Midwest States
Smart Work Zone Deployment Initiative

2002 Evaluation Plan

Year 4

DRAFT #1

Initial Draft for Discussion
at the
Technical Committee Meeting
on
Tuesday, January 29, 2002

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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. In 2001, Wisconsin joined the MwSWZDI. During the first three years of MwSWZDI, a total of 30 technologies were deployed and evaluated in the five states. The results of the technology evaluations during the first two years are posted on the Mid-America Transportation Center (MATC) website (www.matc.unl.edu). The technical report documenting the results of the third year technology evaluations is in preparation and will be available from the MATC website in June 2002.

The five states have decided that the technologies to be evaluated in 2002 should address one of the following problem statements:

<u>Problem Statement #1 – Freeway Work Zone Advisory System</u>: Motorists have an expectation that traffic ahead of them is traveling at the same speed as themselves. When work zones cause traffic backups, rear-end crashes can occur.

<u>Problem Statement #2 – Freeway Lane Merge System</u>: At freeway lane closures using traditional advance warning signs, "forced" merges are common, as some drivers merge into the proper lane far ahead of the lane closure taper but others drive up to the merge taper before changing lanes. This disrupts traffic flow at the merge taper, reduces capacity of the open lane, and increases the potential for road rage and crashes.

<u>Problem Statement #3 – Count Timer</u>: The problem is driver frustration with not knowing how long the wait will be during a pilot car operation or a construction operation that causes an extended queue. Enhanced frustration for a driver may lead to verbal abuse of on-site workers or lead to erratic and unwarranted driving behavior

<u>Problem Statement #4 – Portable Lighting for Nighttime Work Zones</u>: The increasing amount of work done at night requires more use of portable work area lighting. Use of the lighting can create glare for motorists, causing potential driver confusion and greater potential for crashes.

<u>Problem Statement #5 – Flagger Paddle Visibility</u>: Visibility and compliance with flagger signals and paddles is a continuing concern. Failure to obey flagger signals has the potential consequence of serious injury for the flagger or other workers.

<u>Problem Statement #6 – Self-Deploying Work Zone Traffic Control Devices</u>: Traffic control devices are sometimes left in place longer than necessary because of the effort necessary to set them up and take them down. This practice causes drivers to loose respect for the devices. In addition, safety of the workers who deploy these devices is sometimes at risk.

The states have selected 14 deployments of 10 technologies for evaluation in 2002. These deployments are listed in Table 1.

In addition to technologies addressing the six problem statements, the states decided to investigate the following issues:

- Effectiveness of Extra Enforcement in Construction and Maintenance Zones
- Driver Recognition of Channelizing Devices/Direction Indicator Drums

These evaluations are also listed in Table 1.

Universities in the participating states will conduct the evaluations. The universities that will be involved in the evaluations in the third year are:

- Iowa State University,
- University of Kansas,
- University of Missouri-Columbia,
- University of Nebraska-Lincoln,
- University of Wisconsin-Milwaukee, and
- Marquette University.

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 June 2002. All evaluations will be completed by May 31, 2003.

TABLE 1 Technology Evaluations.

Evaluation	Technology	State
1	Intellizone - Quixote	Iowa
2	Effectiveness of Extra Enforcement in C&M Zones	Iowa
3	Dynamic Late Merge System - IRD	Kansas
4	CALM System - Scientex	Kansas
5	SHO Fixture Portable Lighting System - Allmand	Kansas
6	Portable Lighting Tower - Tower Solutions	Kansas
7	Paddle Pal - Rick Watson Innovations	Kansas
8	Autoflagger – Safety Technologies	Kansas
9	Relectorized Sleeves for Barrel Delineators - Reflexite	Kansas
10	Intellizone – Quixote/Hoosier	Missouri
11	D-25 Speed Advisory Sign System - MPH	Nebraska
12	Freeway Speed Advisory System - National ITS	Nebraska
13	Intellizone - Quixote	Wisconsin
14	Portable Lighting Tower - Tower Solutions	Wisconsin
15	Paddle Pal - Rick Watson Innovations	Wisconsin
16	Driver Recognition of Channelizing Devices	Wisconsin

EVALUATIONS

IOWA

Two evaluations will be conducted by Iowa. They are:

- Evaluation #1 – Intellizone – Quixote
- Evaluation #2 – Effectiveness of Extra Enforcement in Construction and Maintenance Zones

Evaluation #1 – Intellizone – Quixote

Technology

The work zone speed advisory system developed by Nu-Metrics Inc. utilizes various types of technologies. A newly developed traffic sensor/analyzer being referred to as "Road Hog" is installed on the road surface rather than the usual intrusive PVC canister, which is drilled into the pavement. The ROADHOG utilizes vehicle magnetic imaging to measure the disturbance in the magnetic fields of the earth caused by each passing vehicle. The ROADHOG provides:

- Vehicle volume count
- Vehicle speed and length
- Occupancy
- Average speed

The detected data is transmitted to a roadside-processing unit via a transmitter. The transmitter can receive data from as many as sixteen ROADHOGS. The data is sent to the remote processing unit (RPU) where it is further processed. The RPU contains a very powerful algorithm that infuses the user-developed parameters with actual road data to determine what conditions exist at any time. When traffic conditions are such that preset thresholds are tripped (decreasing speed or increasing occupancy), the RPU signals the command and control function to activate a variable message sign (VMS) or a highway advisory radio (HAR) to convey information and give warning to oncoming motorists. Narrow band radio frequency messages or cellular communications can be utilized to control the various display devices.

Figure 1 shows a schematic of a work zone consisting of three mobile count units per lane, two VMS units per direction and one mobile command unit (MCU). The command unit can be placed in the middle of the work zone to facilitate the incident detection and management using a pan-tilt-zoom camera. The Hoosier Company Inc. (a manufacturer's representative for Nu-Metrics) will provide the described system (excluding the MCU and two VMS units) at no cost for a 30-day evaluation period at a specified time and location.

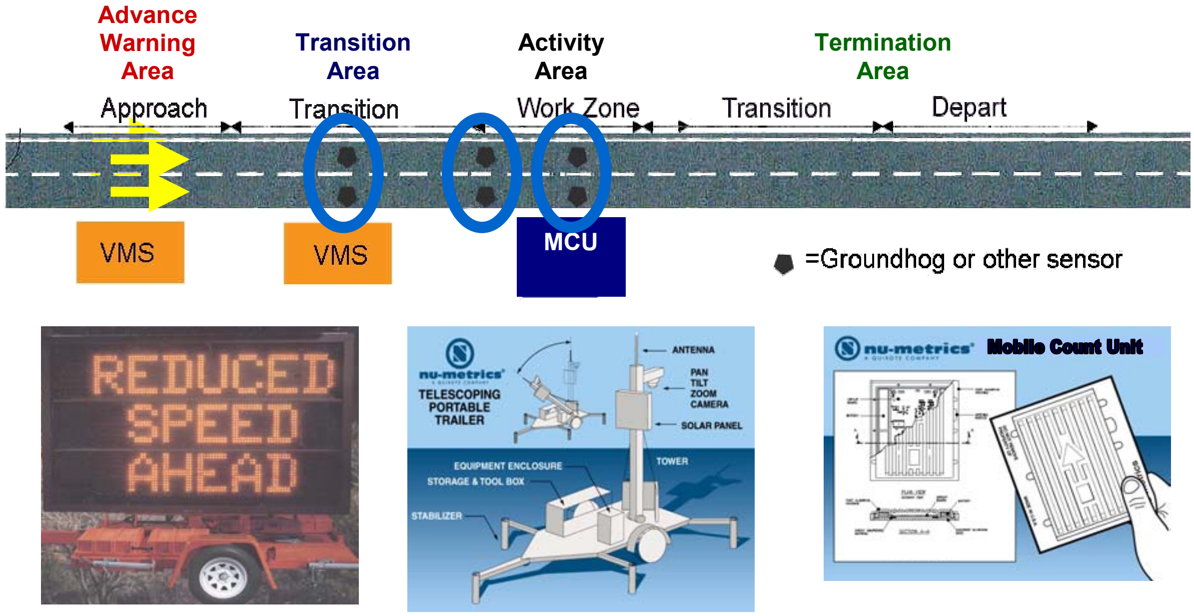


Figure 1. Speed Advisory System at a Work Zone

<u>Objectives</u>

- Reduction in approach speed
- Increase in headways
- Driver acceptance
- System ability to perform

<u>Study Site</u>

The selected site study is a work zone on the east side of Interstate 80 in Council Bluffs, Iowa. This location will likely have backups during the afternoon hours, which would make it an ideal site for testing the speed advisory system.

<u>Performance Measures</u>

- Speed parameters
- Headways and speed uniformity
- Results of interviews with drivers
- System reliability

<u>Evaluation Methodology</u>

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 ROADHOG sensors detect the presence of traffic backup prior to lane closures at work zones by the decreases in the speed and headway and increases in the volume and lane occupancy. Based on the preset system parameters, the RPU then activates display devices (e.g., VMS and/or HAR) to provide visual warning to approaching motorists. By providing drivers with advance warning, it is assumed that traffic will approach the end of the queue more cautiously, avoiding high speed rear-end collisions.

Traffic data will be collected using the two CTRE traffic data collection trailers. The trailer includes a pneumatic mast to hoist two video cameras 30 feet above the pavement's surface in order to videotape traffic operations. Traffic flow performance data (vehicle speed, headways, volume, etc.) will be recorded before and after the speed advisory system is in place. Using the Autoscope image processing technology, the recorded videotapes will be analyzed to determine the vehicle types (i.e., passenger cars and non-passenger cars), arrival times, and speeds of approaching vehicles.

