Midwest States
Smart Work Zone Deployment Initiative

Evaluation Plan

Year 2

May 18, 2000

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INTRODUCTION

In 1999, the states of Iowa, Kansas, Missouri, and Nebraska created the Midwest States Smart Work Zone Deployment Initiative (MwSWZDI), a pooled-fund study to develop better ways of controlling traffic through work zones, which improve the safety and efficiency of traffic operations and highway work. During the first year of MwSWZDI, a total of 18 technologies were deployed and evaluated in the four states.

The results of the technology evaluations were presented at the Midwest Smart Work Zone Conference - *New Approaches*, *New Solutions*, which was held in Omaha on January 26-27, 2000. On the second day of the conference, technology providers proposed technologies for deployment and evaluation during the second year of the initiative. After the conference, the states agreed to continue the MwSWZDI for a second year.

The states have selected 11 technologies for evaluation in the second year, which are shown in Table 1. The evaluations in each state will be conducted by a university within the state. The universities that will be involved in the evaluations in the second year are:

- Iowa State University;
- University of Kansas;
- University of Missouri-Columbia; and
- University of Nebraska-Lincoln.

The Mid-America Transportation Center (MATC) will coordinate the overall evaluation process and compile the results of the evaluations into a final report.

The descriptions and budgets of the technology evaluations are presented in this plan. Evaluations will begin in May, 2000. All evaluations will be completed by March 30, 2001.

TABLE 1 Technology Evaluations.

	Technology	IA	KS	MO	NE
1	Construction Area Late Merge System				4
2	Multiple Placement of Radar Speed Reporting Devices				4
3	Self-Illuminating Safety Vest		4		
4	Q-Cam			4	
5	Brown Traffic Real-Time CMS Control & Iteris Wireless Detection			4	4
6	Radar Speed Display		4		
7	ASTI Traffic Management System	4			
8	Reflectorized Sleeves for Barrel Delineators		4		
9	Removable Orange Rumble Strips		4		
10	Mobile HAR		4		
11	Wizard CB Alert System		4		

EVALUATIONS

There will be 12 evaluations of the 11 technologies as indicated in Table 1. One of the technologies (Brown Traffic Real-Time CMS Control & Iteris Wireless Detection) will be evaluated in two states, Missouri and Nebraska. The other 10 technologies will be evaluated in just one state. The evaluations to be conducted in each state are described below.

IOWA

One technology, the ASTI Traffic Management System, will be evaluated in Iowa. The evaluation will be conducted during the summer of 2000 at a work zone on Interstates 35 and 80 in West Des Moines.

ASTI Traffic Management System

As traffic volumes increase above the roadway capacity, traffic backups occur. These backups typically begin just prior to the merge point and grow until the volume through the work zone is less than the volume approaching the work zone. The ASTI system detects the presence of traffic backup prior to lane closures at work zones and activates lights on advance warning signs. By providing drivers with advance warning, it is assumed that traffic will approach the end of the queue more cautiously.

The system essentially consists of a trailer with flashing beacons, the ASTI Queue Detector receiver, transmitter (mounted separately), ASTI Radio, appropriate signage and a solar charging system to allow it to be self-sufficient. The system costs about $76,000.

The trailer will be positioned at the taper and at predetermined locations upstream. The Queue transmitter would be positioned opposite the trailer on the roadside or on a barrier or guardrail using the designed bracket. Using this system a signal would be transmitted via the radio network to a single or series of trailers when queues develop.

The ASTI system can be interfaced with up to ten different queue detector trailers within a 3 to 5 miles radius. For example, if traffic begins to back up at point 7 (see Figure 1), the detector at point 7 will activate the flashing lights on the signs at points 5 and 6. If the queue of stop-and-go vehicles lengthens to point 6, then the detector at point 6 activates the flashing lights on signs at points 4 and 5.

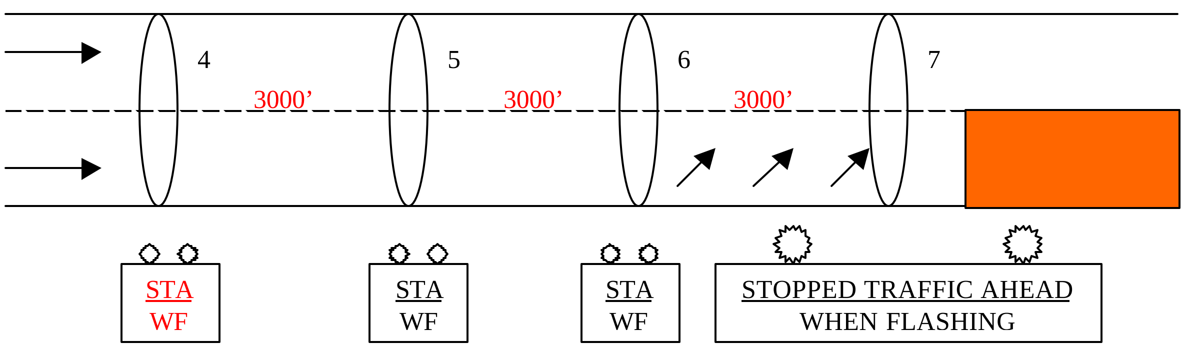

FIGURE 1 Schematic of the ASTI Traffic Management System at a Work Zone.

