RESEARCH

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SCAN TOUR OF SAFETY-RELATED INTELLIGENT TRANSPORTATION SYSTEMS ACROSS THE UNITED STATES

Prepared For:

Utah Department of Transportation
Research Division

Submitted By:

WCEC Engineers

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16. Abstract

The Utah Department of Transportation (UDOT) has long been on the forefront of nationwide efforts to improve roadway safety. Their safety focus encompasses infrastructure improvements as well as non-infrastructure elements such as education and enforcement.

The use of intelligent transportation systems (ITS) technology is one method that UDOT uses to improve safety. ITS devices include variable message signs (VMS), vehicle detection, and other electronic systems that convey information to drivers or sense traffic conditions. UDOT is working to deploy ITS technology on the state roadway system where it can be an effective means of reducing crashes and crash severity.

UDOT commissioned a scan tour and research study to identify potential safety-related ITS devices and practices in use around the US that could be adapted to Utah's roadway system. This report documents the process used to determine scan tour locations, describes the information learned during the scan tour visits, and then presents recommendations for using the information to inform safety-related ITS applications in Utah.

The research team emailed a list of survey questions about safety-related ITS applications to safety and research staff at other state DOTs around the county. A total of 33 responses to the initial survey were received, representing input from 25 states and the Canadian province of British Columbia. Responses were used to select Iowa and Minnesota as scan tour destinations.

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LIST OF ACRONYMS

AGM	Absorbant Glass Mat
DOT	Department of Transportation
DSW	Dynamic Speed Warning
FHWA	Federal Highway Administration
FYA	Flashing Yellow Arrow
InTrans	Iowa State University Institute for Transportation
ISU	Iowa State University
ITS	Intelligent Transportation System
RICWS	Rural Intersection Conflict Warning System
SHRP2	Strategic Highway Research Program 2
SPR	State Planning & Research
TAC	Technical Advisory Committee
TROWS	Truck Rollover Warning System
UDOT	Utah Department of Transportation
VMS	Variable Message Sign
VSL	Variable Speed Limit
WWD	Wrong-Way Driving

EXECUTIVE SUMMARY

The Utah Department of Transportation (UDOT) has long been on the forefront of nationwide efforts to improve roadway safety. Their safety focus encompasses infrastructure improvements as well as non-infrastructure elements such as education and enforcement. UDOT's Traffic and Safety Division is tasked with managing the Zero Fatalities initiative in cooperation with other divisions and the region offices. These varying groups within UDOT work together to continue recent long-term trends of fewer fatalities and serious injury crashes on Utah's roadways.

Roadway safety is influenced by many elements, some of which are intrinsic to roadway characteristics such as pavement, geometry, adjacent land use, roadside barriers, and regulatory devices like traffic signals. Other elements of roadway safety are related to human factors such as drowsiness, distraction, aggression, impairment, and improper restraint. UDOT continually seeks to address a wide variety of roadway and human factor elements in their quest to reduce injuries and fatalities.

The use of intelligent transportation systems (ITS) technology is one method that UDOT uses to improve safety. ITS devices include variable message signs (VMS), vehicle detection, and other electronic systems that convey information to drivers or sense traffic conditions. UDOT is working to deploy ITS technology on the state roadway system where it can be an effective means of reducing crashes and crash severity.

UDOT commissioned a scan tour and research study to identify potential safety-related ITS devices and practices in use around the US that could be adapted to Utah's roadway system. Key UDOT staff members with an interest in safety and ITS deployment were included in the Technical Advisory Committee (TAC). TAC members were instrumental in helping to determine the subset of ITS devices that were the subject of this research focus. ITS equipment can also be used to improve roadway operations but operational benefits were not the focus of this research.

This report documents the process used to determine scan tour locations, describes the information learned during the scan tour visits, and then presents recommendations for using the information to inform safety-related ITS applications in Utah

The research team developed an initial list of survey questions about safety-related ITS applications of interest and presented it to the TAC for their review. The questions were then finalized based on TAC input and uploaded to the *SurveyMonkey* website. TAC members provided names and email addresses of their nationwide peers as well as access to listserves where other relevant contributors could be reached. The online survey link was emailed to 95 people directly, plus a state DOT research director listserve. A total of 33 responses to the initial survey were received, representing input from 25 states and the Canadian province of British Columbia.

Responses to the initial survey were used to refine the list of potential scan tour destinations to seven states that could be emailed a more detailed follow-up survey. Following evaluation of the follow-up surveys, the decision was made to visit Iowa and Minnesota based on their willingness to participate, experience with many of the ITS devices of interest to UDOT, and their geographic proximity to one another. The scan tour group visited Iowa on May 4-5, 2015 and spent the following day (May 6) in Minnesota.

Descriptions of the scan tour's experience in both states are given in Chapter 3. Chapter 4 contains specific recommendations for translating the knowledge gained during the scan tour into action items for follow up by specific groups represented on the TAC. An appendix at the end of the document provides supporting documentation for some of the ITS treatments described in the report.

1.0 INTRODUCTION

1.1 Background

The Utah Department of Transportation (UDOT) has long been on the forefront of nationwide efforts to improve roadway safety. Their safety focus encompasses infrastructure improvements as well as non-infrastructure elements such as education and enforcement. UDOT's Traffic and Safety Division is tasked with managing the Zero Fatalities initiative in cooperation with other divisions and the region offices. These varying groups within UDOT work together to continue recent long-term trends of fewer fatalities and serious injury crashes on Utah's roadways.

Roadway safety is influenced by many elements, some of which are intrinsic to roadway characteristics such as pavement, geometry, adjacent land use, roadside barriers, and regulatory devices like traffic signals. Other elements of roadway safety are related to human factors such as drowsiness, distraction, aggression, impairment, and improper restraint. UDOT continually seeks to address a wide variety of roadway and human factor elements in their quest to reduce injuries and fatalities.

The use of intelligent transportation systems (ITS) technology is one method that UDOT uses to improve safety. ITS devices include variable message signs (VMS), vehicle detection, and other electronic systems that convey information to drivers or sense traffic conditions. UDOT is working to deploy ITS technology on the state roadway system where it can be an effective means of reducing crashes and crash severity.

1.2 Problem Statement

UDOT commissioned a scan tour and research study to identify potential safety-related ITS devices and practices in use around the US that could be adapted to Utah's roadway system. Key UDOT staff members with an interest in safety and ITS deployment were included in the Technical Advisory Committee (TAC). TAC members were instrumental in helping to determine the subset of ITS devices that were the subject of this research focus. ITS equipment can also be used to improve roadway operations but operational benefits were not the focus of this research.

1.3 Objectives

UDOT must continually look for new ways to improve safety as they pursue their Zero Fatalities goal. One means to this end is studying what other roadway agencies around the US have done to improve safety. The objectives of this study were to:

- Research safety-related ITS devices and practices in use around the country
- Determine a subset of these devices with the greatest potential for adaptation to Utah's roadway environment
- Gather information from other state departments of transportation (DOTs) about their use of those devices
- Organize a scan tour for a group of UDOT employees to visit a few locations where the selected devices are being used
- Record activities and discussion points of the scan tour group
- Formulate a final report to document the study process and summarize the information gained from it

1.4 Technical Advisory Committee Composition

A TAC comprised of UDOT staff from a variety of divisions and groups with a stake in roadway safety was formed for the purpose of guiding the research study and scan tour effort. Table 1.1 lists TAC members' names, groups, and positions.

Table 1.1 TAC Members

Name	UDOT Group	Position
Cameron Kergaye	Research Division	Director of Research
Kevin Nichol	Research Division	Research Project Manager
Scott Jones	Traffic & Safety Division	Safety Programs Engineer
Rob Clayton	TOC	Traffic Management Engineer
Glenn Blackwelder	TOC	Traffic Operations Engineer
Mark Taylor	TOC	Traffic Signal Operations Engineer
John Haigwood	TOC	Freeway Management Engineer
Danny Page	Region 2 Office	Traffic Operations Engineer
Brian Phillips	Region 3 Office	Traffic Operations Engineer

1.5 Report Outline

The rest of the report is organized as follows:

- Chapter 2 – Survey Questions & Responses.
- Chapter 3 – Scan Tour Visits
- Chapter 4 – Summary of Recommendations
- Appendix A – Raw Responses to Agency Follow-Up Survey
- Appendix B – Automated Flashing Chevron Product Sheet
- Appendix C – Sample RICWS Plan Sheet (Iowa DOT)
- Appendix D – RICWS Journal Article
- Appendix E – Iowa DOT Message Mondays List
- Appendix F – Iowa DOT 2014 Seatbelt Survey

2.0 SURVEY QUESTIONS & RESPONSES

2.1 Overview

A series of two surveys was created to solicit feedback from DOTs across the US about their use of particular safety-related ITS devices. Results from the initial survey were used to narrow the research focus from a broad range of possibilities to a smaller group of devices and the DOTs that use them. The follow-up survey presented more detailed questions to drill deeper into how certain DOTs are utilizating the ITS devices that the TAC was most interested in learning about. Results of the follow-up survey played a central role in determining eventual scan tour destinations.

2.2 Initial Survey

The research team developed an initial list of survey questions and presented it to the TAC for their review. The questions were then finalized based on TAC input and uploaded to the *SurveyMonkey* website. The research team used online searches to compile a list of individuals around the US that work in roles related to safety and ITS. Additionally, TAC members provided names and email addresses of their nationwide peers as well as access to listserves where other relevant contributors could be reached.

Table 2.1 lists the individuals who received the survey link directly. Table 2.2 shows the survey questions and the menu of answers available for each question.