The trailers will be placed about 500 feet upstream of each variable message sign (see Figure 2). One camera will monitor the approaching traffic on the open lane, while the other one will be pointed toward the sign to observe the message board. This camera setup will enable us to detect the speed changes while the signs are active. During the data analysis, the videotapes recorded at each station will be synchronized to examine the impact of the system in reducing the approach speed. Furthermore, in order to determine whether the difference between the mean traffic speed and headway before and after the system implementation was statistically significant, t-tests will be conducted at the 0.05 level of significance.

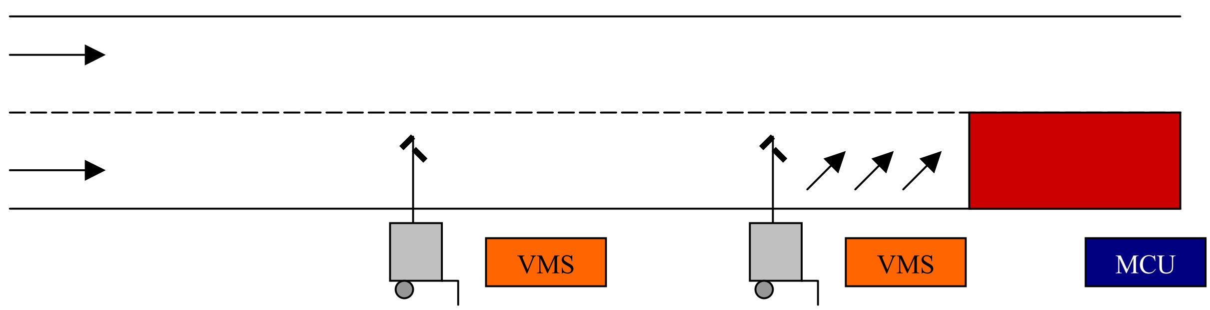


Figure 2. Data Collection Location Layout at a Work Zone

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, and average approach headway may become larger.

The system functionality will be observed throughout the data collection period. The observation includes monitoring the timely activation of message signs due to traffic backup. Two individuals will observe the queue formation and dissipation as well as the sign activities at the site. One individual observes the traffic movement inside the work zone, while the other one keeps an eye on the sign message changing performance. As soon as a queue starts to form or dissipate, the sign observer will be notified of the situation through a cell phone or a two-way radio. Consistency of the queue and sign activities will be indicative of good system performance. Other system's 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 speed advisory system at the work zone. 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 in one day. It will, therefore, require five days to obtain 150 interviews.

Work Plan

1. Conduct data collection - Traffic data will be collected five days before and five days after system implementation in July 2002. Data collections will be conducted on the latter parts of two consecutive weeks to capture the site's Friday and Sunday afternoon backups. Considering the travel distance between Ames and Council Bluffs, the two individuals who will conduct the data collection will stay in Council Bluffs for the duration of study.

2. Observe system functionality - The system performance will be observed sporadically for a total of eight hours during the course of data collection period.

3. Conduct interviews - Motorists will be surveyed to gather their opinion about the implemented system. The survey will consist of a few simple yes/no questions to improve the response rate.

4. Analyze Data - Information on videotapes will be reduced and the data will be statistically analyzed to conduct an evaluation of the employed speed advisory system.

5. Prepare a final report - A report will be prepared and edited by CTRE's in-house editorial staff.

Schedule

The speed advisory system will be evaluated during the months of July through September of 2002.

Tasks	**July**	**August**	**September**
1. Conduct data collection	■		
2. Observe system functionality	■		
3. Conduct interviews	■		
4. Analyze Data		■	
5. Prepare a final report			■

Evaluation #2 – Effectiveness of Extra Enforcement in C & M Zones

Problem Statement

The frequency of maintenance activities and the potential severity of work zone crashes have intensified the importance of safe and efficient handling of traffic in work zones. A number of speed reduction techniques are currently used by transportation agencies throughout the country to control speeds and reduce speed variation at work zones. Many agencies consider police enforcement as one of the most effective speed reduction strategies at work zones. However, there are some concerns that enforcement presence may cause additional traffic congestion at work zones. For example, in a few cases in Iowa, congestion increased as motorists noticed the enforcement vehicles near the work area.

The purpose of this study is to determine the appropriate use of enforcement agency personnel to patrol active construction or maintenance work zones. Many highway work zones are not designed to allow for safe ticketing of offending motorists, thus research into proper pull-off locations and design of these locations also needs to be undertaken.

The study will be conducted in two phases. Phase I of the study examines existing extra enforcement policies and procedures for highway work zones. The project will exhaustively review the existing and proposed enforcement practices being applied in long-term, short-term, and moving work zones throughout the country. The research outcomes will be used as a basis to recommend a limited number of field trials and evaluations to be conducted in Phase II of the project. Appendix I includes brief descriptions of extra enforcement practices currently conducted at some of state agencies.

Work Plan

The proposed study will follow the tasks listed below:

Task I. Form an advisory committee and develop a detailed work plan - An advisory committee comprised of interested transportation professionals will be formed. The research team will develop a detailed work plan to be reviewed in the first advisory committee meeting. A brief task summary report containing committee members, contact information, and their role in the project will be prepared.

Task 2. Conduct literature review - This task will involve reviewing relevant literature to determine extra enforcement strategies that have been employed or evaluated to control speed in work zones throughout the country. A task report containing an annotated bibliography of the literature on law enforcement practices to control motorist speed at work zones will be prepared. This report will be used in identifying candidate enforcement strategies to use in Task 4.

Task 3. Conduct a survey - To learn more about other state practices in using extra enforcement at work zones, a survey will be conducted. The research team will contact every state DOT and a number of non-DOT transportation agencies in other states (e.g., state turnpike commissions) using Iowa DOT letterhead in the hope of improving the likelihood of a response. Consequently, responses will be entered into a database to allow queries to be conducted under different categories (e.g., type of practices, degree of effectiveness, costs etc.). The database built in Microsoft Access will be customized to include necessary report and query files.

Task 4. Identify most promising extra enforcement practices - A summary of state extra enforcement practices will be presented to the project advisory committee. The committee members, along with the research team, will identify the most promising approaches for field evaluations to be conducted in Phase II of the study.

Task 5. Propose evaluation plan - The research team will develop plans to evaluate the most promising extra enforcement strategies. The plans will include a description of the evaluation physical layout, criteria, and estimated costs.

Task 6. Prepare final report and recommendations - A final report will be prepared that describes all project tasks. An Executive Summary will clearly describe the practical findings.

Evaluation Schedule

The extra enforcement study at work zones will be conducted during the months of April through October of 2002.

Tasks	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**
I. Form an advisory committee							
2. Conduct literature review							
3. Conduct a survey							
4. Identify promising practices							
5. Propose evaluation plan							
6. Prepare final report							

Appendix I Current Extra Enforcement Practices at Work Zones

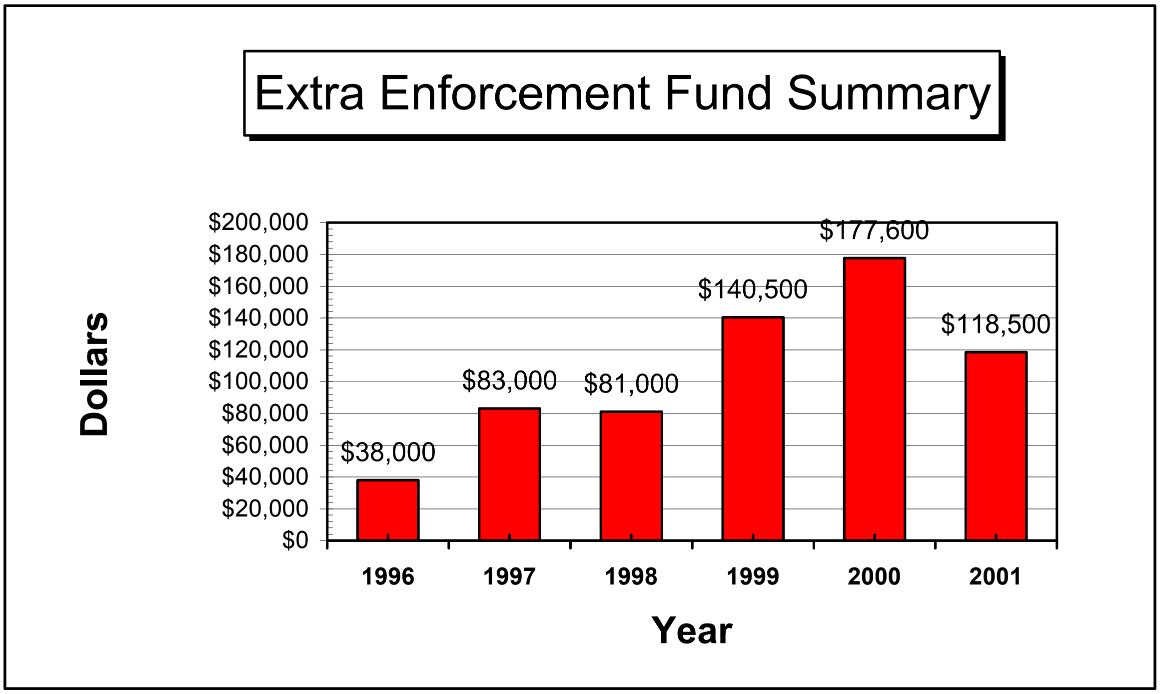
Iowa

Iowa uses extra-enforcement in construction work zones to patrol and enforce existing motor vehicle laws. Officers that work in construction zones are on voluntary and overtime status. The project fund reimburses the officer and the vehicles mileage.