Evaluation Methodology

There will be three parts to the evaluation.

1. Performance measurement of traffic in the presence of the system
2. System reliability and its ability to perform its intended function
3. Driver acceptance

To measure traffic behavior, two video detection trailers with four video cameras will be used. Because two trailers are required, two students will go out with the equipment. One trailer will be placed upstream of the first message sign so that it can observe the merge point. The second trailer will be located approximately 6,000 feet upstream of the merge area to observe the traffic as it approaches the lane closure when the signs are activated. If traffic conditions warrant, data should be collected for a minimum of ten days with and without the system. If the signs have an impact on traffic, approach speed should decrease, vehicles should merge to the open lane sooner, and average approach headway may become larger.

The system functionality will be observed throughout the data collection period. This observation includes monitoring the timely activation of message signs due to traffic back up. Other system components will also be examined against normal wear and tear and weather conditions.

A survey will also be conducted to assess drivers' opinion on the effectiveness of the ASTI system. The survey will be performed at the first service station or rest stop downstream of the work zone. It is assumed that one interviewer can conduct 30 interviews per day. It will, therefore, require five days to obtain 150 interviews.

Measures of Effectiveness

- Reduction in approach speed
- Increase in headways
- Earlier lane change
- Driver acceptance

Evaluation Parameters

- Speed distribution parameters
- Headways and speed uniformity
- Lane distribution of traffic versus volume
- Results of interviews with drivers

KANSAS

Six technologies will be evaluated in Kansas. They are:

- Self-Illuminated Safety Vest;
- Radar Speed Display;
- Reflectorized Sleeves for Barrel Delineators;
- Removable Orange Rumble Strips;
- Mobile Highway Advisory Radio (HAR); and
- Wizard CB Alert System.

Self-Illuminated Safety Vest

Description

These vests are self-illuminating, increasing their conspicuity for nighttime operations.

Study site

I-35, Wyandotte and Johnson Counties

Performance Measures

The objectives of this application and the associated performance measures are as follows:

Objectives	Performance Measures
Increase visibility of workers during nighttime maintenance operations	1. Subjective conspicuity 2. Visible distance
Minimize maintenance requirements	3. Vest durability 4. Batter Life
Permit ample freedom of movement	5. Comfort

Experimental Design

Study type: Comparison with reflective vests.

Data to be Collected

Visible Distance

Collection method: Video/Drive-by Inspection
Sample size: NA
Analysis technique: comparison of distances at which vests first become visible (comparing self-illuminated vests with reflective vests). Vest without power will also be tested.

Durability

(of particular concern are the electrical components)

Collection method: Run over vest with an automobile until vest circuitry fails.

Sample size: NA

Analysis technique: Summary report.

Battery Life

Collection method: Measure time to deplete battery under continuous use.

Sample size: NA

Analysis technique: Summary report.

Comfort

Collection method: Worker testimonials.

Sample size: NA

Analysis technique: Summary report.

Work Plan

The testing and evaluation of the technology application will consist of the following tasks:

Task	Responsibility
1. Discuss vest options with vendor	KDOT/Vendor
2. Select project	KDOT
3. Order/ship vests	KDOT/Vendor
4. Select field personnel to wear vests	KDOT/Contractor
5. Make nighttime observations of illuminated/non- illum. Vests	KDOT/KU
6. Perform destructive durability tests.	KU
7. Analyze Data	KU
8. Write Report	KU

Schedule

Task	April				May				June				July				August				September				October			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
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8	January-March																											

Radar Speed Display

Description

A speed trailer will be used which displays vehicle speeds. The device is capable of observing three speed thresholds. First, a speed may be set at which a strobe flash is activated simultaneous with the displayed speed changing to flash mode. A second threshold can be set at which an alarm is sounded toward the construction site to warn workers of an incoming vehicle traveling at a reckless speed. The third threshold is the upper limit of the speed displayed, discouraging drivers from "competing" to register higher speeds.

Study site

(To Be Determined)

Performance Measures

The objectives of this application and the associated performance measures are as follows.

Objectives	Performance Measures
Reduce speeds in work zones	1. Speed
Reduce speed variance in work zones	2. Speed distribution

Experimental Design

Study type: Before/after

Data to be Collected

<u>Vehicle Speeds</u>

Collection method: Laser speed gun

Sample size: 2 hrs daytime and 2 hours nighttime, before installation, each of the following days after installation—[1, 2, 4, 7, 14, 21]. All observations should be on week days in order to capture repeat traffic.

Analysis technique: Comparison of 85th percentile, mean, standard deviation, and percent speeding.

Work Plan

The testing and evaluation of the technology application will consist of the following tasks.