Table 2.1 Recipients of Initial Survey

Name	DOT	Email Address
Tim Barnett	Alabama	barnettt@dot.state.al.us
Jeff Jeffers	Alaska	Jeff.Jeffers@alaska.gov
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Jennene Ring	Washington	ringj@wsdot.wa.gov
Bruce Kenney	West Virginia	Bruce.Kenney@wv.gov
Scott Kozlik	Wisconsin	Scott.Kozlik@dot.wi.gov
Brian Porter	Wisconsin	Brian.Porter@dot.wi.gov
Matt Carlson	Wyoming	Matt.Carlson@wyo.gov

Table 2.2 Questions Contained in Initial Survey

Question	Answer Menu
1. Does your agency currently operate any of the following safety-focused ITS applications? Please check all that apply.	Check boxes were provided for: • Wrong-way driver detection and signing on freeways • Variable speed limit signing • Dynamic speed warning signing • Fog warning systems or other weather-related detection • Dynamic work zone monitoring • Red light monitoring (not enforcement) and measures to mitigate red light running • Traffic-responsive curve lighting (e.g. chevrons that light up as drivers negotiate a curve) • Flashing yellow arrows, particularly operating them in a lagging operation • Automated pedestrian detection at signals • Bicycle detection
2. Please provide basic information (e.g. installation dates, number of locations, etc.) related to the boxes you checked in Q1.	Free form text window
3. Please give basic descriptions of any safety-related ITS applications (focused on motor vehicles, pedestrians, or bicyclists) that your agency uses, but which were not listed in Q1.	Free form text window
4. Would you be willing to fill out a follow-up questionnaire related to your safety-related ITS applications if we would like more detail?	Radio buttons for “Yes” and “No”
5. What is your preferred phone number	Free form text window
6. What is your email address?	Free form text window

Table 2.3 cross-references each responding agency with the ITS applications that survey respondents indicated are being used there. The most frequently-cited ITS applications were flashing yellow arrows (FYA), variable speed limit signing (VSL), and dynamic speed warning (DSW) signing. The least frequently-cited applications were red light monitoring, automated pedestrian detection, and bicycle detection. It is important to note that the data are based solely on responses. Some devices may be in use in states that did not respond to the survey.

Table 2.3 Matrix of ITS Applications & States

DOT	ITS Applications*									
	1	2	3	4	5	6	7	8	9	10
British Columbia			X				X			X
California			X	X						
Sacramento County (California)			X							X
Colorado		X	X	X	X		X			
Connecticut					X					
Florida	X	X		X				X	X	X
Georgia		X						X		
Idaho								X		
Iowa	X	X	X	X	X		X	X	X	X
Kentucky		X						X		
Maine	X	X	X				X			
Maryland				X	X					
Michigan				X				X		
Minnesota		X	X		X			X		
Missouri	X		X		X			X		
Montana		X	X	X			X	X		
Nebraska										
Nevada		X		X				X		
New Hampshire		X								
Oregon		X			X			X		X
South Dakota			X							
Tennessee		X		X				X		
Texas	X		X					X		
Washington	X	X		X	X		X			X
Wisconsin	X		X				X	X		
Wyoming		X						X		
# of States Citing Each Device	7	14	12	10	8	0	7	15	2	6

* (1) Wrong-way driving detection, (2) VSL signing, (3) DSW signing, (4) Fog warning/weather systems, (5) Dynamic work zone monitoring, (6) Red light monitoring, (7) Traffic-responsive curve lighting, (8) FYA, (9) Automated pedestrian detection, (10) Bicycle detection

Answers to Question #2 were used to refine the check box data supplied in Question #1. It was evident from responses to Question #2 that some states misunderstood the device descriptions and were not really using the devices that corresponded to boxes that they checked. For example, one agency checked the box in Question #1 for “red light monitoring” but their response to Question #2 clearly indicated that they were using advance warning signs upstream from intersections rather than actually monitoring red light running. The research team manually adjusted answers to Question #1 in such cases.

Question #3 allowed the TAC and research team to learn about safety-related ITS devices that UDOT may not already be aware of but that could also be considered for further research. Table 2.4 shows the most applicable responses to this question. A consistent prevailing theme was use of rural intersection conflict warning systems (RICWS).

Table 2.4 Answers to Question #3 of Initial Survey

State	Additional ITS Applications
Iowa	(1) Intersection conflict warning systems. (2) Bridge overheight detection systems.
Washington	(1) Working on queue warning systems for interstate off ramp back-ups in Seattle now. (2) Intersection conflict warning systems.
Montana	(1) Dynamic flashing beacons on stop signs, triggered by approaching traffic. (2) Intersection conflict warning systems.
Minnesota	Intersection conflict warning systems.
Wisconsin	Intersection conflict warning systems.
Georgia	We have a "presence detection system" that uses video detection to look out for stopped vehicles in the HOV lane. If a vehicle is detected, it alerts our operators, who put up electronic sign messages to warn approaching drivers.
Kentucky	Intersection conflict warning systems.
South Dakota	Intersection conflict warning systems.
Maryland	(1) Dilemma zone protection systems. (2) Flashing red arrows. Essentially operates the same as FYA except that drivers are required to stop before making the turn (enforcement of this is very lax, however).
Missouri	In summer of 2015 they plan to activate an automated VMS system based on real-time traffic condition data supplied by a vendor. The system will prompt speed warning or congestion messages on the rural VMS as needed. They plan to also use the data to send text messages to construction, maintenance, and emergency response personnel to alert them of adverse driving conditions so that they can more efficiently respond to the scene, if necessary.

2.3 Detailed Follow-Up Survey

All respondents to the initial survey indicated that they would be willing to fill out a more detailed follow-up survey if requested. The research team and TAC used the initial survey answers to narrow the list of states to a smaller group for the detailed follow-up. The primary factors in the narrowing process were:

- Use of devices that UDOT is most interested in potentially implementing
- Use of multiple devices in close proximity so that a scan tour visit would yield opportunities to view several different ITS treatments with minimal travel
- Proximity to Utah so that flight times and costs could be minimized

The following states were chosen for detailed follow-up based on the aforementioned factors:

- Florida
- Iowa
- Minnesota
- Nevada
- Texas
- Washington
- Wisconsin

Each state on the narrowed list was emailed a series of questions and asked to answer them for the ITS applications they are currently using. This included applications from both the pre-selected list (Table 2.3) and the list of additional treatments (Table 2.4). Table 2.5 shows the series of follow-up questions. Appendix A contains the raw responses provided by each agency for their ITS applications.

Table 2.5 Follow-Up Survey Questions

Question
1. When was the treatment installed?
2. Where has the treatment been installed?
3. Do you use it broadly or is it still in a trial phase?
4. What safety problem were you intending to solve with the treatment?
5. What is the installation cost and what funding source(s) did you use?
6. Did you use sole source procurement for the equipment, and if so, why did you choose that vendor?
7. What are your ongoing operational/maintenance costs and what funding source(s) do you use?
8. What are your ongoing staff resource requirements related to the treatment?
9. What data do you have to document effectiveness of the treatment?
10. What aspects of the treatment have worked well?
11. What aspects of the treatment have been challenging or have not worked as well as you hoped?
12. How has the treatment been accepted by your internal agency/DOT staff?
13. What feedback have you received from external sources such as other agencies or the public?
14. Do you have any standard drawings or specifications related to the treatment?
15. Would you be willing to host a small group (4-6 people) visiting your area for all or part of a day to learn more about the treatment?

2.4 Scan Tour Location Decision

The decision was made by the research team and TAC to select Iowa and Minnesota as locations for the scan tour based primarily on the following reasons:

- Demonstrated interest from both agencies' staff
- Iowa's implementation of nearly all the pre-selected treatments mentioned in the initial survey, plus a few additional treatments that the TAC was interested in
- Experience in Minnesota with pioneering the use of RICWS, which the TAC expressed an interest in learning more about
- Adjacency of the two states, which minimized travel time and cost
- Existing relationships between UDOT TAC members and DOT staff in both states

2.5 ITS Device Research Spin-Offs

The research team and TAC also determined to spin off research of several ITS devices into their own stand-alone efforts.

2.5.1 Wrong-Way Driving

The TAC concluded that wrong-way driving (WWD) detection, signing, and related communications was a large undertaking deserving of its own focused research. The Research Division has since initiated a separate scan tour and research study specifically targeted at WWD mitigation. However, information regarding WWD is documented in Chapter 3 because a few discussions related to this topic occurred during the scan tour group's visit with Iowa DOT staff although it was not a focus point of the visit.

2.5.2 Flashing Yellow Arrows

UDOT's focus surrounding FYA usage was narrowly targeted to lead-lag operations and it was this specific subset of FYA operations that the surveys described. Nevertheless, many of the survey responses addressed generic FYA operations not pertinent to this subset. An additional challenge encountered with research into FYA lead-lag operations was that local jurisdictions in Iowa (not Iowa DOT) operate all of the traffic signals and a separate set of meetings with local agencies would be required during the scan tour.

For these reasons and because the specific issue of lead-lag FYA operations was important primarily to a single member of the TAC (Mark Taylor), the decision was made to forward all contacts and information about this topic to Mark and facilitate direct contact between him and agency staff. The main sources of FYA lead-lag information came from contacts in Reno (NV), Des Moines (IA), and Minneapolis (MN).

2.5.3 Bridge Overheight Detection

Several bridge overheight detection systems are in use in Iowa but the TAC determined that such systems were not a high priority for further research compared to some of the other devices that could have a greater safety benefit. However, the TAC did feel that some effort could be expended on viewing Iowa's systems during the scan tour if bridge overheight detection was a priority for UDOT's Structures Division. The research team contacted the Structures Division and determined that forwarding information (e.g. design plans) received from Iowa DOT to the Structures Division would satisfy their interest and that a field visit would not be needed.

3.0 SCAN TOUR VISITS

3.1 Overview

A subset of UDOT staff from the TAC was selected to participate in the scan tour visits with DOT staff in Iowa and Minnesota. Table 3.1 shows the participants. One member of each key TAC group (Research, Traffic & Safety, TOC, and region offices) was represented.

Table 3.1 Scan Tour Participants

Name	UDOT Group	Position
Kevin Nichol	Research Division	Research Project Manager
Scott Jones	Traffic & Safety Division	Safety Programs Engineer
Glenn Blackwelder	TOC	Traffic Operations Engineer
Danny Page	Region 2 Office	Traffic Operations Engineer

3.2 Iowa Department of Transportation

The scan tour group spent two full days in Iowa (May 4-5, 2015) interacting with Iowa DOT and Iowa State University (ISU) staff listed in Table 3.2. The focus of the first day was visiting safety-related ITS device sites in the Ames-Des Moines area of central Iowa. The second day was spent at the Iowa DOT headquarters exchanging information, discussing safety operations, and visiting their traffic management center. Willy Sorenson and Tim Simodynes were Iowa DOT's primary contacts. Both of them accompanied UDOT's scan tour group on the site visits and were present during the in-office discussions. The other two people listed in Table 3.2 participated in select discussions only during the in-office visits.