Extra-enforcement in work zones has not been widely used in Iowa. However, the Bi-State Council of Governments in the Quad Cities funded an extra-enforcement campaign from 1993 to 1995. This campaign used the Iowa State Patrol, Scott County Sheriff, Davenport, Bettendorf, and Le Claire Police Departments to patrol work zones on the state, county, and city levels. The project was considered to be successful and local media picked up on the campaign. In 1996 additional funding was allocated to expand the use of extra-enforcement in work zones statewide. Project funds are being used in Iowa to subsidize extra enforcement. The extra-enforcement is being assigned to work zones by taking the following factors into consideration:

- Traffic volume
- Enforcement personnel availability
- Potential work zone congestion
- Remaining highway capacity
- Construction work zone type

The Iowa DOT annual extra enforcement expenditure since 1996 is shown in the chart below.



New York

New York occasionally employs extra enforcement in work zones. They believe overuse of police in work zones will lessen the positive impact of police presence in work zones and draw large amount of Regional Capital Program funds.

New York's policy in engaging enforcement is to first request State Police to patrol work zones. Local agencies may be approached to patrol the work zone if the State Police are unavailable.

The decision to use dedicated police services in New York work zones is normally made during the design process of a project. High-speed, high volume traffic flow in combination with any of the following factors are applied to determine if dedicated police services need to be part of the project Traffic Control Plan:

- Construction activities (paving, etc.), closely adjacent to traffic without positive protection
- Restrictions to traffic flow based on geometry; no shoulder, reduced shoulder width, reduced lane width, and reduced number of travel lanes
- Locations where incidents will produce substantial congestion and delays on the facility
- Special operations that require temporary or frequent shifts in traffic patterns

- Locations where traffic conditions and accident history indicate substantial problems may be encountered during construction
- Nighttime construction which may create special concerns involving the Traffic Control Plan.
- Projects with heightened public concern regarding the impacts of the Traffic Control Plan

The decision to engage dedicated police in a work zone may also come after the project is underway if there is a recurrence of traffic accidents, objectionable delays and congestion, and/or widespread driver disregard for speed limits and other regulations. Dedicated police enforcement costs are paid through the Region's Capital program. These costs are eligible for Federal reimbursement on Federal Aid Projects at the same percentage as Federal participation on the project. The Engineer in Charge has control of the hours the State Police are present at the work zone.

California

Caltrans has a program known as the Construction Zone Enforcement Program or Maintenance Zone Enhanced Enforcement Program (COZEEP/MAZEEP) in which the California Highway Patrol will be contracted to enforce speed compliance in work zones.

Conditions warranting COZEEP/MAZEEP activity are the following:

- Facility closures at night:
- Daytime construction activity that is not obvious when inactive
- Work zones protected by flaggers with or without pilot cars
- End of queue management
- Poor highway alignment approaching the work zone, high truck counts, or other unique situations
- Workers exposed to traffic and escape route blocked
- Night construction activity that is not obvious when inactive
- Activities with a large number of truck movements at the work area
- Night work in an identified work zone that requires a lane closure
- Work on Freeways with 6 or more lanes.

New Jersey

New Jersey has a dedicated New Jersey State Police (NJSP) Construction Unit assigned to the New Jersey Department of Transportation (NJDOT) construction projects. This unit assists the NJDOT in monitoring and enforcement of the approved traffic control plans. All members of this unit must receive specific work zone safety training. The NJSP construction unit is used on an as-needed basis at the request of the Resident Engineer for a variety of project types and classifications.

Colorado

Colorado has created a program called the CHILL Campaign to slow motorists in work zones. CHILL is a public awareness and enforcement effort that targets aggressive drivers in work zones. This program has been active for the past three years. The organizations involved in CHILL Campaign include the Colorado DOT (CDOT), the Colorado State Patrol, and local law enforcement agencies. A total of 53 law enforcement agencies participate in CHILL. Funding for the CHILL Campaign comes from CDOT's safety budget, which is allocated by the State Transportation Commission.

Other State Agencies

There are many other states that engage police enforcement in their work zones. Following is a list of agencies with some type of enforcement practices:

Wisconsin

- On some high-volume, high-speed roadways Wisconsin funds overtime enforcement during the construction project

Hawaii

- Park police car with flashing blue light
- Have police present at construction work zones--this method is used sparingly

Kentucky

- Have double fine policy

Maryland

- Have a State Police Liaison Officer to provide input on work zone safety

Oklahoma

- State Police can be hired by the contractor to patrol work zones

New York Thruway

- State police intermittently park in work zones for brief periods (15-30 minutes) with their lights flashing
- Post signs that fines double in work zones
- Place ghost cars (recycled State Police cars) in work zones

KANSAS

Seven evaluations will be evaluated in Kansas. They are:

- Evaluation #3 – Dynamic Late Merge System - IRD
- Evaluation #4 – CALM System - Scientex
- Evaluation #5 – SHO Fixture Portable Lighting System - Allmand
- Evaluation #6 – Portable Lighting Tower – Tower Solutions
- Evaluation #7 – Paddle Pal – Rick Watson Innovations
- Evaluation #8 – Autoflagger – Safety Technologies
- Evaluation #9 – Reflectorized Sleeves for Barrel Delineators - Reflexite

Evaluation #3 – Dynamic Late Merge System – IRD

Technology

System of CMS and non-intrusive traffic detectors that monitor traffic and dynamically set the CMS to display merge instructions based on real-time traffic conditions.

Objective

To improve the safety and efficiency of the work zone by informing drivers of the appropriate time to merge based on current traffic conditions.

Study Site

I-135, Wichita, between 17th street and 37th street, reconstruction.

Performance Measures

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

Objectives	Performance Measures
Improve work zone efficiency	1. Travel time
	2. Throughput, capacity

Evaluation Methodology

Study type: Comparison with similar site with standard traffic control

Data to be Collected:

Travel Times
Collection method: video-based re-identification
Sample size: NA
Analysis technique: Summary

Capacity
Collection method: video-based counts
Sample size: NA
Analysis technique: summary

Work Plan

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

Task	Responsibility
1. Deploy system	Vendor/KU/KDOT
2. Collect data	KU
3. Post-process data	KU
4. Analyze data	KU
5. 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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Evaluation #4 – CALM System – Scientex

Technology

This system of CMS and non-intrusive traffic detectors is intended to improve the safety and efficiency of the merging operation by instructing drivers to use both lanes until the lane drop, then take turns.

Objective

Once a queue forms, the system reduces the length of the queue by using both lanes for storage and improves the efficiency of the merge by effectively assigning the right of way to alternating lanes.

Study Site

I-135, Wichita, between 17th street and 37th street, reconstruction.

Performance Measures

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

Objectives	Performance Measures
Improve capacity	1. Travel time
	2. Throughput, capacity

Evaluation Methodology

Study type: Comparison with similar site with standard traffic control

Data to be Collected:

Travel Times
Collection method: video-based re-identification
Sample size: NA
Analysis technique: Summary

C*apacity*
Collection method: video-based counts
Sample size: NA
Analysis technique: summary

<u>Work Plan</u>

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

Task	Responsibility
1. Deploy system	Vendor/KU/KDOT
2. Collect Data	KU
3. Post-Process Data	KU
4. Analyze Data	KU
5. Write report	KU

<u>Schedule</u>

Task	May				June				July				August				Sept				Oct				Nov			
	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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Evaluation #5 – SHO Fixture Portable Lighting System – Allmand

<u>Technology</u>

The portable work zone lighting unit will be evaluated for functionality and efficiency. The model to be tested is 30' tall.

<u>Objective</u>

The objective of this product is to provide the maximum illumination of the workspace with minimal glare to approaching drivers and at minimal cost.

Study Site

Quantitative data will be collected in an unlit parking lot or similar facility prior to moving the unit to the work site.

US-69 between College Blvd and I-35; night work, very fast mobile patching operation, high volume traffic; 2-3 months starting May 2002.

Performance Measures

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

Objectives	**Performance Measures**
Improve workspace illumination	1. Illumination pattern
Minimize glare for drivers	2. Contrast ratios from specified distances
Maximize ease of use	3. Setup/takedown time 4. Contractor testimonials

Evaluation Methodology

Study type: Assessment of cost effectiveness

Data to be Collected

Illumination pattern
Collection method: lux meter
Sample size: NA
Analysis technique: cost per sq. ft illuminated

Glare profile
Collection method: relationship of distance and contrast ratio (recorded via luminance meter) from driver's vantage point
Sample size: eye heights of 4 ft and 8 ft
Analysis technique: summary of qualitative evaluation

Setup/Takedown time
Collection method: repeat setup and takedown procedures, recording time for each
Sample size: 3
Analysis technique: summary of qualitative evaluation

Contractor Testimonials
Collection method: interview with supervising contractor
Sample size: NA
Analysis technique: summary of qualitative evaluation

Work Plan

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

Task	Responsibility
1. Obtain light unit	KDOT, Vendor
2. Collect data	KU
3. Analyze data	KU
4. 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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Evaluation #6 – Portable Lighting Tower – Tower Solutions

Technology

The portable work zone lighting unit will be evaluated for functionality and efficiency. The model to be tested is 80' tall.

Objective

The objective of this product is to provide the maximum illumination of the work space with minimal glare to approaching drivers and at minimal cost.

Study Site

Quantitative data will be collected in an unlit parking lot or similar facility prior to moving the unit to the work site.