Task	Responsibility
1. Obtain trailers	KDOT, SML
2. Collect before data	KU
3. Setup trailer	SML, KU, KDOT
4. Collect after data	KU
5. Analyze data	KU
6. Write report	KU

Schedule

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Reflectorized Sleeves for Barrel Delineators

Description

The drum sleeves slip over and wrap around a traditional drum. The color scheme is retroreflective material with 6” bands of green, orange, white and green working from the bottom to the top.

Study site

(To Be Determined)
The location of the skirts will be within the construction zone at the gore area of various exit ramps. One exit will be designated as the test exit.

Performance Measures

The objectives of this application and the associated performance measures are as follows.

Objectives	Performance Measures
Make the exit ramp locations more distinguishable to the driver	1. Subjective conspicuity 2. Speed characteristics of exiting vehicles 3. Local survey
Improve traffic flow within work zone	4. Speed characteristics of mainline traffic
Reduce potential rear end accidents	5. Visual Study of driver behavior 6. Speed characteristics of exiting vehicles (prior to exit)
	7. Maintenance requirements

Experimental Design

Study type: Before/after

Data to be Collected

Conspicuity

Collection method: Drive section with subjects and mark distance at which exit could be identified.
Sample size: 10 subjects before and 10 after.
Analysis technique: Comparison of recognition distances between before group and after group.

Speed characteristics (mainline and exiting traffic)

Collection method: Pneumatic tubes at three locations, 500 ft upstream of the exit, immediately prior to the exit, and 50 feet down the ramp.
Sample size: 1 week before, 1 week after.
Analysis technique: Comparison of 85th percentile, mean, standard deviations. Analysis will be performed separately for mainline traffic and for exiting traffic.

Local Survey

Collection method: mail out survey
Sample size: 150 mailed
Analysis technique: summary of qualitative comparisons.

Visual study of driver behavior

Collection method: video traffic and review braking patterns of exiting traffic
Sample size: 1 hour on 2 consecutive days before installation, repeat after installation
Analysis technique: comparison of distance prior to exit at which brakes are first applied (exiting vehicles only).

Durability

Collection method: review maintenance records and review existing drum sleeves at the end of the project

Sample size: 50-100 drum sleeves

Analysis technique: check percentage of replacement and retroreflective condition of each drum sleeve

Maintenance Requirements

Collection method: project crew will review daily with the rest of the traffic control

Sample size: NA

Analysis technique: review field records and interview inspector and contractor personnel.

Work Plan

The testing and evaluation of the technology application will consist of the following tasks.

Task	Responsibility
1. Purchase/receive drum skirts	KDOT (Mike McKenna)
2. Designate locations to install	KDOT (tech comm)
3. Finalize data collection plans	KU, KDOT (tech comm)
4. Install evaluation equipment	KU, KDOT (traffic ctrl)
5. Install drum sleeves	Contractor
6. Review project daily	Inspector
7. Periodic night reviews	KU, KDOT
8. Collect data, including interviews	KU, KDOT
9. Analyze Data	KU
10. Write Report	KU

Schedule

Task	April				May				June				July				August				September				October			
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10	January-March																											

Removable Orange Rumble Strips

Description

Advance Traffic Markings will provide enough "orange rumble strip" (ORS) @ $1 per foot to install rumble strips in advance of a signal operation for a one lane bridge project. ORS is a 150 mils thick self-adhesive plastic strip, which is orange in color. The ORS will be applied in a double thickness. The product is marketed to be placed across the roadway in order to cause noise and minor vibration of the vehicle when the vehicle traverses the strips. The noise and vibration therefore heightens drivers' attention to the roadway conditions.

Study Site

(To Be Determined)

Performance Measures

The objectives of this application and the associated performance measures are as follows.

Objectives	Performance Measures
Provide advance warning to drivers and provide a practical process for field application	1. Speed 2. Visibility
Perform for life of project	3. Durability and removability

Experimental Design

Study type: Comparison of speeds upstream and downstream of strips

Data to be Collected

<u>Speed</u>

Collection method: tube counters
Sample size: 48 hours during first week following installation, 48 hours during second week, and 48 hours during fourth week;
Analysis technique: comparison of 85th percentile, mean, standard deviation and percent speeding by vehicle class and lighting condition.

<u>Visibility</u>

Collection method: video
Sample size: N/A
Analysis technique: visibility distance and subjective comparison of video before and after application during daylight and nighttime lighting conditions.

Durability and Removability

Collection method: testimonials of construction inspector
Sample size: N/A
Analysis technique: summary.

Work Plan

The testing and evaluation of the technology application will consist of the following tasks.

Task	Responsibility
1. Contact Contractor	KDOT
2. Purchase ORS	KDOT
3. Have ORS delivered to area	KDOT
4. Contact area for traffic control and set date	KDOT
5. Collect *before* data	KU
6. Install ORS	Vendor/KDOT/KU
7. Collect *after* data upsteam	KU
8. Remove ORS and data collection equipment	Vendor or KU
9. Analyze data	KU
10. Write report	KU

Schedule

Task	**April**				**May**				**June**				**July**				**August**				**September**				**October**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
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Highway Advisory Radio (HAR)

Description

Portable HAR will be used in conjunction with signing to advise drivers of striping activity ahead, warning drivers not to cross the centerline to pass the striping truck, and informing drivers that the truck will pull over every 15 minutes to allow traffic to flow. Signs will mark the start and end of the section being striped and advise drivers of the AM frequency over which the advisory message can be heard.