Table 3.2 Scan Tour Participants

Name	Group	Position
Shaunna Hallmark	ISU	Associate Director, Center for Transportation Research & Education
Michael Jackson	IDOT	Traffic Operations Engineer
Tim Simodynes	IDOT	ITS Engineer
Willy Sorenson	IDOT	Traffic & Safety Engineer

The research team found during visit preparation that Iowa DOT had useful information to share about general ITS maintenance considerations, safety-focused VMS messaging, and seatbelt usage in addition to the specific ITS device installations. The following subsections review information obtained about each of the ITS devices and other discussion topics.

3.2.1 Programs & Budgets

Iowa DOT allocates 0.5% of their total state construction funds to safety. This results in approximately $4.5 million of state funds for safety projects annually. For comparison, UDOT allocates $2 million per year of state funds for safety-specific projects.

Iowa DOT's total ITS budget has grown from approximately $3 million per year in the mid-2000s to a current total of $19 million per year, which is consistent with strong upper management support described by Iowa DOT staff. Not all of the $19 million is used for projects that specifically address safety but a considerable amount of it is.

3.2.2 Maintenance & Contracting Considerations

The ITS budget is used for both installation and maintenance of equipment. The agency's director is a strong supporter of properly maintaining the ITS system. ITS devices were initially maintained by regular Iowa DOT maintenance crews but they have since transitioned to a different method. One of the main drawbacks with using internal maintenance crews was that replacement parts came out of the crews' budgets, thereby creating a negative incentive to properly maintain the equipment.

Iowa DOT currently structures their ITS construction contracts to require two years of maintenance by the contractor performing the initial installation. This method gives a positive incentive to contractors to do a quality installation on the forefront. Procurement contracts are used to hire a contractor to maintain the equipment after the initial two-year period expires.

Historicaly, UDOT has typically installed most of its ITS devices as part of large construction projects. Iowa DOT on the other hand normally installs its ITS devices through stand-alone contracts not associated with large construction projects. They also use "Best Value" bidding instead of traditional low bid selections because they believe that getting quality equipment is more important than getting the lowest cost. Iowa DOT believes that this bidding method has been beneficial for their agency.

3.2.3 Automated Flashing Chevrons

ISU's Institute for Transportation (InTrans) worked with Iowa DOT to install speed-activated light-emitting diode (LED) flashing chevrons at a horizontal curve on IA-144 in Boone County. The purpose was to study results obtained at this location and decide whether the treatment should be expanded to other locations.

The system works by placing a radar sensor on an advance curve warning static sign. The sensor detects approaching vehicles and transmits a signal to activate LED flashers on the downstream chevron signs. The system can be configured to have the signs all flash in unison or in sequence to deliver a "pull-through" effect for drivers going around the curve. TAPCO™ produces the equipment used by InTrans at this location. Iowa DOT reported a cost of approximately $1,500 per chevron sign to install. Installation was straightforward and did not reqire different equipment than is used to install static chevron signs. Public feedback has been positive. A product sheet with more details is included in the appendix.

The UDOT scan tour team was not able to observe the flashing chevron signs in the field because InTrans had already completed their evaluation and removed the electronics from the signs prior to May 2015. However, Figures 3.1 and 3.2 show what the sign array looked like when it was operational. A video showing the perspective of a driver going around the curve can be viewed at https://youtu.be/z-neMzucsEo.

Figure 3.1 Night View of LED Flashing Chevron

Figure 3.2 Sign Array on IA-144 in Boone County

InTrans's initial analysis showed a good reduction in crashes after installation. However, only two years of post-installation data were collected, which is not enough to use for creating a treatment-specific crash modification factor. InTrans has also tested other curve treatments like reflective posts and on-pavement curve messaging in addition to the flashing chevrons signs.

3.2.4 Dynamic Speed Warning Signs on Curves

InTrans authored a research study published in January 2015 to evaluate DSW signs on horizontal curves along rural two-lane highways. The study was based on 22 locations spread between seven states including Iowa. The national study calculated a CMF of 0.93 for this treatment (only applicable to total crashes in the direction facing the sign).

The scan tour team attempted to visit a DSW site on US-69 south of Indianola but the sign had already been removed. InTrans staff later said that they had problems with this particular sign being stolen repeatedly and finally stopped reinstalling it. Figure 3.3 shows the message displayed on the blank-out sign on US-69 when vehicles traveling faster than the threshold speed triggered the sensor. This sign was configured to have the radar sensor activate the blank-out sign if an approaching vehicle was traveling more than 5 mph faster than the 50% speed or the speed limit, whichever was lower.

Figure 3.3 US-69 Blank-Out Sign Message

Figure 3.4 shows another type of display used in a similar installation on US-67 near the town of Princeton. When triggered, this sign initially activates both a message alerting the driver to slow down and the vehicle's current speed. The speed value disappears after the initial message display in order to disincentivize drivers from accelerating to "test" the sign at higher speeds. It may, however, encourage some drivers to turn around and make a second pass through the curve at a higher speed once they realize that the sign will display their speed initially.

Figure 3.4 US-67 Blank-Out Sign Message

3.2.5 Variable Speed Limit Signing

Iowa DOT is currently testing a VSL system on I-35 between Des Moines and Ames. The system will be fully functional by winter 2015-2016. Pole-mounted infrared pavement sensors were placed to detect ice cover and pavement friction. These sensors are aimed at the left wheel track of the outside lane. Eight sensors (four in each direction) are spread out approximately every mile or two over an eight-mile section. Visibility sensors were also placed to detect low-visibility conditions. Iowa DOT uses Vaisala™ products for the pavement and visibility sensors. Wavetronix™ speed sensors were already present prior to this project. Absorbant Glass Mat (AGM) batteries are used for power. The scan tour group noted that UDOT may want to look into using them based on Iowa's success.

A key part of Iowa DOT's VSL system is alternating an advisory speed and a short message conveying a reason for the advisory as shown in Figure 3.5. The expectation is that motorists will more likely obey the recommendation if a specific reason is given and the speed reduction doesn't feel arbitrary. Pavement and visibility sensors will be used to gather information necessary to display the proper message about the reason for the recommended speed reduction.

Figure 3.5 Advisory Speed & Condition VMS Boards

The recommended speed will be based on real-time data gathered by speed sensors in keeping with the principle of speed harmonization, which presupposes that prevailing speeds are a good indication of safe travel speeds. Iowa DOT is planning to post the advisory based on the average speed measured for the previous three minutes, but they are also considering other algorithms. One specific option they are considering is only using the average speed in the left lane and ignoring the right lane speeds as UDOT currently does for a VSL segment on I-80 in Parley's Canyon. Iowa DOT does not intend at this time to make the variable speed limits regulatory. Figure 3.6 shows the speed and condition message combinations that Iowa DOT plans to use. Figure 3.7 depicts the pole-mounted Wavetronix and Vaisala sensor equipment.

Figure 3.6 Possible Speed & Condition Message Combinations

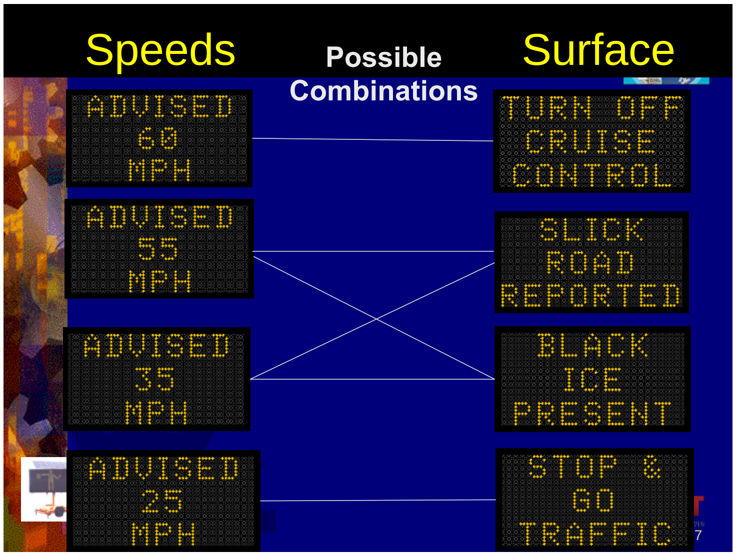


Figure 3.7 Pole-Mounted Speed & Visibility Sensors

This approximately 10-mile VSL system is being funded with a combination of state money and $100K of federal State Planning and Research (SPR) funds. The friction sensors cost a total of $202K, with electrical and software configuration costing $10K each. Another $15K is being allocated to evaluate the system's effectiveness after it is installed. Iowa DOT plans to use portable VMS signs for the short term and possibly install permanent signs when the system is more mature.

The test project was initiated at the request of upper management and is located on a stretch of roadway with Iowa's highest crash rate. The general public is not yet aware of it so feedback has not yet been received from roadway users. Iowa DOT plans to evaluate the following types of issues related to their VSL test installation:

- Applicability to entire corridors versus spot locations
- Optimal sensor density
- Driver compliance with advisory speeds
- Speed harmonization
- Message comprehension
- Change in crash frequency and severity

3.2.6 Speed-Activated Variable Message Signing in Work Zones

Speed-activated VMS systems have been used by Iowa DOT in work zones to prepare drivers for entry into temporary curve situations such as median crossovers. The purpose is to alert drivers of an upcoming curve and reduce speeds prior to entry. The system generally consists of an advance warning sign, followed by a static regulatory speed limit above a "your speed is" dynamic sign, and finally a blank-out sign that flashes the speed limit only when drivers are exceeding a threshold speed set by Iowa DOT engineers. Figures 3.8 through 3.10 illustrate each of these three components. Members of the UDOT scan tour team noted that this type of system could have applicability to upcoming reconstruction work on I-215 in western Salt Lake County.