Performance Measures

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

Objectives	Performance Measures
Improve work space illumination	1. Luminance pattern
Minimize glare for drivers	2. Contrast ratios from specified distances
Ease of use	3. Setup/takedown time 4. Contractor testimonials

Evaluation Methodology

Study type: Assessment of cost effectiveness

Data to be Collected:

Illumination pattern
Collection method: light meter
Sample size: NA
Analysis technique: cost per sq. ft illuminated

Glare profile
Collection method: relationship of distance and contrast ratio within 15 degree cone from driver's vantage point
Sample size: eye heights of 3 ft, 6 ft and 9 ft.
Analysis technique: summary of qualitative evaluation

Setup/Takedown time
Collection method: repeat setup and takedown procedures, recording time for each
Sample size: 3
Analysis technique: summary of qualitative evaluation

Contractor Testimonials
Collection method: interview with supervising contractor
Sample size: NA
Analysis technique: summary of qualitative evaluation

Work Plan

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

Task	Responsibility
1. Obtain light unit	KDOT/Vendor
2. Collect data	KU
3. Analyze data	KU
4. 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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Evaluation #7 – Paddle Pal – Rick Watson Innovations

Technology

The Paddle Pal is a device to be used to supplement standard flagger paddles with flashing lights. The device consists of a brick-sized casing with two red lights on one side and two yellow lights on the other side. The lights on either side alternate flashing while that side is activated. The device is designed with a (toolless) friction mount compatible with nearly any common diameter of handle.

Objective

To improve the conspicuity of flaggers.

Study Site

K-4 from the US-24 junction to Atchison County line; hot surface recycle, asphalt overlay, and re-striping, 3-4 months, starting May 2002.

Performance Measures

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

Objectives	Performance Measures
Increase the conspicuity of flagger/paddle.	Subjective observation Glare potential based on contrast ratios
Affix reliably to paddle handle	Drop distance necessary to dislodge from various handle types
Minimize additional maintenance	Battery life

Evaluation Methodology

Study type: Before and after

Data to be Collected:

Contrast Ratios
Collection method: luminance meter
Sample size: 3 readings at distance increments of 50 ft up to 500 ft for each color
Analysis technique: comparison of longitudinal profile to glare threshold

Drop distance
Collection method: drop test
Sample size: 3 different diameters of handle
Analysis technique: summary

Battery life
Collection method: continuous on
Sample size: 3 trials
Analysis technique: summary

Flagger testimonials
Collection method: interviews
Sample size: dependant on contractor operating policies
Analysis technique: summary

Work Plan

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

Task	Responsibility
1. Collect quantitative data	KU
2. Deploy in work zone for 2 weeks	KU
3. Conduct interviews	KU
4. Analyze data	KU
5. 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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Evaluation #8 – Autoflagger – Safety Technologies

Technology

Device is a trailer-mounted system comprising a standard flagger paddle mounted on a motorized pivot. The device operator can control the paddle remotely, allowing one flagger to operate both ends of a work zone. (Note: operator must be able to see the devices at all times to verify proper operation.)

Objective

The objective of this device is to eliminate the need for a second flagger and to allow flagging operations to be conducted more safely by allowing the flagger operator to stand well out of the way of oncoming vehicles.

Study Site

K-4 from US-24 junction to Atchison County line; hot surface recycle, asphalt overlay, and re-striping, 3-4 months, starting in May 2002.

Performance Measures

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

Objectives	Performance Measures
Reduce traffic control costs	1. Comparison of flagger wages with the cost of procurement and maintenance of the Autoflagger
Improve worker safety	2. Subjective evaluation 3. Worker testimonials

Evaluation Methodology

Study type: Cost effectiveness and subjective evaluation

Data to be Collected:

Range
Collection method: field tests
Sample size: NA
Analysis technique: summary

Testimonials
Collection method: interviews
Sample size: NA
Analysis technique: summary

Work Plan

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

Task	Responsibility
1. Set up Autoflagger	KDOT/Contractor
2. Collect data	KU
3. Analyze data	KU
4. 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
1																												
2																												
3																												
4																												

Evaluation #9 – Reflective Sleeves for Barrel Delineators - Reflexite

Technology

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

Objective

The intended use of the sleeves is to better delineate exit ramps where construction activities have required changing the ramp entrance, the shoulder is protected by drums on both the ramp and the mainline, and drivers may have difficulty discerning which two drums constitute the mouth of the ramp. The sleeves may have other useful applications, such as highlighting a lane drop, but only the application described above will be considered in this evaluation.

Study Site

TBD.

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. Speed characteristics of exiting vehicles 2. Noise speed characteristics of mainline flow

Evaluation Methodology

Study type: Before/after

Data to be Collected:

Speed characteristics (mainline and exiting)

Collection method: pneumatic tubes at three locations, immediately prior to exit, and 200 feet from the beginning of the gore area on both the ramp and the mainline.

Sample size: 1 week before, 1 week for each of 2 configurations.

Analysis technique: comparison of 85^{th} percentile, mean, standard deviation. Analysis will be performed separately for mainline traffic and for exiting traffic. Primary measures are the speed characteristics of exiting vehicles just prior to the exit.

Work Plan

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

Task	Responsibility
1. Install evaluation equipment	KU
2. Collect before data	KU
3. Install drum sleeves	KU
4. Collect data (configuration 1)	KU
5. Reconfigure drum sleeves	KU
6. Collect data (configuration2)	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
1																												
2																												
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4																												
5																												
6																												
7																												
8																												

MISSOURI

Evaluation #10 – Intellizone – Quixote/Hoosier will be conducted by Missouri.

Evaluation #10 – Intellizone – Quixote/Hoosier

Technology

The Quixote *Intellizone* is a freeway work zone speed advisory system. Three mobile count units (which can measure flow, speed, and density) are placed in each lane where queues could form due to the construction zone. Two variable message signs (VMS units) are placed approximately two miles and five miles upstream from the detectors. One mobile command unit is placed between the detectors and the VMS units. The command units take information from the sensors on average speed and send signals to the VMS units to indicate an appropriate message, using either line-of-sight or cellular communication. Under free flow conditions the message would provide a standard warning of the construction zone. When queues cause significant speed reductions the VMS units can warn of the reduced speed ahead by displaying the downstream speed, based upon a rolling 3- to 5-minute average.

Objective

The objectives of the evaluation are to determine whether the system:

1. Performs as described.
2. Affects the speed pattern positively.
3. Reduces traffic conflicts.
4. Is understood and accepted by the driving public.

Study Site

The study site will be Eastbound I-70 near Wentzville Pkwy. and Pearce Blvd. which is just west of St. Louis. This highway work-zone involves significant congestion during the morning peak period from 6 am – 8 am. This work-zone is currently active so data collection can begin at any time. A backup site is located on I-44 near Six Flags. Should neither of these sites be available, another site in Missouri will be considered.

Performance Measures

Deployment Objective	MOE	Measurement Instrument/Method	Location
Driver Understanding and Acceptance			
Driver Understanding	% Drivers Who Understand	Roadside Interviews	Downstream of Deployment
Driver Acceptance	% Drivers Who Like Deployment	Roadside Interviews	Downstream of Deployment
Speed			
Lower Speeds	Mean Speed 85^{th}-%tile Speed	Detectors	Downstream of Deployment
Smaller Speed Variance	Standard Deviation 10-mph Pace Range	Detectors	Downstream of Deployment
Safety			
Fewer Conflicts	Number of Conflicts Conflict Rates Conflict Types	Conflict Studies	On Work Zone Approach

Evaluation Methodology

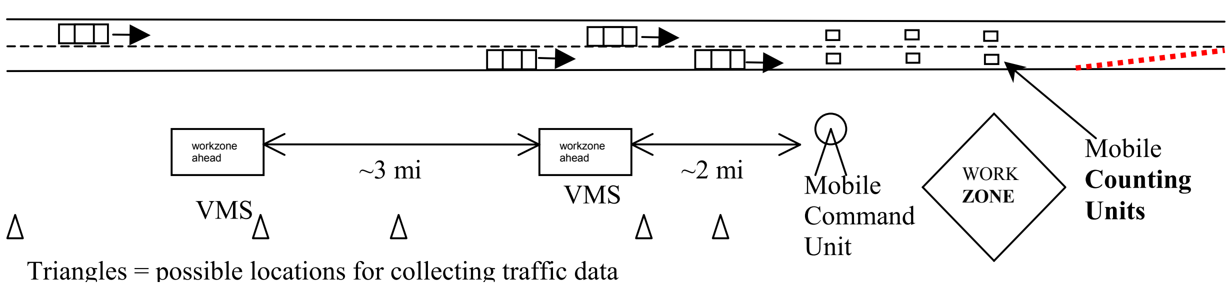

Figure 3. Conceptual Diagram of Intellizone Evaluation

A before-and-after study will be performed to determine whether the system lowers speeds, reduces speed variance, and reduces conflicts.

- Speed data will be collected using the three mobile count units (which can measure flow, speed, and density) placed in each lane for the system plus additional units upstream from the TMS units for evaluation purposes. Alternately, the speed data for evaluation can be collected by using standard MoDOT equipment from the TMS Division. The advantages of using the Quixote mobile count units are that it is an existing technology and all of the speed, flow, and density data can be collected in the same format and logged onto a single data file. Cellular communications is recommended for data collection due to terrain and for ease of downloading data. Three or more collection points for evaluation speed data are recommended. The first one is for measuring speeds prior to any work zone signing or activity. The second is to measure the immediate effect of the VMS. The third is to confirm that any effect of the VMS is persistent and remains after the vehicle has traveled away from the VMS. Figure 1 is a "conceptual diagram" of the Intellizone system and possible evaluation data collection locations (components and distances are not shown to scale).

