a secure wireless link.				
5.6.2	Wireless connection shall perform in heavy rain and snow conditions up to and including 3 inches per hour rainfall.				

6.0	Data Requirements:				
6.1.0	Data Content: The system shall monitor and record system performance				
6.1.1	The data shall be retained within the system, on-board for a period of 96 hours.				
6.1.2	The system shall retain individual events with a time stamped record for each event.				
6.1.3	The system shall also keep a daily running total (i.e tallies) of system events.				
6.1.4	Tallied data totals shall be available via wireless laptop access to the system and/or by removal and access of the memory card.				
6.1.5	The time stamped event data shall only be available through removal and access of the memory card.				
6.1.6	The systems shall record system events such as: Vehicle detected [node(s)]				
6.1.7	Speed at time of detection				
6.1.8	Mean Speed (radar)				
6.1.9	Mean time of detection (radar) used for validation				
6.1.10	Number of secondary presence detector detections				
6.1.11	Mean Peak detection level (secondary presence detection) used for validation				
6.1.12	Status (secondary detection)				
6.1.13	Sign On				
6.1.14	Sign Off,				
6.1.14	Failsafe- Enter,				
6.1.15	Recovery from failsafe				
6.1.16	Monitor On				
6.1.17	Monitor Off				
6.1.18	System Restart				
6.2.0	Data Record Frequency				
6.2.1	For each Event				
6.2.2	Heartbeat record in absence of events				
6.2.3	Communications loss				
6.3.0	Data Archive and Retrieval: Data shall be maintained in individual nodes				
6.3.1	Data shall be maintained in individual nodes and shall be accessible from the warning sign node wirelessly during service operations				
6.3.2	The system shall continue to operate during data collection and downloading.				

7.0 Enabling Requirements:					
7.1.0	Road Geometry and Volume: The IWS system shall be suitable for installation on roadways that have a two-lane, two-way geometry.				
7.2.0	Roadway Volume: The IWS shall be designed to operate on solar power				
7.2.1	detailed design process and the final test results shall be used to identify the maximum AADT that a roadway may have and still allow the IWS to operate				
7.3.0	Installation: The system shall be easy to deploy.				
7.3.1	Installation of this system shall require a minimum of infrastructure to make the system operational.				
7.3.2	The IWS shall be a stand alone, self-contained system.				
7.4.0	Parts / Materials / Components: Wherever practical, the components of the system such as radar, secondary presence detection, data radio, and warning sign shall be standard off the shelf, field proven devices.				
7.5.0	The system shall comply with FCC emission requirements. The system shall be able to meet needed FCC approvals when design is complete.				
7.6.0	System Costs: The system shall be considered low cost.				
7.6.1	System cost for basic detection and communications is relatively fixed, the variable cost items are related to solar panel and battery installation.				
8.0 Test and Evaluation Requirements:					
8.1.0	System data shall be provided in a readily usable format.				
8.2.0	System data shall be downloadable from the warning sign node.				
8.3.0	System data shall be retained for 7 days.				
8.4.0	System data shall be individually time stamped.				
8.4.1	System clocks shall be synchronized and maintained to within +/- 2 seconds.				
8.5.0	System data shall include:				
8.5.1	Fault type				
8.5.1.1	Loss of radio communication between nodes of the system				
8.5.1.2	Malfuction of sensor nodes (radar/secondary presence detection)				
8.5.1.3	Failure of warning sign node (indication)				
8.5.1.4	Low power (battery failure)				
8.5.2	Vehicle detection by node (radar)				
8.5.3	Vehicle detection by node (secondary)				
8.5.4	Vehicle speed by node (radar)				
8.5.5	System activation				
8.5.6	System deactivation				
8.5.7	Failsafe – enter				
8.5.8	Failsafe – recovery				
8.5.9	System restart				