Figure 3.8 Work Zone Advanced Curve Warning Sign

Figure 3.9 Speed Limit & Dynamic Speed Signs

Figure 3.10 Final VMS Sign Prior to Curve

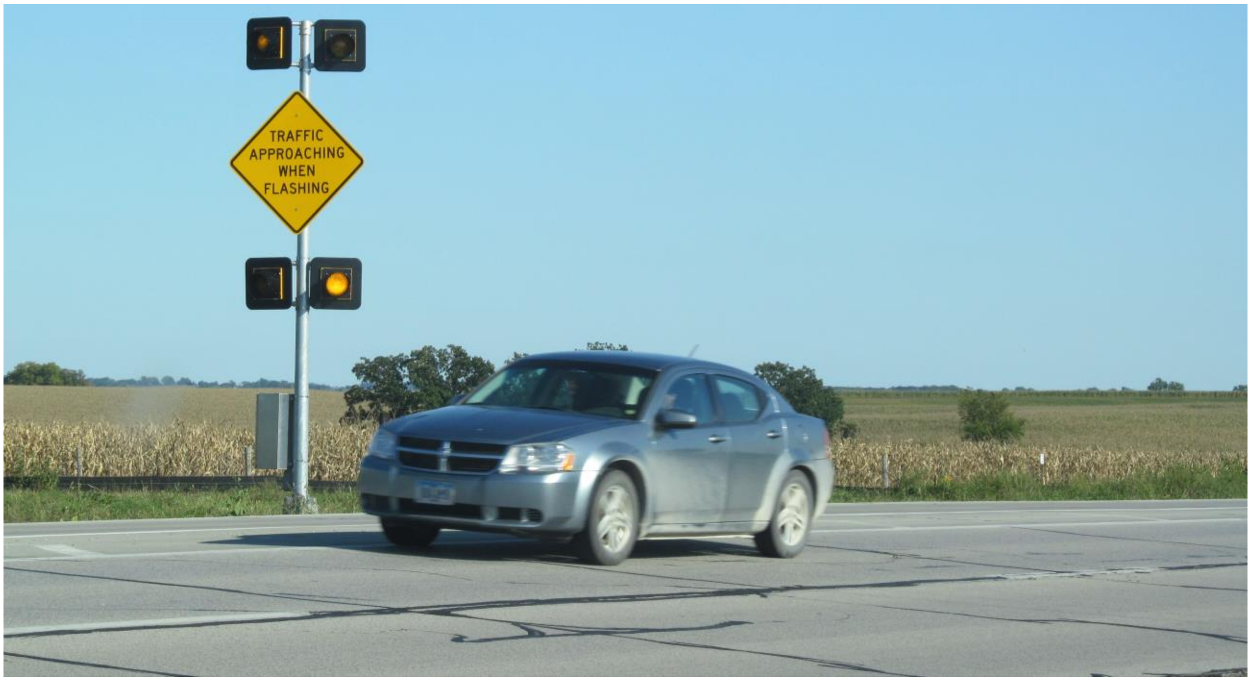
3.2.7 Rural Intersection Conflict Warning Systems

The purpose of RICWS is to mitigate angle crashes at high-speed at-grade crossings where crash history shows that minor street traffic is not yielding properly to mainline traffic. These types of crashes tend to be very severe due to the speeds and angles involved. Iowa DOT's RICWS installations generally involve a minor street crossing a divided highway with a median refuge that allows cars from the minor road to cross the major street in two separate steps.

RICWS sign arrays have been installed by Iowa DOT such that warnings are given to vehicles on the minor road when traffic is approaching on the mainline divided highway. In these types of installations, warning signs and flashers are oriented so that drivers on the minor road will see the warnings in the direction where they are looking for approaching traffic. Flashers only activate when cross traffic is present. Figures 3.11 and 3.12 show what drivers on the side of the road and in the highway median see when they look in the direction of oncoming traffic.

Figure 3.11 View of RICWS Sign from Minor Street

Figure 3.12 View of RICWS Sign from Highway Median



One challenge with this type of installation is that sign placements may not foster illumination by vehicle headlights. Iowa DOT is evaluating the following options for improving sign visibility:

- Adjusting sign placements
- Using blank-out signs that only illuminate when triggered by approaching vehicles rather than using static warning signs
- Placing cobra head lights above the signs

Iowa DOT is now considering installing RICWS with warnings for mainline traffic when a car is approaching from the minor road. Their interest in this method is largely driven by the success that Minnesota and Wisconsin have seen with this type of RICWS application.

Cameras are included with RICWS installations so that maintenance crews can remotely check operations. Iowa DOT has also found that the cameras have been very helpful with investigating crashes that occur at these intersections as well as justifying future intersection grade separation projects. Power is wired to the signs in lieu of solar panels. Monitoring devices are placed with each installation so that an on-call electrician will be notified to fix the equipment if it is not working properly.

Each RICWS location costs approximately $50K to install. To date, loop detectors have been used for vehicle detection but IDOT is considering using Wavetronix radar equipment in future installations so that lanes don't need to be shut down for loop installation. Before-after evaluations of system effectiveness have not been conducted to date but Iowa DOT staff would like to complete such an analysis.

Iowa DOT staff members believe that existing installations have been well-received by the public and they receive periodic requests for more of them. Although RICWS locations are generally not very expensive to maintain, Iowa DOT is concerned about constructing too many and increasing their maintenance burden. Staff would generally prefer to achieve the intended purposes through geometric improvements rather than RICWS but the high cost precludes that from being more of an option. A sample RICWS plan sheet from Iowa DOT and a journal article about RICWS are included in the appendix.

3.2.8 Wrong-Way Driving Infrastructure

Iowa DOT has deployeed a WWD detection system with 20 sensors on US-30 through Ames. US-30 is a divided limited access freeway in this area. The system relies on Wavetronix equipment to detect vehicles traveling in the wrong direction. Iowa DOT staff members estimate that 95% or greater of the WWD "calls" reported by the sensors are false events (i.e. no actual WWD behavior observed). This poor recognition rate has kept Iowa DOT and law enforcement agencies from aggressively responding to reported events or installing WWD notification signs directed at motorists.

Currently only a few people in Iowa DOT's Traffic & Safety Division and at their Traffic Management Center receive automatic notifications when WWD sensors are tripped. Iowa DOT was actively working with Wavetronix to resolve some of the issues at the time of scan tour visit. The following specific challenges have been observed:

- Difficulty with clouds and shadows
- Difficulty pinpointing WWD entry points, causes, and trends because sensors serve other functions (speed sensing and volume counts) and were placed in the system to serve those functions, not WWD-specific needs

- Maintenance crews performing shoulder mowing can trip sensors
- Tow trucks and others assisting disabled vehicles can trip sensors when backing up

Iowa DOT staff members believe that their signing, striping, reflectivity, and lighting treatments have been fairly effective at reducing some of the WWD-related 911 calls. All of their WRONG WAY ramp signs and pavement markings use high reflectivity materials to heighten awareness.

ITS camera footage is currently being stored for three days by Iowa DOT on a large server. It has proven very helpful with determining after the fact whether reported WWD events are real or false. An intern reviews the video to determine the legitimacy of each WWD notification triggered by the sensors. Iowa DOT also gets 911 reports from law enforcement agencies and they use the video to investigate those reports as well. At least one instance has occurred where video has confirmed a real WWD event that was not picked up by the sensors.

Iowa DOT staff remain optimistic about the potential safety benefits of WWD detection despite the problems experienced to date with getting the system calibrated correctly. Local law enforcement agencies believe there is a serious problem with WWD and are excited about the effort. Iowa DOT staff members would like to deploy additional sensors on freeway ramps in order to better determine where WWD events are originating but have not yet been able to achieve buy-in to make this happen.

3.2.9 Safety-Focuced Variable Message Signing

Iowa DOT’s director asked their traffic and safety staff to develop a program for using VMS boards to display safety messages beginning in the summer of 2013. The resulting program has been dubbed “Message Mondays”. Iowa DOT staff coordinated with their local Federal Highway Administration (FHWA) representatives at the outset to determine how to operate the program. FHWA said that displaying only fatality numbers would not be compliant with the Manual on Uniform Traffic Devices but that it would be acceptable to display such numbers if a safety message was displayed along with the statistics.

An intentional decision was made to post the safety messages only one day a week to prevent them from becoming too frequent and losing their impact. Iowa DOT also decided to alternate standard safety messages with clever, “catchy” messages during different weeks to attract attention and lead to discussion in the community, particularly among the 18-30 year old age demographic.The standard practice is for VMS boards to switch between a traffic fatality statistic message and a safety message at an interval of a few seconds. Figure 3.13 shows an example of the statistic message. Figures 3.14 and 3.15 illustrate examples of standard and catchy safety messages, respectively. A full list of the weekly messages used between August 2013 and March 2015 is included in the appendix.

Figure 3.13 VMS Traffic Statistic Message

Figure 3.14 Standard VMS Safety Message

Figure 3.15 Catchy VMS Safety Message

Iowa DOT assembles a team of people to brainstorm message ideas every six months. Ideas are then presented to upper management for more vetting. They generally do not use the same message twice. Staff members believe that their tactic of using humor paired with statistics has been very successful at reaching the intended goal of creating conversations about the importance of traffic safety within the community. They get both positive and negative comments about their messages on social media but they believe that feedback is about 93% positive. This level of support has allowed them to keep pushing the envelope with regard to how "edgy" they can be with their messaging.

Staff members say that negative feedback is inevitable but that it's important to have thick skin and stay the course. They also recommend deflating criticism from particularly negative people by asking them to suggest what they think should be used for future safety messages.