Study site

District 6 in Southwest Kansas

To be used on a rural two-lane roadway during striping operations with a moving striping train. A portable HAR unit will be deployed at the beginning of the work area and another at the end of the work area to provide broadcasts to vehicles approaching from both directions. Static signage will be used to inform drivers to tune to the HAR for information. These will be placed at both ends of the work area.

Performance Measures

The objectives of this application and the associated performance measures are as follows.

Objectives	Performance Measures
Reduce the number of vehicles crossing centerline in paint area	1. Percent of vehicles passing paint truck
Inform drivers of expected delays	2. Percent of drivers who tune to radio message 3. Percent of vehicles passing paint truck 4. Percent of drivers who complain about delays (via survey)
Reduce claims to KDOT for paint damage to vehicles	5. Number of claims for paint damage compared to other striping crews

Experimental Design

Study type: *Before and after*

Data to be Collected

Percent of vehicles passing paint truck

Collection method: video train from ahead

Sample size: 4 hours baseline, 4 hours with HAR, same time of day on consecutive week days.

Analysis technique: comparison of baseline conditions, and additional signage with HAR.

Percent of drivers who tune to radio message

Collection method: poll drivers in queue

Sample size: NA

Analysis technique: summary

Percent of drivers who complain about delay

Collection method: survey downstream from train

Sample size: 4 hours baseline, 4 hours with HAR, same time of day on consecutive week days

Analysis technique: comparison of subjective delay ratings

Number of drivers who claim paint damage

Collection method: Track claims for 30 days following paint operation.

Sample size: NA

Analysis technique: Compare damage claims with claims received by other striping crews or in past years.

Work Plan

The testing and evaluation of the technology application will consist of the following tasks.

Task	Responsibility
1. Procure Equipment	KDOT District 6
2. Apply for FCC License	Ed Geer, KDOT
3. Make Static Signs	KDOT District 6
4. Finalize Data Collection Plan	KU, KDOT
5. Develop driver survey	KU, KDOT
6. Determine Test Schedule	KU, KDOT
7. Determine Test Locations	KDOT District 6
8. Perform Striping and Collect Data	KU, KDOT
9. Analyze Data	KU
10. Write Report	KU

Schedule

Task	April				May				June				July				August				September				October			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
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10	September-December																											
11	January-March																											

Wizard CB Alert System

Description

The Wizard CB Alert System may be either vehicle mounted or self-contained as a trailer mounted unit that involves the use of a CB radio transmitter with a recorded message, alerting CB users approaching a work zone of the road and traffic conditions ahead. This evaluation will be of the vehicle-mounted version.

Study Site

US-50 in Chase County is a 2-lane conventional highway of Portland cement concrete pavement construction. The project involves concrete pavement patching and the replacement of cracked concrete panels through the use of flaggers with or without pilot cars and also temporary traffic signals. This section of roadway has moderate traffic volumes with a high percentage of large commercial traffic with a posted speed limit of 65 mph.

Performance Measures

The objectives of this application and the associated performance measures are as follows.

Objectives	Performance Measures
Provide advance warning of approach to a flagger or temporary traffic signal	1. Percent of truckers who received the message prior to seeing the first work zone sign 2. Percent of truckers who said it helped improve their awareness of the approaching work zone. 3. Number of trucks locking brakes to stop for queue of traffic 4. Before and after speeds measurements at the first construction warning sign and at the ONE LANE ROAD AHEAD sign
Assess performance characteristics of the Wizard CB Alert	5. Maximum distance the message can be heard under various weather conditions and with various CB radio receivers
Assess ease of operations and acceptance by State and Contractor personnel	6. Time to install initially 7. Time to change message 8. Survey of users for subjective comments

Experimental Design

Study type: Before and after

Data to be Collected

Percentage of truckers hearing the message prior to seeing work zone signs

Collection method: survey of truckers stopped in queue of traffic
Sample size: 100 truckers at each work zone location
Analysis technique: Overall percentage of survey respondents who heard the message prior to seeing the first sign

Percentage of truckers who thought the message was useful

Collection method: survey of truckers stopped in queue of traffic
Sample size: 100 truckers at each work zone location
Analysis technique: Overall percentage of survey respondents who believe the message was effective

Number of trucks locking brakes to stop for queue of traffic

Collection method: Observation by flagger

Sample size: 20 construction days prior and 20 constructions days after activation of the Wizard CB Alert

Analysis technique: compare number before versus number after

Compare Before and After Speeds

Collection method: laser speed measuring device

Sample size: 100 trucks prior and 100 trucks after

Analysis technique: comparison of 85^{th} percentile, average and pace speeds of trucks before and after

Broadcast range of device

Collection method: observation

Sample size: 5 different types of CB radios under clear, partly cloudy and overcast conditions, and at various work sites where terrain can also be considered

Analysis technique: measurement of maximum range under each condition with each radio

Work Plan

The testing and evaluation of the technology application will consist of the following tasks.