- Traffic conflict studies will be performed downstream from the TMS units before and after the *Intellizone* installation using the techniques described in ITE's *Manual of Transportation Engineering Studies*.

Traffic conditions and TMS unit displays will be monitored to determine whether the system performs as described.

A user survey will be conducted downstream from the installation to gauge user acceptance and understanding of the system. The type of user survey (e.g., mailback, interview, etc.) will depend upon characteristics of the survey location.

Examples of previous evaluations

Work zone safety continues to be an important area of research for public agencies. Past field studies on interstates such as Texas (Richards 1985) or South Dakota (McCoy 1995) have shown that changeable message signs (CMS) are effective as a speed control method in work zones. The range of speed reduction reported in Texas range from 3-9 mph with CMS displaying speed only, and speed with informational message.

The message content of variable message signs have significant influence on driver behavior. Studies by Dudek (1999) have shown that drivers traveling at 55mph have only about 8 seconds to read a CMS message. Studies conducted in Indiana along the Borman Expressway have shown that drivers react differently to passive and active messages (Peeta 2000).

Sometimes roadside surveys have been used to study driver response under VMS. Studies have used a laboratory approach (Wardman 1998) or field approach by surveying drivers at rest stops downstream from the VMS (Peeta 2000).

References

Dudek, C. (1999) Changeable Message Sign Messages for Work Zones. *Transportation Research Record 1692*. pp. 1-8.

Institute of Transportation Engineers, *Manual of Transportation Engineering Studies (1991)*.

McCoy, P., Bonneson, J., and Kollbaum, J. (1995) Speed Reduction Effects of Speed Monitoring Displays With Radar in Work Zones on Interstate Highways. *Transportation Research Record 1509*. p 65-72.

Peeta, S, Ramos, J., and Raghubhushan, P. (2000) Content of Variable Message Signs and On-Line Driver Behavior. *Transportation Research Record 1725*. pp. 102-108.

Richards, S, Wunderlich, R., and Dudek, C. (1985) Field Evaluation of Work Zone Speed Control Techniques. *Transportation Research Record 1035*. pp. 66-78.

Wardman, M, Bonsall, P., and Shires, J. (1998) Driver Response to Variable Message Signs: a Stated Preference Investigation. *Transportation Research Part "C".* Vol. 5, No. 6, pp.389-405.

Work Plan

Task	Responsibility
1. Coordination meetings	MU, MoDOT, Quixote
2. Install devices	Traffic Control Subcontractor, MoDOT
3. Collect traffic data	MU, Quixote, MoDOT
4. Collect user survey data	MU
5. Analyze data	MU
6. Final report	MU

Schedule

	2002										2003			
Task	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**
1														
2														
3														
4														
5														
6														

NEBRASKA

Two evaluations will be conducted by Nebraska. They are:

- Evaluation #11 – D-25 Speed Advisory Sign System – MPH
- Evaluation #12 – Freeway Speed Advisory System – 3M/National ITS

Evaluation #11 – D-25 Speed Advisory Sign System – MPH

Technology

The MPH D-25 Speed Advisory Sign System is a series of radar speed display trailers configured to measure and display the speed of traffic ahead. The objective of the system is to warn drivers of stopped or slow-moving traffic ahead and thereby enable them to reduce their speeds and avoid rear-end crashes with these vehicles.

The system deployed for the purpose of this evaluation will consist of a series of three MPH D-25 speed trailers placed at approximately ¼ to ½-mile intervals depending on the weather, terrain, and prevailing roadway and traffic conditions. Each trailer will be equipped with: (1) an LED display with 25-inch speed digits, (2) directional radar directed toward downstream traffic, (3) two flashing strobes to warn drivers of downstream problems, (4) TRAFFIC SPEED AHEAD sign mounted over the speed display, and (5) SPEED WARNING WHEN FLASHING sign mounted beneath the speed display. An illustration of the trailer is shown in Figure 4.

The three MPH D-25 speed trailers will operate independently. The on-board radar will monitor speed trends downstream of the trailer and identify the onset of traffic slowdowns. When a traffic slowdown is detected, the strobe lights will flash. The speed display will show the speed of the downstream traffic. When there is no slowdown, the strobe lights will be off and the display will show the speed of traffic downstream or the work zone speed limit, which ever is lower.

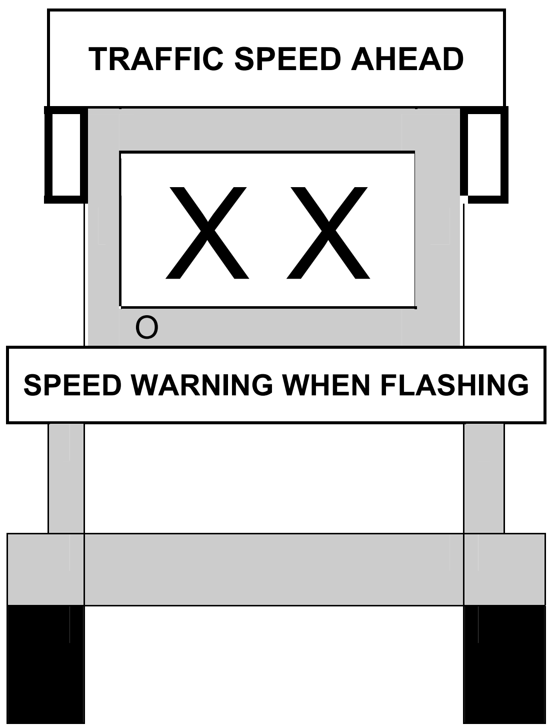

Figure 4. Speed Trailer

<u>Objective</u>

The objectives of the evaluation are to: (1) assess the effectiveness of the MPH D-25 Speed Advisory System in reducing traffic speeds upstream of traffic slowdowns and (2) determine the optimum spacing between speed trailers.

Study Site

The MPH D-25 Speed Advisory System will be deployed in advance of a work zone on westbound West Dodge Road (US Highway 6) in the vicinity of 168th Street in Omaha, Nebraska. The work zone involves a reduction in the number of traffic lanes. The posted speed limit in advance of the work zone is 60 mph, and the posted speed in the work zone is 55 mph. The average daily traffic on this section of West Dodge Road is about 40,000 vehicles per day, of which 3 percent are trucks.

The speed advisory system will include three speed trailers placed on the right shoulder of the westbound West Dodge Road upstream of the lane reduction. The spacing between the speed trailers will be varied between about ¼ and ½ miles during the evaluation in order to determine the most effective spacing. Thus, the zone of protection that will be evaluated by the study will range from approximately ¾ to 1½ mile in advance of the work zone

Performance Measures

Objective	Measure of Effectiveness
To reduce traffic speeds upstream of traffic slowdowns.	Changes in traffic speed distribution parameters at selected points before and after the deployment of the speed advisory system.

Evaluation Methodology

Speed, volume, and occupancy data will be measured simultaneously at five points. One point will be at the location of the bottleneck at the lane reduction and the other four points will be ½-mile intervals upstream of the bottleneck. Thus, data will be collected over the 2-mile section of roadway immediately upstream of the bottleneck. The data at the 2-mile point and the bottleneck will be collected with video detection; and the data at the ½, 1, and 1½-mile points will be collected with microwave sensors. The video cameras and the microwave sensors will be mounted on 30-foot poles along the roadway outside of the clear zone. The data will be obtained during a two-week period before and a six-week period after the speed advisory system is deployed. During the six-week after period, the spacing between the speed trailers will be varied. During the first two weeks, the trailers will be spaced at ¼-mile intervals with the trailer farthest upstream being ¼ mile in advance of the bottleneck. In the next two weeks, the trailers will be spaced at ½-mile intervals with the trailer farthest upstream being ½ mile in advance of the bottleneck. In the last two weeks, the trailers will be spaced at ¾-mile intervals with the trailer farthest upstream being ¾ mile in advance of the bottleneck. In each case, data collection will begin after the trailers have been in placed for one week.

A total of 40 hours of data will be collected. Ten hours of data will be collected during the before period and during each speed trailer spacing in the after period. The data will be collected during high traffic volumes when congestion is likely to occur. Speed distribution parameters, volumes, and occupancies will be computed for each 5-minute interval. The differences in the speed distribution parameters, volumes, and occupancies among the five data collection locations will be computed for each 5-minute interval. The speed parameter differences will be compared to assess the effectiveness of the speed advisory system and the trailer spacing. An analysis of covariance will be conducted to account for the effects of volume and occupancy on the speed parameters differences.

<u>Work Plan</u>

Task	Responsibility
1 – Deliver system.	MPH
2 – Calibrate system and set speed thresholds.	MPH, NDOR, MATC
3 – Install data collection detectors.	NDOR, MATC
4 – Collect before data.	MATC
5 – Deploy speed trailers.	NDOR
6 – Collect after data.	MATC
7 – Analyze data.	MATC
8 – Report results.	MATC

<u>Schedule</u>

Task	June	July	Aug.	Sept.	Oct.	Nov.
1 – Deliver system.						
2 – Calibrate system and set speed thresholds.						
3 – Install data collection detectors.						
4 – Collect before data.						
5 – Deploy speed trailers.						
6 – Collect after data.						
7 – Analyze data.						
8 – Report results.						

Evaluation #12 – Freeway Speed Advisory System – National ITS

<u>Technology</u>

The National ITS Speed Advisory System is a work zone traffic management system configured to inform drivers of the speed of traffic ahead by means of fixed message warning signs equipped with flashing beacons strategically located in advance of work zone bottlenecks. The primary objective of the system is to warn drivers of stopped or slow-moving traffic ahead and thereby enable them to reduce their speeds and avoid rear-end crashes with these vehicles. In addition, the speed information and DMS displays are communicated to a traffic management center so conditions in the work zone can be monitored and, if necessary, responses to incidents can be initiated in a timely manner.