3.2.10 Seatbelt Usage

The scan tour team had a short discussion with Iowa DOT staff about the subject of seatbelt usage in Iowa. This was a hot topic at the time because Utah had very recently passed a primary seat belt law that will sunset after three years and UDOT will need to provide justification in 2018 for why the law should be extended. Iowa's primary seatbelt law was enacted approximately 30 years ago and they complete an annual seat belt use survey to quantify compliance. Their 2014 survey report is included in the appendix for reference. The report discusses the methodology and results. Important points from the 2014 report and from the discussion with Iowa DOT staff are as follows:

- The seatbelt survey includes 5 separate sites in 15 different counties for a total of 75 sites
- All collection personnel and quality control managers were properly trained
- Data were collected during the month of June
- Data collectors could not assess seat belt use for approximately 3% of drivers and passengers surveyed but observations were possible for the other 97%
- Iowa's overall seat belt use rate was 92.8% with less than 1% standard error (for comparison, Utah's seat belt rate is approximately 84%)

Iowa's standard law enforcement crash report includes two specific questions about seat belt usage. The first asks officers to state whether occupants of the vehicle(s) involved in the crash were wearing seatbelts. The other question asks them to assess whether those wearing seat belts would likely have died had they not been wearing a belt. The latter question makes it possible for Iowa DOT staff to assess crash records and calculate an estimate of how many lives were saved each year by seat belt use. Staff members believe that officers are conservative in estimating lives saved and that the annual totals are thus also conservative.

3.2.11 Miscellaneous Discussion Points

A few noteworthy discussions unrelated to the specific ITS applications described in previous sections occurred during the scan tour. The following bullets summarize the discussions worth documenting in this research paper:

- Michael Jackson from Iowa DOT stated that FHWA Strategic Highway Research Program 2 (SHRP2) would look favorably upon a joint submittal from UDOT and Iowa DOT for a lane closure project application. Glenn Blackwelder from the scan tour team said that UDOT would be happy to partner on such an application and that he would share the website address for UDOT's current lane closure electronic application. Michael was particularly interested in the application's queue length reporting functions.
- Iowa DOT runs "flush" cycles at select interchange ramp signals where queues sometimes back onto freeways lanes and affect freeway operations as well as safety. The purpose of such cycles is to give more green time to movements that will flush out the queues and prevent them from affecting the mainline freeway lanes. UDOT's scan tour team felt that this type of process could be applicable at locations such as the I-15/9000 South interchange where queues can back to the freeway during peak hours.
- Iowa DOT has installed a few 55 mph reduced speed school zones on roads with 65 mph speed limits near rural schools. Their particular focus is making it safer for school buses turning into and out of the schools – not the traditional approach of helping children cross the road. They use a Daktronics™ product with 90-degree LED lights that cut through fog well. Iowa DOT's post-installation speed studies show that average speeds only decreased by about 2 mph but that the treatment was successful at reducing excessive speeds. Figure 3.16 shows an example of one of the reduced speed school zones.

Figure 3.16 Reduced Speed School Zone Sign

3.3 Minnesota DOT

UDOT's scan tour group spent most of one day in Minneapolis (May 6, 2015) interacting with the Minnesota DOT (MnDOT) personnel listed in Table 3.2. Unlike the Iowa visit, time did not permit the group to visit any locations in the field. The MnDOT information exchange occurred in a classroom setting with different MnDOT staff members speaking to specific ITS safety devices that they have been involved with implementing. The following subsections review information obtained about each of the ITS devices.

Table 3.3 MnDOT Scan Tour Participants

Name	Position
Rashmi Brewer	ITS Project Manager
Tiffany Dagon	Metro Traffic Work Zone Engineer
Terry Haukom	FMS Systems Architect & Design
Cory Johnson	Traffic Research Director
Brian Kary	Freeway Operations Engineer
Jesse Larson	Assistant Freeway Operations Engineer
Derek Leuer	Traffic Safety Planning
Morrie Luke	MnPASS Operations Engineer
Steve Misgen	Metro District Traffic Engineer
Daniel Rowe	ITS Project Manager
Kevin Schwartz	Metro Traffic Signals Engineer

3.3.1 Freeway Smart Lanes

MnDOT tested so-called “smart lanes” on I-35W and I-94 in the Minneapolis area. These lanes have blank-out signs placed above them periodically (approximately every half-mile) to give motorists advisory speeds (not regulatory) that can differ from lane to lane. The signs can also be used to display messages about lane closures or upcoming merging activities. The purpose of the smart lanes is to inform motorists about events occurring ahead so that they can travel safely. Figure 3.17 illustrates display options for the blank-out signs, while Figure 3.18 depicts an actual location in Minnesota showing the orientation of the blank-out signs in relation to traffic lanes.

Figure 3.17 Smart Lane Blank-Out Sign Options

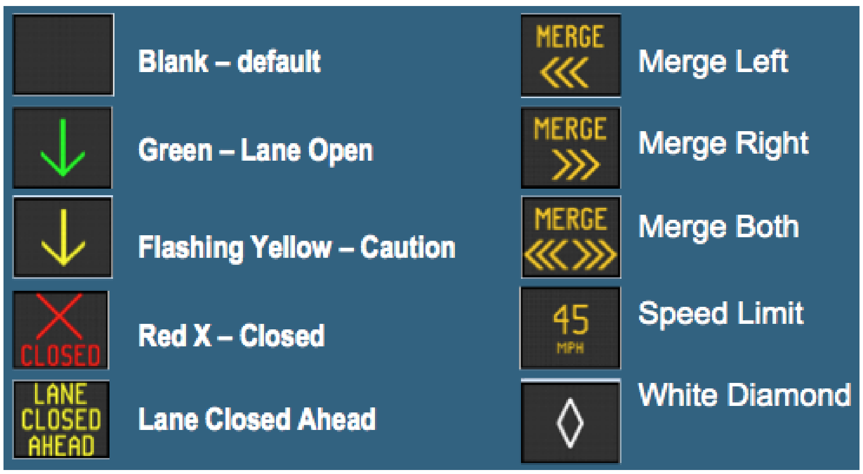


Figure 3.18 Smart Lane Installation in Minnesota

The smart lane system works by measuring traffic speeds along the corridor and then using the information to recommend speeds upstream as far as 1.5 miles. MnDOT performed human factors studies including driving simulations to test message effectiveness and understanding with 160 participants in four discrete age groups between 18 and 70+ years old. Results showed that the messages were well-understood overall but that further study was needed to determine how motorists would use the information in the real world with other factors at play, such as gap acceptance, queue jumping, and skepticism about sign messages.

Results of on-the-road system testing show that although people seem to understand the sign messages, compliance with them is still an issue. Other system results include:

- Mimimal mobility improvements
- Improvements in speed differential approaching congestion
- Reduced shockwaves
- No improvement in crash numbers (although results are still preliminary)

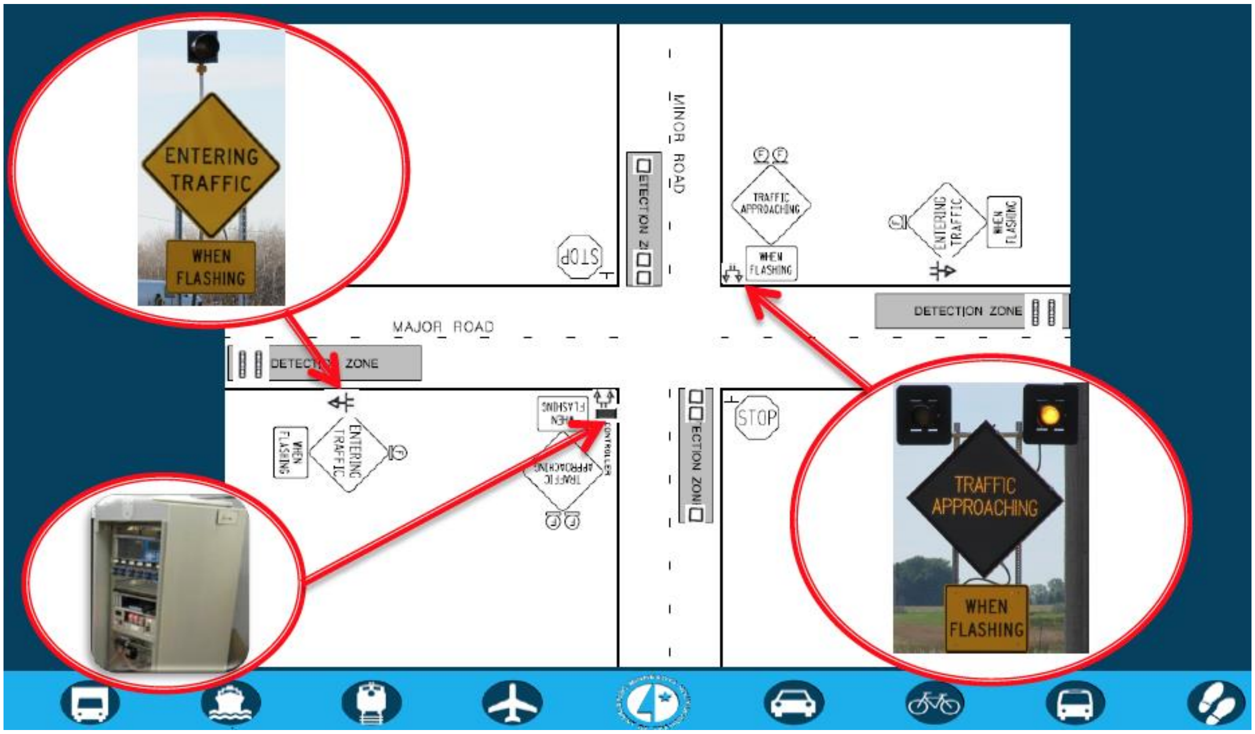
The most important thing to note about MnDOT's smart lane deployment is that they have temporarily suspended it. They found recently that it was not responding well to conditions and compliance was poor. MnDOT plans to investigate better detection methods and algorithm improvements before re-launching the system.

3.3.2 Rural Intersection Conflict Warning Systems

MnDOT uses RICWS installations to influence driver behavior at stop-controlled intersections (typically with speeds 45 mph or greater on the major road) where right angle crashes are the predominant crash type. Sometimes they install warning signs on both the major road and the minor road, while in other instances they only provide the warning to vehicles on the major road. This differs from Iowa DOT's practice of providing warning signs oriented to minor road traffic if only one of the roads will be signed.