Task	Responsibility
1. Discuss with vendor and field office	KDOT/Vendor
2. Determine vehicle(s) to mount device(s) in	KDOT/Contractor
3. Ship device(s)	Vendor
4. Install device(s)	KDOT/Contractor
5. Determine appropriate message(s)	KDOT/Vendor/Cont.
6. Prepare survey questions	KU/KDOT
7. Survey truckers	KU
8. Observe stopping patterns	KU/Contractor
9. Collect speed data	KU/KDOT
10. Analyze data	KU
11. Write report	KU

Schedule

Task	April				May				June				July				August				September				October			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
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10	September-December																											
11	January-March																											

MISSOURI

Two technologies will be evaluated in Missouri. They are:

- Q-Cam, and
- Brown Traffic Real-Time CMS Control & Iteris Wireless Detection.

Q-Cam

The Q-cam is designed to transmit real-time images of a section of highway over the Internet. It is portable and intended to be used for verification of queues or incidents detected by another device.

Site Location

The devices will be evaluated during the 2000 construction season at a work zone in the St. Louis area. The site will be chosen such that drivers will have an alternate route recommended in cases of queuing prior to the work zone.

Performance Measures

The study will answer the question "How much useful information about traffic flow conditions can be gained from real-time images from the Internet?" The researchers will use the real-time images to study traffic flow conditions at the traffic diversion site. The performance measure and corresponding measure of effectiveness are shown below.

Performance Measure	Measure of Effectiveness
Useful traffic flow information is derived from the technology.	Usefulness of traffic flow information as judged by MoDOT personnel and researchers.

Experimental Design

The images provided by the Q-Cam will be compared to the records of when queues are detected by the wireless detection system.

Work Plan

Task	Responsibility
1. Coordination meetings.	MU, MoDOT, vendors
2. Install devices.	MoDOT, vendors
3. Collect data.	MU
4. Analyze data.	MU
5. Final report.	MU

Schedule

The schedule is tentative because the installation times for the devices have not been finalized.

	2000								2001		
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Brown Traffic Real-Time CMS Control & Iteris Wireless Detection

The Brown Traffic Real-Time CMS Control enables changeable message signs (CMS) to be activated by a signal from the Iteris Wireless Detection, which indicates that congestion is present. The CMS can advise drivers to take an alternate route when congestion is present. The wireless detection for work zones monitors traffic conditions and sends a wireless signal to the Brown Real-Time CMS Control when a queue occurs.

Study Location

The devices will be evaluated during the 2000 construction season at a work-zone in the St. Louis area. The site will be chosen such that drivers will have an alternate route recommended in cases of queuing prior to the work zone.

Performance Measures

The study will answer the question "What percentage of the traffic is diverted?" The researchers will also examine the traffic flow rate on the main road, the travel time on the main road relative to the alternate route, and the adequacy of equipment communication. The performance measures and corresponding measures of effectiveness are shown below.

Performance Measure	Measure of Effectiveness
Traffic is diverted.	Percentage of traffic diverted.
Travel times on the main road decrease.	Travel times on main road and alternate route.
Wireless detection provides adequate information to CMS.	Adequacy of performance as judged by MoDOT personnel and researchers.

Experimental Design

Vehicle counts will be collected at a point upstream of the CMS on the main road after the exit point for the alternate route, and at a point close to the work zone. These counts will also be used to calculate the diversion and estimated traffic flow.

The researchers will drive several passes during congested conditions on both the main and alternate routes to compare the travel times. In addition, a series of "before" travel times on the main route will be obtained for comparison purposes.

Work Plan

Task	Responsibility
1. Coordination meetings.	MU, MoDOT, vendors
2. Install devices.	MoDOT, vendors
3. Collect data.	MU
4. Analyze data.	MU
5. Final report.	MU

Schedule

The schedule is tentative because the installation times for the devices have not been finalized.

Task	2000								2001		
	M	J	J	A	S	O	N	D	J	F	M
1	■	■	■	■	■	■	■	■	■	■	■
2		■	■								
3		■	■	■							
4			■	■	■	■	■	■			
5							■	■	■	■	■

NEBRASKA

Three technologies will be evaluated in Nebraska. They are:

- Construction Area Late Merge System;
- Multiple Placement of Radar Speed Reporting Devices; and
- Brown Traffic Real-Time CMS Control & Iteris Wireless Detection.

Construction Area Late Merge System

Description

The construction area late merge system (CALM) is a dynamic late merge system. CALM utilizes the conventional advance lane closure signing to advise drivers of a lane closure and encourages them to merge to the open lane during periods of uncongested flow. As traffic approaches congested flow, CALM automatically switches to late merge control in order to increase the capacity and reduce the conflicts of the merging operations and the length of congestion upstream of the lane closure.

However, successful deployment of the CALM system will require a knowledge of the traffic flow threshold conditions that govern the switch from conventional merge control during periods of uncongested flow to late merge control during periods of congested flow, and vice versa. Also, the type of signing that is most understandable to the driver for implementing the CALM system must be determined.