The system deployed for the purpose of this evaluation will consist of four primary components: (1) speed sensors; (2) warning signs equipped with flashing beacons; (3) *Its*workzone™ software, and (4) *Its*wire™ FM narrow band technology. The sensors will detect traffic speeds at each warning sign in advance of the work zone and at the work zone bottleneck to provide drivers with warnings of stopped or slow-moving traffic ahead up to approximately 4 miles in advance of the work zone. The 1- to 2-minute average speeds measured at the these points will be inputted to the sign control logic and the flashing beacons will be activated on the appropriate signs to when stopped or slower traffic is detected. The *Its*workzone™ software will serve as the control system, which will process the speed detector data and determine when the flashing beacons need to be activated. The *Its*wire™ FM narrow band technology will provide the communications between the detection system and the DMSs. It will also provide communications to the Nebraska Department of Roads (NDOR) District 2 office, which will enable the system to be controlled and monitored by NDOR personnel. The control system will be able to alert the NDOR personnel when speeds drop below a selected threshold and enable them to initiate incident response measures when necessary.

Objective

The objectives of the evaluation are to: (1) determine the effectiveness of the National ITS Speed Advisory System in reducing traffic speeds upstream of traffic slowdowns and (2) assess its utility as a work zone traffic management tool.

Study Site

The National ITS Speed Advisory System will be deployed in advance of a work zone on eastbound I-80 between Highway 370 and Highway 50 about 3 miles southwest of Omaha, Nebraska. The work zone involves reconstruction to widen I-80 from four to six lanes. Two lanes with lanes shifts in each direction will be maintained in the work zone during the reconstruction. The posted speed limit in advance of the work zone is 75 mph and the work zone speed limit is 55 mph. The average daily traffic on this section of I-680 is about 50,000 vehicles per day, of which 15 percent are trucks.

Four warning signs, spaced at 1-mile intervals, will be placed on the right shoulder of eastbound I-80 beginning 4 miles in advance of the work zone as illustrated in Figure 5. The detectors will be placed at the work zone bottleneck and at the three warning signs nearest the work zone.

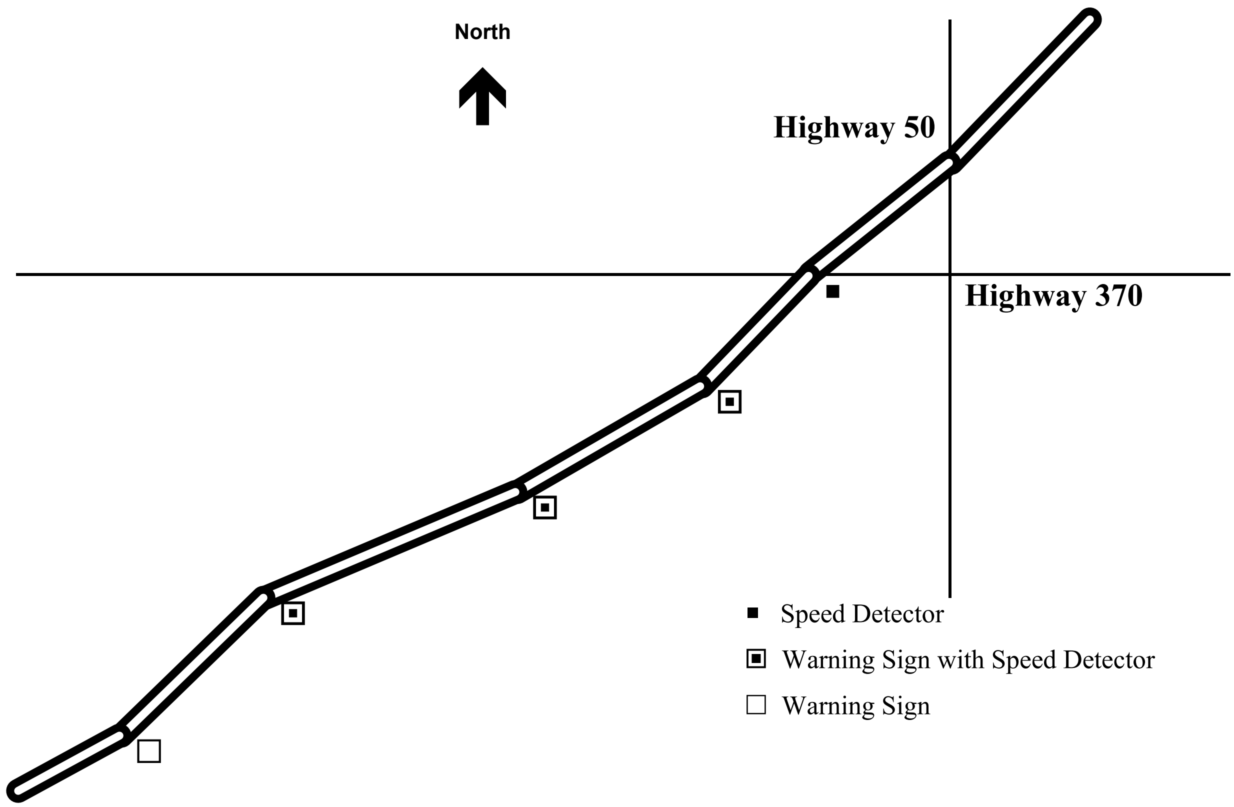

Figure 5. Study Site

<u>Performance Measures</u>

Objective	Measure of Effectiveness
To reduce traffic speeds upstream of traffic slowdowns.	Changes in traffic speed distribution parameters at selected points before and after the deployment of the speed advisory system.
	Responses to driver survey on control system web page regarding the usefulness and effectiveness of the system.
To facilitate traffic management during incidents and periods of congestion in the work zone.	Opinions of Nebraska Department of Roads (NDOR) personnel regarding the usefulness of the system.

<u>Evaluation Methodology</u>

Speed, volume, and occupancy data will be measured simultaneously at five points. One point will be at the location of the work zone bottleneck and the other four points will be approximately ¼-mile downstream of each warning sign. Thus, data will be collected over the 3¾-mile section of roadway immediately upstream of the work zone bottleneck. The data at the

3¾-mile point and the bottleneck will be collected with video detection; and the data at the immediate points will be collected with microwave sensors. The video cameras and the microwave sensors will be mounted on 30-foot poles along the roadway outside of the clear zone. The data will be transmitted to the NDOR District 2 office via the *Its*wire™ FM narrow band and logged on the control system computer by the *Its*workzone™ software. The data will be obtained during a four-week period before and a four-week period after the speed advisory system is deployed.

The data logged by the control system computer during the before and after periods will be analyzed. Speed distribution parameters, volumes, and occupancies will be computed for each 5-minute interval. The differences in the speed distribution parameters, volumes, and occupancies among the five data collection locations will be computed for each 5-minute interval. The speed parameter differences will be compared to assess the effectiveness of the speed advisory system. An analysis of covariance will be conducted to account for the effects of volume and occupancy on the speed parameters differences.

The system will have a web plug-in, which will enable the speed detector data and the status of the beacons on the warning signs to be viewed by the public on the NDOR web site. A survey form will also be put on the web page to solicit feedback on the usefulness and performance of the speed advisory system from drivers. The responses to the survey will be compiled.

NDOR personnel who worked with the system will be interviewed. Problems they encountered with the system will be identified. Their opinions regarding the usefulness of the system and their suggestions for improving the system will be noted.

Work Plan

Task	Responsibility
1 – Install system.	National ITS, NDOR
2 – Design flashing beacon activation criteria.	National ITS, NDOR, MATC
3 – Install data collection detectors.	NDOR, MATC
4 – Collect before data.	MATC
5 – Prepare web page.	National ITS, NDOR, MATC
6 – Implement warning sign system.	National ITS, NDOR, MATC
7 – Implement web page.	National ITS, NDOR, MATC
8 – Collect after data.	MATC
9 – Analyze system logs.	MATC
10 – Analyze driver survey.	MATC
11 – Conduct NDOR personnel interviews.	MATC
12 – Report results.	MATC

Schedule

Task	May	June	July	August	Sept	Oct
1 – Install system.						
2 – Design flashing beacon activation criteria.						
3 – Install data collection detectors.						
4 – Collect before data.						
5 – Prepare web page.						
6 – Implement warning sign system.						
7 – Implement web page.						
8 – Collect after data.						
9 – Analyze system logs.						
10 – Analyze driver survey.						
11 – Conduct NDOR personnel interviews.						
12 – Report results.						

WISCONSIN

Four evaluations will be conducted by Wisconsin. They are:

- Evaluation #13 – Intellizone – Quixote
- Evaluation #14 – Portable Lighting Tower – Tower Solutions
- Evaluation #15 – Paddle Pal – Rick Watson Innovations
- Evaluation #16 – Driver Recognition of Channelizing Devices

Evaluation #13 – Intellizone – Quixote

Technology

The Work Zone Speed Advisory System is an interface between traffic detectors and portable changeable message signs. The recommended traffic detector has been dubbed "Road Hog" by the vendor and is surface-mounted to the roadway. This particular detector reports vehicle counts, average speed, and occupancy. The detector transmits data to a "remote processing unit" (RPU) by spread-spectrum radio operating at 2.45 GHz. The RPU analyzes the data and can relay traffic information to message signs by a variety of technologies, including cellular. Thus, information can be provided at arbitrary distances ahead of the work zone. The system can handle up to sixteen detectors.