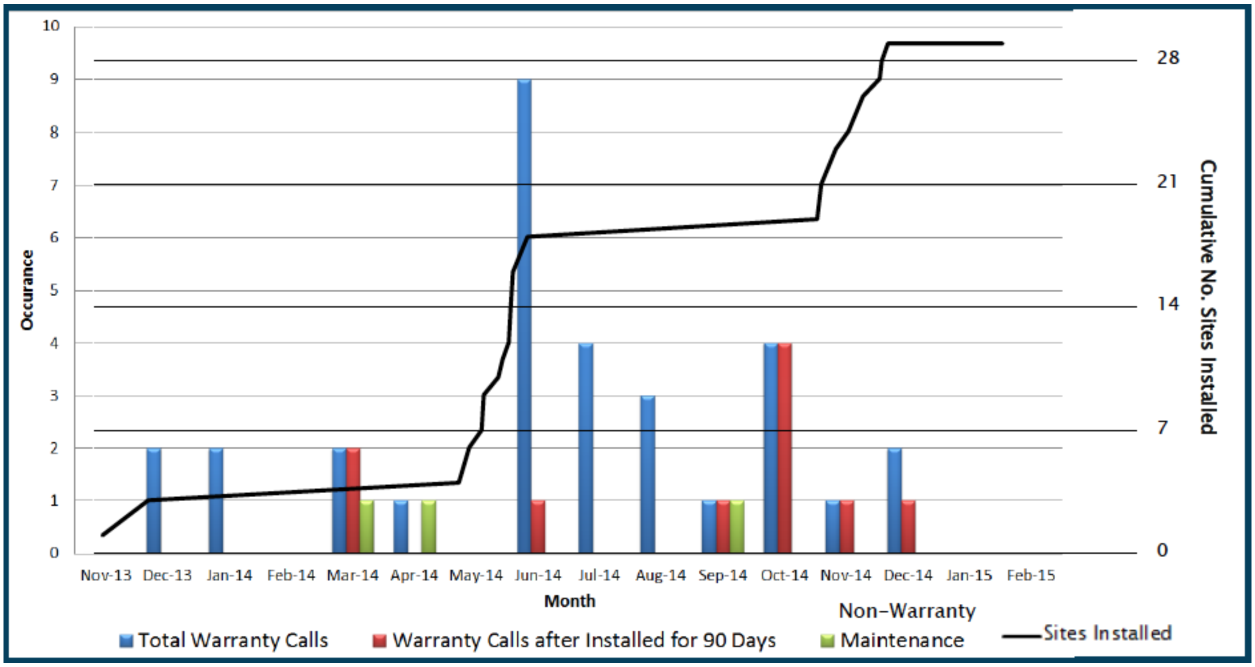
Figure 3.19 shows a typical MnDOT schematic layout of an installation with warnings for both major and minor road traffic. Drivers on the major road see a static sign (with flashers on top) with a message of "Entering Traffic When Flashing". Minor road drivers see a blank-out sign that displays “Traffic Approaching” (with flashers on top and a static “when flashing” sign on bottom) when sensors detect traffic on the major road.

Figure 3.19 MnDOT Typical RICWS Schematic



MnDOT has found that a very high degree of system reliability is key to RICWS effectiveness. Their goal is 99.95% accuracy, which equates to one error in every 2,000 vehicles. MnDOT also has a goal of 72-hour response time for fixing equipment malfunctions. The warranty required by their installation specifications covers construction defects and errors in controller logic or settings, whereas MnDOT maintenance crews are responsible for vandalism and sign assembly knock-downs. Figure 3.20 illustrates MnDOT’s history of warranty calls and maintenance needs with respect to their growing number of RICWS installations. The figure shows that calls have not increased in proportion to the number of installations and that maintenance crews were only called out three times in the first year of operation.

Figure 3.20 Warranty & Maintenance Calls



MnDOT intentionally develops maintenance-minded RICWS designs to lessen long-term upkeep needs. They do this by using commercial off-the-shelf products that technicians are already familiar with. MnDOT has used both design-build and design-bid-build methods for constructing RICWS sites. They feel that design-build can offer the following advantages:

- Allows the contractor to meet a performance specification
- Allows for innovation
- Truncates construction schedules

One important lesson learned from Minnesota's experience with RICWS is that cookie cutter approaches to specific locations do not work well because each intersection environment is unique. It is very important to have inspectors experienced in staking, testing, and adjusting designs in the field. Location-specific considerations include:

- Presence of driveways on the major or minor road approaches where vehicle detection needs to be placed
- Whether the major road is a divided expressway with a median or an undivided highway
- Whether other minor road intersections exist in close proximity to the intersection where RICWS is being installed

- Presence of horizontal curves and/or skew angles
- Presence of at-grade railroad crossings, bridges, or culverts within detection zones

Miscellaneous properties of the RICWS sites include:

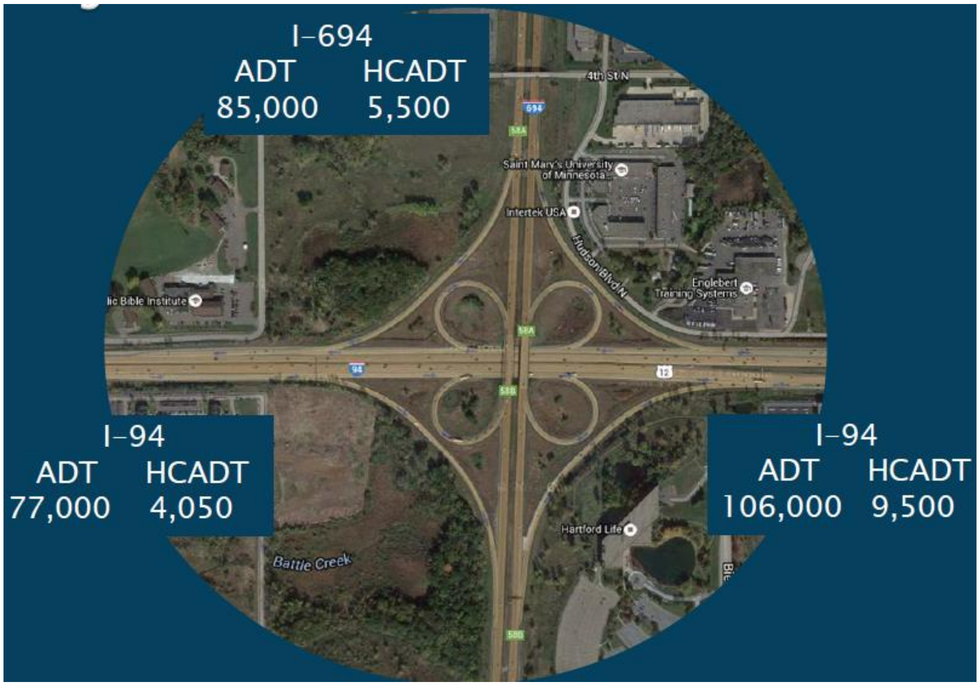
- Estimated 25-30% reduction in total crashes
- Power consumption of 60-100kWh per month (per site)

3.3.3 Truck Rollover Warning System

MnDOT manages roadways where a history of truck rollover crashes is present. In 2014 they implemented a test project for a truck rollover warning system (TROWS) at the interchange of I-694 and I-94 in the Minneapolis-St. Paul metro area. This location was chosen because of its high truck volumes and history of rollover crashes on the southbound-to-eastbound ramp movement. That one movement alone exhibited six truck rollover crashes between January 2007 and May 2012. The tight curvature of the clover leaf ramp geometry is the main factor contributing to the need for trucks to slow down while making this movement. Figure 3.21 depicts the ramp where TROWS was implemented. Figure 3.22 shows the traffic and truck volumes for the north, west, and east interchange approaches.