Objective

The objectives of this research are: (1) to develop guidelines for switching between conventional merge control and the late merge and (2) to determine the most effective signing for implementing the CALM system.

Study Site

This research will be accomplished using: (1) computer simulation to develop the guidelines for switching between conventional merge control and the late merge and (2) driver focus groups and surveys to determine the most effective signing for implementing the system.

Performance Measures

Objective	Measures of Effectiveness
Maximize efficiency of merging operation. Maximize safety of merging operation.	Merging delay. Merging conflicts.
Maximize driver understanding of merging operations.	Percentage of drivers who understand the conventional merge control operation. Percentage of drivers who understand the late merge operation. Percentage of drivers who prefer the CALM system to existing systems of merge control.

Experimental Design

A series of computer simulation runs will be made using the WZSIM model developed by MATC. The simulation runs will be conducted over the full range of traffic flow conditions in order to identify the traffic flow threshold values for switching between conventional and late merge control operations, which will minimize the delay and conflicts associated with merging operations.

Two driver focus groups will be conducted to identify and examine the issues related to driver acceptance and understanding of the CALM system. Each focus group will be comprised of about 15 individuals representing a cross section of the driving public, which would include male/female, older/younger, and professional/nonprofessional drivers. Information obtained from these sessions will be used to design signing alternatives for the CALM system. Surveys will be conducted at the driver examination stations in Lincoln and Omaha to assess drivers' acceptance of the CALM system and to determine which signing alternative is best understood by drivers. Surveys will be administered to about 400 drivers.

Work Plan

Task	Responsibility
1 – Conduct computer simulation study.	MATC
2 – Develop CALM operation guidelines.	MATC
3 – Conduct focus group sessions.	MATC
4 – Design signing alternatives.	MATC, NDOR
5 – Conduct driver surveys.	MATC
6 – Analyze survey results.	MATC
7 – Report results.	MATC

Schedule

	October				November				December				January				February				March			
Task	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	■	■	■	■	■	■	■	■																
2									■	■	■	■												
3	■	■	■	■																				
4			■	■	■	■																		
5							■	■	■	■	■	■	■	■	■	■								
6																	■	■	■	■				
7																					■	■	■	■

Multiple Placement of Radar Speed Reporting Devices

Description

The SpeedGuard radar trailer and SpeedBoard are speed monitoring displays which inform drivers of their speeds and thereby encourages them to slow down if they are traveling above the speed limit. The objective of these systems is to reduce the speed of traffic and increase speed limit compliance. The SpeedGuard system is a trailer unit with a speed display panel with 24-inch LED numerals, which is shown in Figure 2. The SpeedBoard is a sign-mounted unit with a smaller display with 18-inch LED numerals, which is shown in Figure 3. Both are equipped with radar to measure the speeds of approaching vehicles.

The SpeedGuard system was evaluated in Nebraska during the first year of MwSWZDI. Although it was effective in lowering speeds and increasing the uniformity of speeds, its performance was only measured during the first 7 hours of its deployment. After 7 hours of operation, the system malfunctioned and could not be observed any longer. Consequently, the period of time that its effectiveness can be sustained beyond 7 hours was not observed. Also, the extent of its effectiveness beyond 750 feet downstream was not observed.

Objective

The purpose of this evaluation is twofold. The first objective is to evaluate the temporal and spatial effects of the SpeedGuard system. The second objective is to evaluate the effectiveness of the SpeedBoard in enhancing the effects of the SpeedGuard system.

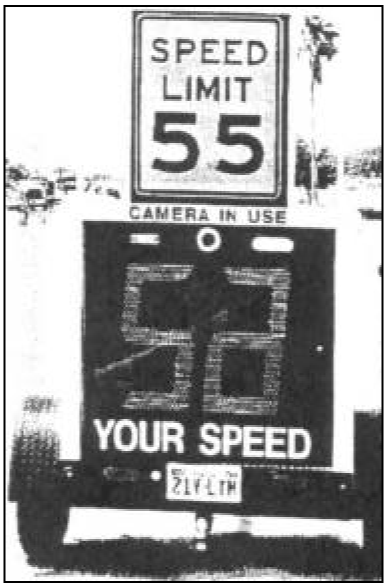

FIGURE 2 SpeedGuard.

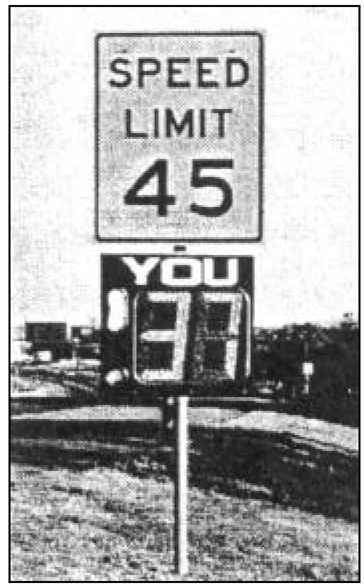

FIGURE 3 SpeedBoard.