Objective

The Workzone Speed Advisory System has the potential to be implemented quickly, reliably and at relatively low cost. The objective of this study will be to determine whether a simple implementation of the Workzone Speed Advisory System provides reliable information in a form that is helpful to drivers.

The Workzone Speed Advisory System has options that can increase both its sophistication and cost, but a balance will be sought between cost and system complexity so as to determine the most cost-effective configuration for a typical application. A case study site will be selected that enables this determination to be made.

Study Site

There are two possible case study sites, both on I-43 in Wisconsin. One site is in Green Bay and the other site is in Milwaukee. The Green Bay site has some particularly desirable attributes: a rural-like interstate highway with only two travel lanes in one direction, large interchange spacing, relatively homogeneous traffic, and a variety of nearby sites that can be used for administering a questionnaire. The Milwaukee site is closer to the study team, so there would be lower travel costs. At this time, the Green Bay site looks to be the most promising and will be described here.

The Green Bay site is on the northbound lanes of I-43. I-43 bypasses Green Bay, looping east and north of the most populated areas of the city. I-43 terminates a few miles north of the site, with most traffic continuing northward on US 41/141. I-43 at this location is heavily used in the summer for vacation travel to recreational opportunities that are up to three hours away. There are not any rest areas north of Green Bay, but there are many sizable restaurants and gas stations that could serve as locations for administering questionnaires. Because most travelers would be on vacation and waiting for food or gasoline at these places, cooperation is expected to be high.

Construction will reduce the facility to one lane. Slowing and queuing is expected to occur near the work zone during periods of high traffic demand. The ADT for July in a single direction is about 18000 vehicles, with considerable peaking on Friday afternoons in the northbound direction.

Performance Measures

Deployment Objective	MOE	Instrument/Method	Location
Improve Driver Awareness of Speeds	% of Drivers with Greater Knowledge	Questionnaire	Downstream of Deployment
Improve Driver Acceptance	% of Drivers Satisfied with Deployment	Questionnaire	Downstream of Deployment
Provide Reliable Information	RMS Deviation from Reported Speeds	Radar/Lidar Gun Detectors	At Equipment Detector Locations
Improve Safety	Crash Rate Crash Severity	Crash Reports	On Work Zone Approach
High Equipment Reliability	% Down Time	Field Reports	At Signs

The vendor asserts that traffic flow will be smoother upstream from the work zone resulting in higher speeds. The validity of that claim cannot be ascertained within a reasonable budget.

Evaluation Methodology

The installation would involve only a few detectors, strategically placed near the beginning of the work zone and somewhat upstream of the work zone where queues are likely to form. No more than three portable changeable messages signs would be positioned well upstream of the end of the longest anticipated queue. Data would be collected on three successive Friday afternoons in July and August. In addition, crash records will be inspected for a period of time before and after the installation to determine whether there were any safety issues with the system.

Data collection will consist of obtaining any information archived from the detectors, any displayed messages, speed reliability data, and opinions of drivers passing through the work zone. Since messages will likely contain information that either explicitly or implicitly refers to speeds, it is important to check the validity of the speeds at the detectors. Speeds will be measured with a laser speed gun or radar gun for an adequate sample of vehicles. A short questionnaire will be administered to a random sample of drivers stopping at a gas station or a restaurant north of the work zone. The number of questions will be small enough so that the questionnaire can be administered orally without causing any additional delays for the traveler. It is anticipated that more than 180 completed questionnaires can be so obtained.

Work Plan

Task	Responsibility
1. Finalize Site Selection/Equipment Locations	WisDOT
2. Develop Traffic Data Collection Plan	UWM/Marquette
3. Develop Questionnaire and Administration Plan	UWM/Marquette
4. Deploy and Test Equipment	WisDOT/Vendor
5. Collect Data	UWM/Marquette/WisDOT/Vendor
6. Analyze Data	UWM/Marquette
7. Report Results	UWM/Marquette/WisDOT

Schedule

Task	May	June	July	Aug	Sept	Oct	Nov	Dec
1. Finalize Site Selection/Equipment Locations								
2. Develop Traffic Data Collection Plan								
3. Develop Questionnaire and Administration Plan								
4. Deploy and Test Equipment								
5. Collect Data								
6. Analyze Data								
7. Report Results								

Evaluation #14 – Portable Lighting Tower – Tower Solutions

Technology

Tower Solutions has developed a portable, self-erecting tower that is stored in an 8’x10’ trailer. The tower can reach heights of 80-100 feet and can be equipped with arrays of lights for use in construction zones. According to the vendor, no assembly or highly trained personnel is required; a tower can fully extend within 3-4 minutes. The particular proposed application involves use of an ML-14 lighting tower, which can reach heights of 10-80 feet, equipped with nine 1500-watt metal halide lights.

Objective

The objective of this evaluation is to compare the Tower Solutions technology to typical work zone lighting equipment used on Wisconsin Department of Transportation (WisDOT) projects. Because of the greater height at which lighting fixtures can be mounted, it is anticipated that glare will be lower for motorists driving through construction zones. The combination of greater lighting fixture height and higher wattage lights may be such that a Tower Solutions device may be sufficient where multiple alternative devices were necessary before. If this is proven to be true, the device may provide more uniform work zone illumination, since a single illumination source will avoid uneven illumination caused by use of multiple overlapping lighting sources. The present evaluation will collect and analyze the necessary data to answer these questions. In addition, the device will be evaluated for its practicality, reliability and cost, compared to currently used devices.

Study Site

A nighttime work zone will be chosen, preferably where no fixed lighting fixtures are available, so illumination measurements will not be affected by light sources external to the evaluation. A stationary work site (for example a bridge) will be sought, since the tower will be set in a fixed position for this evaluation. Tasks performed at the chosen work zone should require a moderate level of illumination (this excludes work involving very fine details requiring high levels of illumination).

Performance Measures

Deployment Objective	MOE	Instrument/Method	Location
Provide Adequate Illumination	Horizontal (Pavement) Illumination	Photometer	At 10 ft Intervals Around the Evaluated Devices
Avoid Glare	Vertical Illumination	Photometer	At 10 ft Intervals Around the Evaluated Devices
Practicality	Ease of use	Questionnaire	Construction Site
Cost	Operating Cost Equipment Cost	Questionnaire	Construction Site
Reliability	% Down Time	Questionnaire	Construction Site

Evaluation Methodology

The tower will be evaluated in terms of illumination parameters and practicality. Illumination will be measured at 10 ft intervals throughout the illuminated area, using a photometer. Measurements will be taken parallel to the road surface (photometer placed on the pavement) in order to measure pavement illumination. Measurements perpendicular to the road surface, both facing and away from the light source, will be taken at a height corresponding to a passenger car driver's eye height, in order to determine glare. Similar measurements will be performed for typical work zone lighting devices used on WisDOT projects. Results from the two data collection efforts will be summarized and compared.

Device practicality will be evaluated (on a comparative basis with currently used devices) using a questionnaire administered to work zone personnel, addressing at least the following issues:

Setup time, ease of setup process, operating costs, labor costs, equipment reliability, terrain adaptability, adequacy and quality of lighting, concerns with shadows, weather-related problems, safety issues.

Work Plan

Task	Responsibility
1. Finalize Site Location Selection	WisDOT
2. Collect Illumination & Device Deployment Data for Typical WisDOT Work Zone Illumination Devices	UWM/Marquette
3. Collect Illumination & Device Deployment Data for Tower Solutions Device	UWM/Marquette
4. Analyze Data	UWM/Marquette
5. Report Results	UWM/Marquette

Schedule

Task	May	June	July	Aug	Sept	Oct	Nov	Dec
1. Finalize Site Location Selection								
2. Collect Data for Typical Illumination Devices								
3. Collect Data for Tower Solutions Device								
4. Analyze Data								
5. Report Results								

Evaluation #15 – Paddle Pal – Rick Watson Innovations

Technology

Paddle Pal is a dual faced (red/amber) flashing light that mounts on a standard flagger paddle. The power source is a 9 volt rechargeable battery capable of up to 40 hours of continuous operation. Use of a red/amber flashing light on a paddle is not included in the MUTCD.

Objective

The objective of the evaluation is to determine whether the Paddle Pal improves driver recognition of the indication provided by the paddle. Driver recognition has the components of both seeing the sign and understanding the message. The Paddle Pal will be compared with a standard paddle (MUTCD 6E.03) and with an "optional" MUTCD paddle with flashing white lights above and below the STOP legend.

Study Site

Paddles will be compared by a random sample of employees of the WisDOT and private citizens in a rigidly controlled setting. Thus, the site will be near a large WisDOT office, most likely one in Waukesha, WI.

Performance Measures

Deployment Objective	MOE	Instrument/Method	Location
Improve Visibility of Paddle	% of Drivers Seeing Device Quickest	Paired Comparisons Experiment	Open Area Near WisDOT Office
Improve Recognition of Message	% of Drivers Best Understanding Device	Paired Comparisons	Open Area Near WisDOT Office
Durable Device	Failures	Ruggedness Tests	Laboratory
Convenience	Battery Life in Typical Use	Battery Tests	Laboratory
Convenience	Ease of Use Rating	Installation Tests	Laboratory

Evaluation Methodology

The three paddle configurations will be tested in a classical paired-comparisons experiment. Paddles will be briefly displayed to subjects at a considerable distance and under a variety of daytime lighting conditions. Respondents will be asked to rate configurations for both visibility and clarity of message.

Clearance from a university "human subjects" review board is required for this experiment. Thus, ample time in the project must be allowed to obtain this clearance.