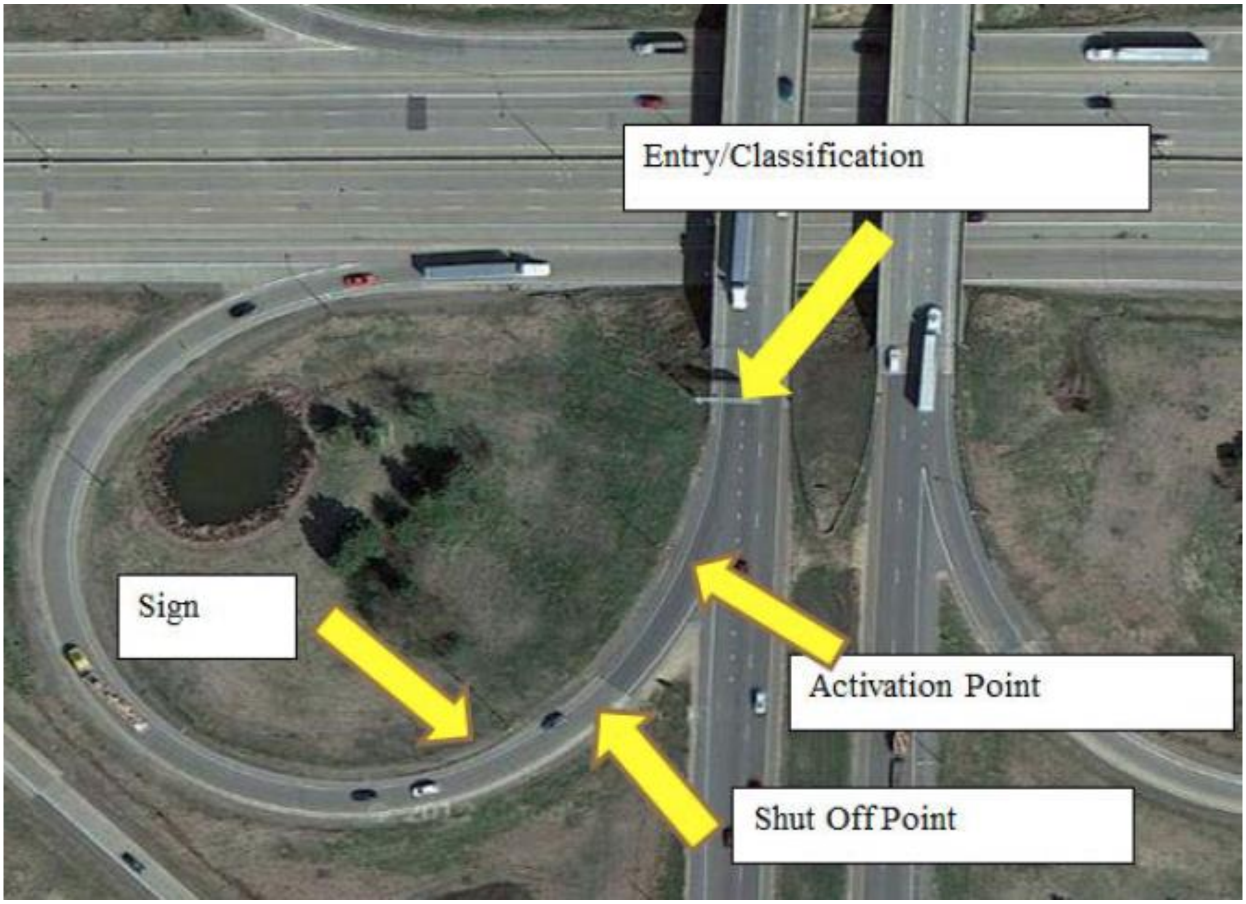
Figure 3.21 TROWS Test Location

Figure 3.22 TROWS Traffic & Truck Volumes



The primary goals MnDOT was attempting to accomplish with TROWS were prevention of driver injury, elimination of secondary crashes, reduction of crash-related economic costs, and mitigation of traffic impacts related to delay time. The system works by sensing vehicle type and speed, then displaying an actuated truck rollover warning sign if a truck is coming into the ramp too fast. Weigh-in-motion sensors (in MnDOT's case, piezoelectric strips) are placed where the ramp entry begins to diverge from the outside mainline freeway lane to detect whether the vehicle about to enter the ramp is a heavy truck. Speed sensors are placed at appropriate places on the ramp (in advance of the warning sign) to gauge whether the truck's weight and speed profile are likely to put the vehicle at risk of a rollover, in which case a blank-out sign is activated to warn the truck driver to slow down. Figure 3.23 shows generally where MnDOT placed its detection and signing for the I-694/I-94 interchange installation.

Figure 3.23 TROWS Sensor Locations



Roadway surface condition sensors can also be used with TROWS to detect whether the roadway is icy. MnDOT uses a surface sensor installed with a detector pan and relays the information to the blank-out sign, which is capable of displaying either the truck rollover sign and advisory speed or an icy road warning. Figure 3.24 shows the inactivated blank-out sign with depictions of the two warning sign possibilities on either side. Figure 3.25 shows what the sign looks like when the truck rollover warning is displayed.

Figure 3.24 TROWS Blank-Out Sign Messages

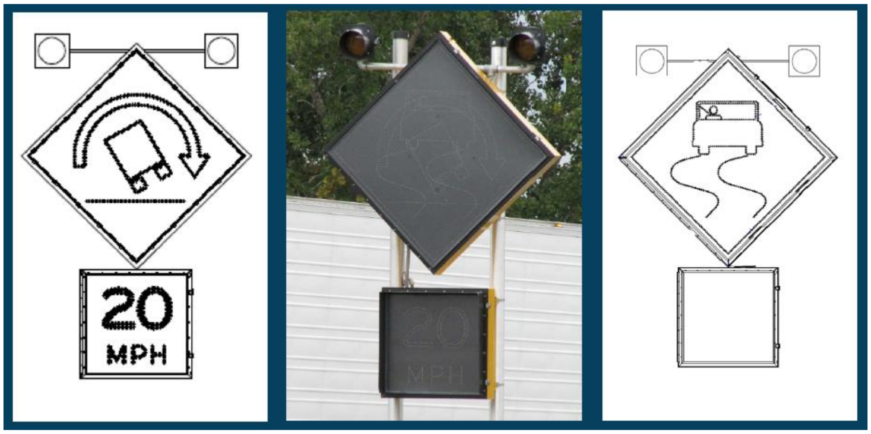


Figure 3.25 TROWS Sign Display

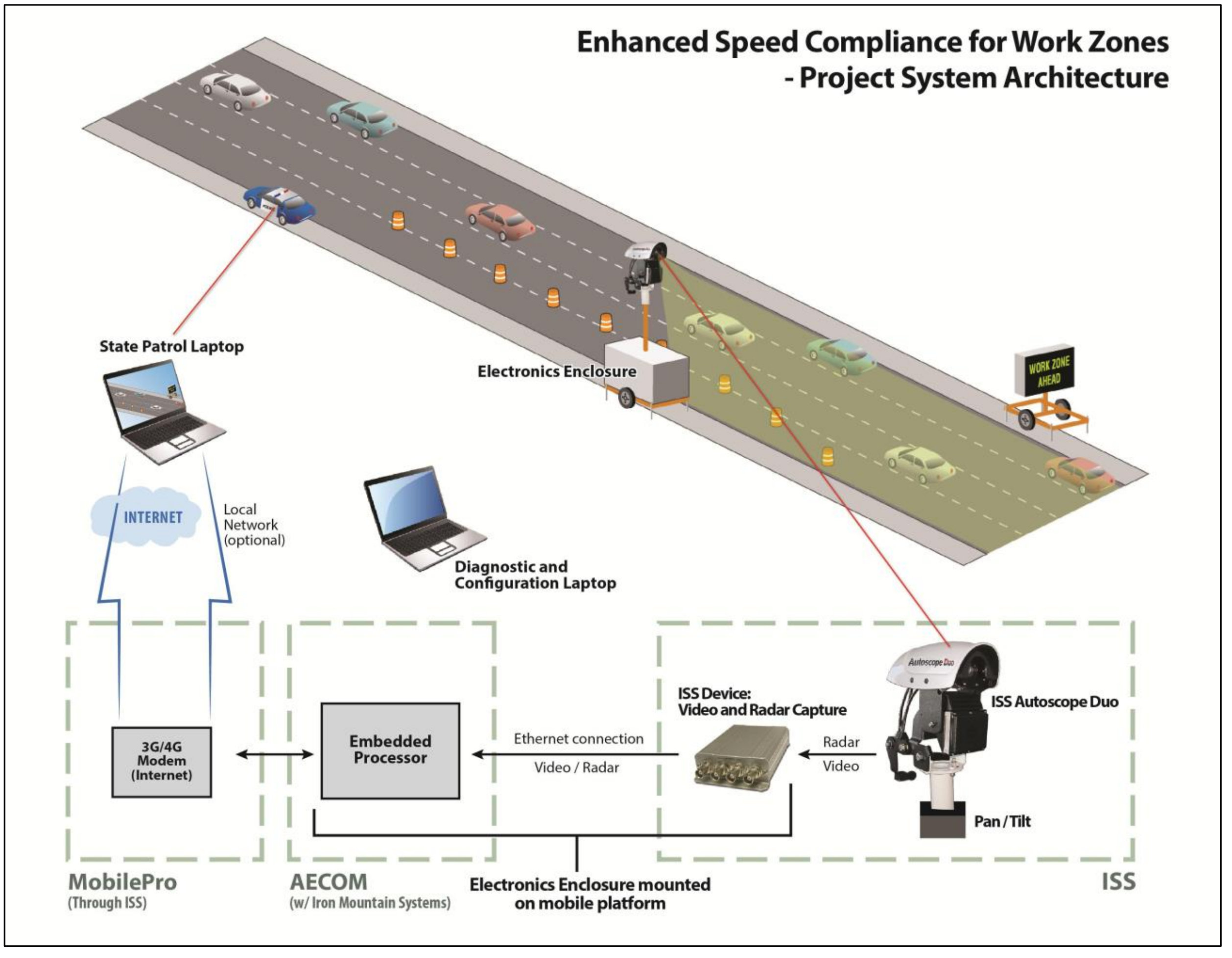
Pre-installation testing showed that 75% of trucks would have triggered the rollover warning had it been active at the time. Post-installation testing showed that approximately 70% of trucks entered the ramp at speeds that triggered the sign to activate, which is a reduction of 5% relative to pre-installation conditions. The TROWS at I-694/I-94 cost $350K to install, with an itemized breakdown as follows:

- Construction – $257K
- Systems Engineering – $25K
- Design – $19K
- Other Consultant Costs – $49K

3.3.4 Enhanced Speed Compliance for Work Zones

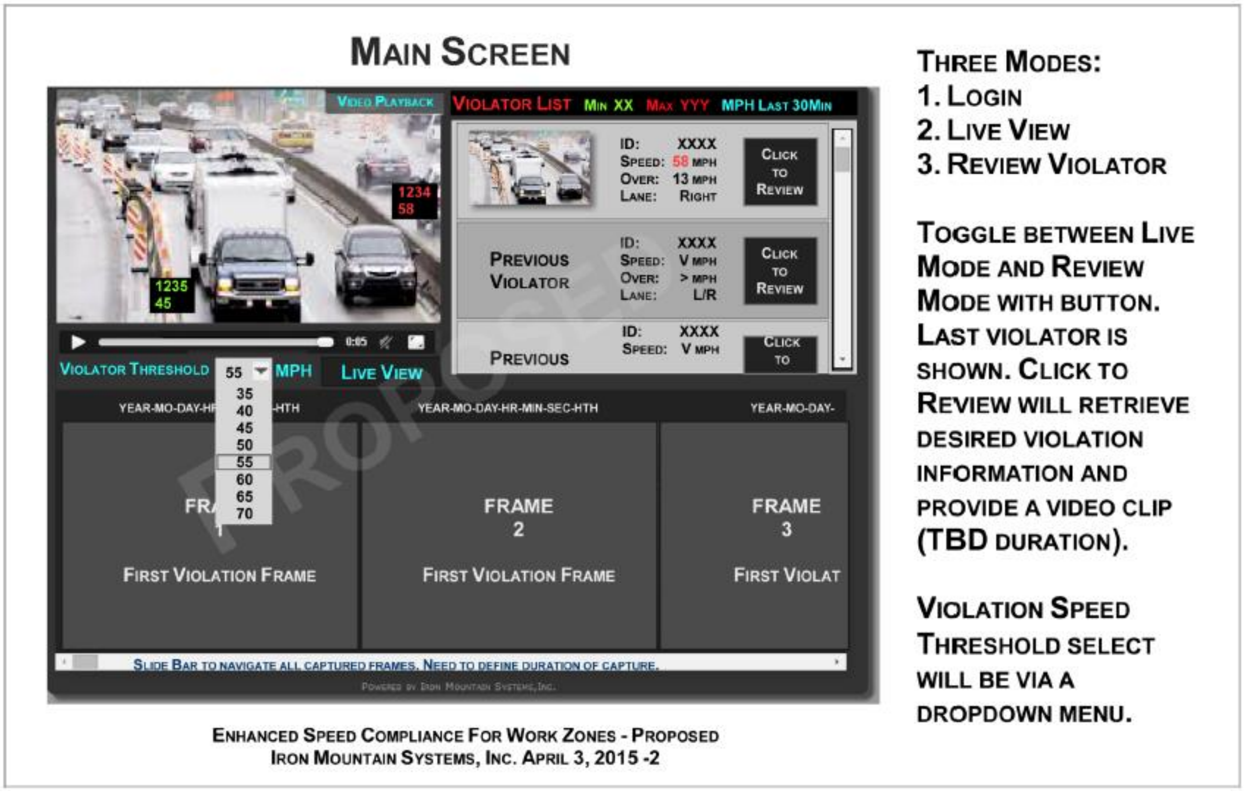
MnDOT sees a need to provide safer ways for their highway patrol officers to enforce speed limits in work zones. To that end, they are developing a mobile enforcement system that they plan to test in 2015. Proposed work zone test sites will be selected jointly by MnDOT and the highway patrol. A consultant (AECOM) is being hired to design the system, collect data, and report findings. Figure 3.26 shows a simple schematic of how the system works.