Study Site

The SpeedGuard system and SpeedBoard will be deployed in a work zone between the Waverly and Greenwood interchanges on I-80 between Lincoln and Omaha. The work zone is a resurfacing project, which involves the closing of one roadway for resurfacing and head-to-head operation on the other roadway. The length of the work zone is about 6.5 miles. The average daily traffic volume on this section of I-80 is approximately 38,000 vehicles per day, of which 21 percent were trucks. The normal speed limit on I-80 is 75 mph. The speed limit is 65 mph in advance of the work zone and 55 mph in the work zone. The SpeedGuard system and SpeedBoard will be deployed in the westbound direction.

Performance Measures

Objective	Measures of Effectiveness
To encourage drivers to slow down.	Traffic speed distribution parameters at selected points in advance of lane closure and throughout the work zone.

Experimental Design

Speed studies will be conducted before and after the deployment of the SpeedGuard system and SpeedBoard units. The SpeedGuard system will be deployed about 1,250 feet in advance of the lane closure taper in the west bound direction on I-80. Three SpeedBoard units will be deployed at approximately 1, 3, and 5 miles downstream of the lane closure taper. The SpeedGuard system will be deployed first. Then after the SpeedGuard system has been in place for two weeks, the three SpeedBoard units will be deployed individually at two week intervals, beginning with the first one at 1 mile downstream from the lane closure taper and proceeding downstream.

A series of 12 speed studies will be conducted at each of five data collection points: (1) about 1 mile before the lane closure taper;,(2) at the taper, (3) about 0.5 miles downstream of the taper, (4) about 2.5 miles downstream of the taper, and (5) about 6 miles downstream of the taper. Speeds will be measured at each point within one day before and after and one week after the deployment of each speed monitoring unit. Speeds will be measured with laser guns.

The statistical analysis will be an analysis of covariance to account for the effects of volume and truck percentage.

Work Plan

Task	Responsibility
1 – Collect speed data.	MATC
2 – Deploy SpeedGuard system and SpeedBoards.	NDOR
3 – Analyze data.	MATC
4 – Report results.	MATC

Schedule

Task	May				June				July				August				September				October			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	■	■	■	■	■	■	■	■																
2		■	■	■	■	■	■																	
3									■	■	■	■	■	■	■	■	■	■						
4																			■	■	■	■	■	■

Brown Traffic Real-Time CMS Control & Iteris Wireless Detection

Description

The Brown Traffic Real-Time CMS Control & Iteris Wireless Detection (RCMSC) is an enroute traveler information system whereby real-time traffic-responsive information is provided to drivers by means of variable message signs (VMSs) strategically placed in advance of diversion points upstream of the work zone. The objective of the system is to advise drivers of a work zone ahead and encourage them to divert to an alternate route when there is congestion in the work zone.

The RCMSC is comprised of a video detection system and portable VMSs. Communications between the video detection system and the VMSs is provided by radio. The video detection is used to measure the speeds of vehicles entering the work zone, which are used by the RCMSC to determine the presence of congestion in the work zone. When congestion is detected in the work zone, the messages on the VMSs advise drivers to use an alternate route. When congestion is not detected in the work zone, the messages on the VMSs advise drivers of roadwork ahead.

The RCMSC was evaluated in Nebraska during the first year of the MwSWZDI. It was found to encourage about 4 percent of the mainline traffic to divert to an alternate route when congestion was detected in the work zone. However, the system has been enhanced to improve the credibility of the information it provides to drivers and thereby increase the percentage of traffic diversion it induces. In addition, the enhanced system is a better traffic management tool. When conditions warrant, the NDOR and Nebraska State Patrol (NSP) will be able to change the messages displayed by the system via cell phone.

Objective

The objective of this evaluation to assess the effectiveness of the RCMSC as: (1) a means of increasing traffic diversion and (2) a traffic management tool for NDOR and NSP.

Study Site

The RCMSC will be deployed in a work zone between the Waverly and Greenwood interchanges on I-80 between Lincoln and Omaha. The work zone is a resurfacing project which involves the closing of one roadway for resurfacing and head-to-head operation on the other roadway. The length of the work zone is about 6.5 miles. The average daily traffic volume on this section of I-80 is approximately 38,000 vehicles per day, of which 21 percent are trucks. The normal speed limit on I-80 is 75 mph. The speed limit is 65 mph in advance of the work zone and 55 mph in the work zone. The RCMSC will be deployed in the eastbound direction.

Performance Measures

Objective	Measures of Effectiveness
To advise drivers of congestion in the work zone and encourage them to divert to alternate route.	Traffic volume distribution between mainline and entrance and exit ramps upstream of work zone during periods of congestion. Credibility of congestion detection algorithm. Percentage of drivers who notice messages. Percentage of drivers who understand messages. Percentage of drivers who believe messages are useful.
To provide an effective traffic management tool for NDOR and NSP.	Opinions of NDOR and NSP personnel regarding usefulness of the system as a traffic management tool.

Experimental Design

Before and after the deployment of the RCMSC, traffic volumes will be counted at the Waverly interchange on the following roadways:

- eastbound I-80;
- eastbound I-80 entrance ramps; and
- eastbound I-80 exit ramp.

The distribution of the traffic volume on these roadways during one-minute intervals will be determined. An analysis of covariance of these data will be conducted to determine the effects of volume, truck percentage, and VMS message on the volume distribution among the roadways.

The logs of the RCMSC video detection system controller will be analyzed to compare the level of congestion indicated by the speed-volume data with the VMS message. The percentage of time that the diversion message is displayed when there is actual congestion in the work zone will be computed.

Drivers will be interviewed at the first rest area downstream of the work zone. The percentage of drivers who noticed the messages, understood them, and thought they were useful will be determined. About 400 interviews will be conducted.

Drivers who commute regularly between Lincoln and Omaha will be surveyed to determine their experience with the system and their opinions regarding its usefulness and their suggestions for improving it. About 100 commuter surveys will be administered.

NDOR and NSP personnel who worked with the system will be interviewed. Problems they had with the system will be identified. Their opinions regarding the usefulness of the system as a traffic management tool will be documented. Their suggestions for improving the system will be noted.

Work Plan

Task	Responsibility
1 – Collect volume data.	MATC, NDOR
2 – Deploy RCMSC.	Brown Traffic, NDOR
3 – Analyze RCMSC controller logs.	MATC
4 – Conduct drivers survey.	MATC
5 – Conduct commuter survey.	MATC
6 – Conduct NDOR and NSP personnel interviews.	MATC
7 – Report results.	MATC

Schedule

Task	May				June				July				August				September				October			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
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BUDGET

The total pooled-fund budget for the evaluation plan is $281,797. This amount does not include the cost share of the state highway agencies and the technology providers. The budget is summarized by technology evaluation in Table 2 and itemized by budget category in Table 3.

The amount of the pooled-fund carryover from Year 1 is $57,000. Therefore, the additional pooled funds needed for Year 2 are $224,797, or $56,199.25 per state.

TABLE 2 Pooled-Fund Budget Summary.

<table>
<tr><th colspan="2" rowspan="2">Technology</th><th colspan="4">Organization</th><th rowspan="2">Total</th></tr>
<tr><th>ISU</th><th>KU</th><th>MU</th><th>MATC</th></tr>
<tr><td>1</td><td>Construction Area Late Merge System</td><td></td><td></td><td></td><td>49,737</td><td>49,737</td></tr>
<tr><td>2</td><td>Multiple Placement of Radar Speed Reporting Devices</td><td></td><td></td><td></td><td>27,541</td><td>27541</td></tr>
<tr><td>3</td><td>Self-Illuminating Safety Vest</td><td></td><td>4,747</td><td></td><td></td><td>4,747</td></tr>
<tr><td>4</td><td>Q-Cam</td><td></td><td></td><td rowspan="2">75,100</td><td></td><td rowspan="2">110,185</td></tr>
<tr><td>5</td><td>Brown Traffic Real-Time CMS Control & Iteris Wireless Detection</td><td></td><td></td><td>35,085</td></tr>
<tr><td>6</td><td>Radar Speed Display</td><td></td><td>5,482</td><td></td><td></td><td>5,482</td></tr>
<tr><td>7</td><td>ASTI Traffic Management System</td><td>26,939</td><td></td><td></td><td></td><td>26,939</td></tr>
<tr><td>8</td><td>Reflectorized Sleeves for Barrel Delineators</td><td></td><td>7,442</td><td></td><td></td><td>7,442</td></tr>
<tr><td>9</td><td>Removable Orange Rumble Strips</td><td></td><td>7,117</td><td></td><td></td><td>7,117</td></tr>
<tr><td>10</td><td>Mobile HAR</td><td></td><td>7,726</td><td></td><td></td><td>7,726</td></tr>
<tr><td>11</td><td>CB Wizard</td><td></td><td>4,680</td><td></td><td></td><td>4,680</td></tr>
<tr><td></td><td>General</td><td></td><td>18,211</td><td></td><td>11,990</td><td></td></tr>
<tr><td></td><td>Total</td><td>26,939</td><td>55,405</td><td>75,100</td><td>124,353</td><td>281,797</td></tr>
</table>

TABLE 3 Itemized Pooled-Fund Budget.

Item	Organization				Total
	ISU	KU	MU	MATC	
Personnel:					
Salaries &Wages	13,444	21,518	41,743	84,281	139,468
Fringe Benefits	2,122	4,828	8,396	19,385	29,903
Subtotal	15,566	26,346	50,139	103,666	169,371
Other Direct Costs:					
Materials & Supplies	800	1,644	300	4,000	5,100
Printing & Copying	200	250	0	1,900	2,100
Postage	25	0	0	0	25
Telephone	100	1,000	0	120	220
Equipment		5,000			
Travel	1,952	5,230	1,000	4,300	7,252
Subtotal	3,077	13,124	1,300	10,320	14,697
Total Direct Cost	18,643	39,470	51,439	113,986	184,068
Indirect Cost	8,296	15,935	23,661	10,366	42,323
Total Cost	**26,939**	**55,405**	**75,100**	**124,353**	**281,797**