Figure 3.26 Work Zone Mobile Speed Enforcement System



A camera within the work zone detects the speed of vehicles and transmits the information (along with video of the violators) through the Internet to a laptop located in the highway patrol car downstream from the work zone. Officers have the option to select a threshold speed that will flag vehicles as violators when exceeded. The primary purpose of this system is to afford officers the opportunity to monitor and enforce work zone speeds without actually needing to be parked inside the work zone itself. Figure 3.27 shows one of the screens officers would use to view violator data.

Figure 3.27 Mobile Enforcement Software Screen



Expected total cost of this pilot project is approximately $230K. The conceptual design takes advantage of a detection and monitoring system previously developed for a red light enforcement system, so they are realizing some cost savings relative to if they had to develop it from the ground up. Expected benefits of the mobile enforcement system include:

- Improved officer safety during enforcement activities
- Improved work zone safety for construction crews and motorists
- System portability
- Easy setup
- Intuitive user interface

3.3.5 360-Degree Radar Detection

A 360-degree radar information system was installed by MnDOT on I-94 east of the Lowry Hill Tunnel near the I-35W overpass. The purpose of the installation is to collect traffic data using 360-degree radar, test system accuracy, and provide a detailed summary of traffic data and driver information at the site. This particular site was chosen because it is one of the highest crash locations in the state. A consultant (AECOM) is responsible for system deployment, data collection, monitoring, and reporting. Figure 3.28 depicts the radar unit and its coverage area.

Figure 3.28 360-Degree Radar Installation

Project Location and Radar Coverage Area

MnDOT's Traffic Management Center detects traffic incidents based on analysis of the traffic data reported by the 360-degree radar unit. Information about the system's effectiveness is somewhat limited at this time because it was installed in late Spring 2015. However, as of mid-August MnDOT staff reported that it seemed to be working well thus far. MnDOT expects the 360-degree radar system to provide the following benefits:

- Ability to perform a radar scan of all objects within a 360-degree radius four times per second
- Provision of data to use for crash reconstruction, if needed
- Provision of automatic crash detection via alerts generated by system software
- Faster emergency response times

4.0 SUMMARY OF RECOMMENDATIONS

4.1 Overview

This chapter summarizes the major impressions gained from the UDOT scan tour group's travels to Iowa and Minnesota. The nature of broad-based scan tours is such that a basic level of information is gained about a variety of topics so that future efforts can drill deeper into particular treatments if there is strong interest in considering implementing the treatments here in Utah. The purpose of this chapter is to briefly summarize recommendations for translating the information in the previous chapters into potential future action. Each recommendation notes the parties primarily responsible for following through.

4.2 Research Spin-Offs

Some of the information obtained during the ITS scan tour is recommended to be spun off to other efforts and not documented here, as follows:

- UDOT has strong interest in doing a focused research project looking at wrong-way driving mitigation. This project is already in its beginning stages and will take place in late 2015 and early 2016.
    - Responsible group: UDOT Research
- During the course of the scan tour effort, information was obtained about agencies across the country that may be operating FYA lead-lag operations, but no such agencies or installations were able to be visited. The information gathered should be shared with Mark Taylor so that he can get in touch as needed with those agencies to compare strategies and methods for improving the safety of intersections utilizing FYA.
    - Responsible group: WCEC Engineers
- Bridge overheight detection systems are not a primary concern of UDOT's Traffic and Safety Division, thus this treatment was not prioritized for a scan tour site visit. However, the survey information received about this treatment from Iowa DOT should be shared with the UDOT Structures Division.
    - Responsible group: WCEC Engineers

4.3 Infrastructure Treatments

The scan tour team visited numerous safety-related ITS infrastructure installations in Iowa and Minnesota. They also learned about several more installation types that they were not able to visit in person. This section summarizes recommendations relative to these installations.

- Automated Flashing Chevrons
    - Screen crash data to find curve locations in Utah with a crash history where this treatment may make sense to implement on a trial basis.
    - This treatment may make the most sense on curves where there is not a lowered advisory speed sign posted on approaches.
    - Responsible groups: Traffic and Safety Division; Region Offices
- DSW Signs
    - Screen crash data to find curve locations in Utah with a crash history where this treatment may make sense to implement on a trial basis.
    - This treatment may make the most sense on curves with a lowered advisory speed posted, similar to how Iowa DOT uses them.
    - Consider using a blank-out sign with a simple message of “too fast” rather than one that displays the vehicle speed so that people aren’t unintentionally encouraged to drive faster to get higher readings.
    - Responsible groups: Traffic and Safety Division; Region Offices
- VSL Signing
    - Consider using AGM batteries to prolong battery life and reduce maintenance needs.
    - Consider pairing reduced speed limits with a secondary VMS message conveying to motorists the reason (e.g. slick roads, ice cover, fog) for the temporary reduction, similar to what Iowa is doing.
    - Responsible group: Traffic Management Division
- Speed-Activated VMS in Work Zones
    - Evaluate applicability of Iowa DOT’s work zone VMS signing for median crossover approaches here in Utah.

    - Particularly consider upcoming reconstruction of the I-215 west belt route (as noted by members of the scan tour group) as a potential trial opportunity.
    - Responsible groups: Traffic Management Division; Region Offices
- RICWS
    - Screen crash data to find locations in Utah with right angle crash history at the junction of a minor road and a high-speed major road, and consider whether to do a trial at one or more of the locations.
    - If a trial is implemented, study the various methods used in Iowa and Minnesota and use them as a guide to developing a system that will work for Utah's needs.
    - Responsible groups: Traffic and Safety Division; Region Offices
- Freeway Interchange Flush Cycles
    - Consider implementing flush cycles at interchanges such as I-15/9000 South that have a history of queues backing from freeway ramps onto the mainline.
    - Responsible groups: Traffic Management Division; Region Offices
- Freeway Smart Lanes
    - Continue to monitor the experience of MnDOT and other DOTs that operate smart lane configurations where advisory speeds for different lanes are posted.
    - Based on Minnesota's recent struggles, it seems unwise at this time to spend lots of effort toward implementing such a system in Utah.
    - Responsible group: Traffic Management Division
- Truck Rollover Warning Systems
    - Screen crash data to find locations in Utah with a history of truck rollover crashes where TROWS may be appropriate.
    - If a trial is implemented, consider whether to incorporate roadway condition information as in the Minnesota example or keep it to only a truck advisory speed.
    - Responsible groups: Traffic and Safety Division; Region Offices
- 360-Degree Radar Detection
    - Discuss whether any locations in Utah exhibit a crash count (and associated traffic delays) high enough to warrant use of a 360-degree radar system to rapidly sense traffic data and automatically notify appropriate parties of crash events.
    - Responsible groups: Traffic and Safety Division; Traffic Management Division

4.4 Non-Infrastructure Elements

The scan tour team also discussed several non-infrastructure efforts used in Minnesota and Iowa to promote roadway safety. This section summarizes recommendations relative to those efforts.

- Message Mondays
    - UDOT instituted a Message Mondays campaign similar to Iowa's in the summer of 2015 shortly after the scan tour took place. It is recommended that UDOT continue collaborating with Iowa DOT on message content and strategies for communicating effective safety messages.
    - Responsible group: Traffic and Safety Division
- Seatbelt Usage
    - Work with the Department of Public Safety (DPS) to institute a comprehensive seatbelt usage annual study similar to Iowa's.
    - Work with DPS to devise a method (similar to Iowa's) for obtaining information from police officers about their judgment on whether a person involved in a crash would likely have been killed had they not been wearing a seatbelt.
    - Responsible group: Traffic and Safety Division
- Maintenance & Contracting
    - Consider requiring two years of ITS equipment maintenance by the installation contractor, followed by hiring a procurement contractor to maintain the equipment after the initial two-year period expires.
    - Consider using Best Value bidding instead of traditional low-bid methods in order to encourage quality equipment installations.
    - Responsible group: Traffic Management Division
- Enhanced Speed Compliance for Work Zones
    - Coordinate with DPS to evaluate the applicability and desirability of using Minnesota's mobile enforcement system idea here in Utah.
    - Responsible group: Traffic Management Division
- SHRP2 Lane Closure Project Application
    - Partner with Iowa DOT to jointly submit the SHRP2 application.
    - Responsible group: Traffic Management Division

APPENDIX

Appendix A – Raw Responses to Agency Follow-Up Survey

Appendix B – Automated Flashing Chevron Product Sheet

Appendix C – Sample RICWS Plan Sheet (Iowa DOT)

Appendix D – RICWS Journal Article

Appendix E – Iowa DOT Message Mondays List

Appendix F – Iowa DOT 2014 Seatbelt Survey

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