In order save money and expedite the experiment, most subjects will be employees of WisDOT. A stratified random sample of employees will be selected so that all ages are fairly represented. Given the small numbers of employees of retirement age working for WisDOT, it will be necessary to supplement the sample with elderly local drivers. The budget for this project assumes that 50 employees and 10 elderly drivers will participate.

The Paddle Pal will be evaluated in a laboratory for durability, convenience, and battery life under both summertime and wintertime atmospheric conditions.

Work Plan

Task	Responsibility
1. Finalize Choice of Site	WisDOT
2. Develop Experimental Protocol	UWM/Marquette/WisDOT
3. Recruit Subjects	UWM/Marquette
4. Conduct Experiment	UWM/Marquette
5. Analyze Data	UWM/Marquette
6. Report Results	UWM/Marquette

Schedule

Task	May	June	July	Aug	Sept	Oct	Nov	Dec
1. Finalize Choice of Site								
2. Develop Experimental Protocol								
3. Recruit Subjects								
4. Conduct Experiment								
5. Analyze Data								
6. Report Results								

Evaluation #16 – Driver Recognition of Channelizing Devices

Technology

Drums, Type II barricades, and other large devices have been used to channelize traffic in work zones on high-speed roadways for many years. Some of these devices lack directional guidance and can be confusing to motorists. Increasingly, work is being limited to nighttime or other short-term periods in order to provide as many lanes as possible for traffic flow during peak hours. Driver recognition of traffic control devices and the amount of time spent setting them up are becoming more critical. If set-up time is long, worker exposure during set-up is increased and the time available to complete the road work is reduced, making for less efficient work operations. For example, tall (36") cones take less time to set-up than drums or barricades. On the other hand, cone recognition distance was found to be shorter than drum recognition distance (NCHRP 236), leading, perhaps, to a less safe work zone environment.

NCHRP 236 provides the most comprehensive device optimization and comparison of channelization devices. The report identified that device type, shape, size, mix of types, spacing, and light condition (day or night) affect driver perception and behavior in response to channelizing devices. In addition, significant variation was found between drivers responding to a particular device.

However, NCHRP 236 was written two decades ago and was geared toward the long-term work zone deployment. A lot of innovations have been introduced since that time, but have not been compared in a field deployment. Midwestern states will benefit from a comparison confined to the devices and device deployments their engineers have identified as most suitable to their needs, especially those relating to nighttime work zone deployments. Devices that provide positive directional information, regardless of orientation to traffic, can promote safer traffic flow through better guidance. Devices that can be deployed faster without negatively affecting driver performance can lead to labor cost savings and more time available to complete road work.

Objective

Compare the performance of a limited set of channelizing devices used by midwestern states in freeway or arterial work zones, in order to identify which devices (or device combinations) are likely to elicit the most appropriate driver responses for a given channelization configuration.

Study Site

For the experiment with pre-chosen subjects, either a highway closed to the public or actual work zones will be used. Ideally all devices will be evaluated by the same subjects in a course that will allow drivers to face device array deployments in different sequences, in order to: i) be able to use fewer subjects, and ii) control for sequence of presentation effects.

For the deployment to an actual work zone, a site would be chosen that would allow redundant devices so that safety would not be compromised.

Performance Measures

Deployment Objective	MOE	Instrument/Method	Location
Easy Device Deployment	Time to Set up Devices	Questionnaire	Maintenance Shop
Easy Device Removal	Time to Remove Devices	Questionnaire	Maintenance Shop
Early Device Detection	Device Detection Distance (avg, SD, 85th percentile)	Laser Gun (distance measurement) Tape-Measured Distances	Closed Roadway/ Parking Lot
Driver Reaction Before Construction Zone	Speed Change Within Detection Zone	Laser Gun	Construction Zone Approach Taper
Early Device Message Recognition	Device Message Identification Distance (avg, SD, 85th percentile)	Laser Gun (distance measurement) Tape-Measured Distances	Closed roadway/parking lot
Driver Behavior Within Construction Zone	Speed Change Within Construction Zone (avg, SD, 85th percentile)	Laser Gun	Construction Zone Along Closed Lane
Driver Behavior Within Transition Zone	Percent drivers remaining in closed lane	Observation	Construction Zone Taper
Driver Behavior in Relation to Device	Lateral distance away from device Number of knockdowns	Tape Switch Daily count of knockdowns	Construction Zone Taper and Along Closed Lane(s)

Evaluation Methodology

Comparisons between evaluated devices based on a field deployment of device arrays. Subjects will be asked to drive a predetermined course where the evaluated devices will have been deployed. Subjects' performance will be monitored and analyzed. In addition, subjects will be asked to rate the visibility and legibility of the devices.

Separate statistics are desirable for daytime and nighttime performance (emphasis on nighttime performance), and for various driver age groups. The number of devices to be evaluated will be kept small (four to five) in order to obtain valid statistical results.

In addition, the possibility of deploying the alternative devices in an actual work zone should be considered. The deployment must be done in a manner that does not compromise the safety of motorists or workers. Statistics of actual driver behavior could then be obtained. Only devices considered to be acceptable in the earlier experiment would be deployed.

Work Plan

Task	Responsibility
1. Solicit devices to be evaluated from participating States.	WisDOT/Marquette/UWM
2. Prepare experiment design.	Marquette/UWM
3. Identify location and time frame for device deployment.	WisDOT/Marquette/UWM
4. Recruit subjects.	WisDOT/Marquette/UWM
5. Field deployment.	WisDOT
6a. Test subjects in closed course.	WisDOT/Marquette/UWM
6b. Test subjects in actual work zone.	WisDOT/Marquette/UWM
7. Analyze results.	Marquette/UWM
8. Write Report	Marquette/UWM

Schedule

Task	A	M	J	J	A	S	O	N	D	J	F
1. Solicit devices .											
2. Experiment design.											
3. Identify location & time											
4. Recruit subjects.											
5. Field deployment.											
6a. Subjects-closed course											
6b. Subjects-work zone											
7. Analyze results.											
8. Write Report											

BUDGET

The total pooled-fund budget for the evaluation plan is $670,674. This amount does not include the cost share of the state highway agencies and the technology providers. The itemized budget by technology evaluation is shown in Table 2.

The budget is summarized by technology deployment in Table 3.

The amount of the pooled-fund carryover from 2001 (Year 3) is $81,277. Therefore, the additional pooled funds needed for 2002 (Year 4) are $589,397 ($670,674 minus $81,277), or $117,879.40 per state.

TABLE 2 Itemized Pooled-Fund Budget.

Item	Evaluation #1 Intellizone - Quixote (IA)	Evaluation #2 Effectiveness of Extra Enforcement in C&M Zones (IA)	Evaluation #3 Dynamic Late Merge System - IRD (KS)	Evaluation #4 CALM System - Scientex (KS)
Personnel				
Salaries & Wages	18,697	19,962	14,640	14,640
Fringe Benefits	3,247	3,875	2,724	2,724
Subtotal	21,944	23,837	17,364	17,364
Other Direct Costs				
Materials & Supplies	800	800	100	100
Printing & Copying	760	1,900	25	25
Postage	50	200		
Telephone & FAX	100	500	25	25
Research Equipment			2,000	2000
Travel	2,500	320	2,842	2,842
Tech Installation			40,000	50,000
Tech Maintenance				
Subtotal	4,210	3,720	44,992	54,992
Total Direct Cost	26,154	27,557	62,356	72,356
Indirect Cost	12,031	12,676	18,234	18,234
Total Cost	38,185	40,233	80,590	90,590

TABLE 2 Itemized Pooled-Fund Budget (continued).

Item	Evaluation #5 SHO Fixture Portable Lighting System - Allmand (KS)	Evaluation #6 Portable Lighting Tower – Tower Solutions (KS)	Evaluation #7 Paddle Pal – Rick Watson Innovations (KS)	Evaluation #8 Autoflagger – Safety Technologies (KS)
Personnel				
Salaries & Wages	4,279	4,279	4,662	3,854
Fringe Benefits	1,088	1,088	1,237	1,046
Subtotal	5,367	5,367	5,899	4,900
Other Direct Costs				
Materials & Supplies	20	20	20	20
Printing & Copying	25	25	25	25
Postage				
Telephone & FAX	25	25	25	25
Research Equipment	1,200	1,200	1,200	
Travel	299	299	373	373
Tech Installation				
Tech Maintenance				
Subtotal	1,569	1,569	1,643	443
Total Direct Cost	6,936	6,936	7,542	5,343
Indirect Cost	2,773	2,773	2,968	1,894
Total Cost	9,709	9,709	10,510	7,237

TABLE 2 Itemized Pooled-Fund Budget (continued).

Item	Evaluation #9 Reflectorized Sleeves for Barrel Delineators - Reflexite (KS)	Evaluation #10 Intellizone – Quixote/Hoosier (MO)	Evaluation #11 D-25 Speed Advisory Sign System - MPH (NE)	Evaluation #12 Freeway Speed Advisory System – National ITS (NE)
Personnel				
Salaries & Wages	8,731	51,534	28,805	21,333
Fringe Benefits	2,111	11,803	6,625	4,907
Subtotal	10,842	63,337	35,430	26,240
Other Direct Costs				
Materials & Supplies	170	500	250	250
Printing & Copying	25	500	250	250
Postage				
Telephone & FAX	25			
Research Equipment		5,000		
Travel	672	1,000	1,050	700
Tech Installation				55,000
Tech Maintenance				
Subtotal	892	7,000	1,550	56,200
Total Direct Cost	11,734	70,337	36,980	82,440
Indirect Cost	4,274	27,580	3,543	2,624
Total Cost	16,008	97,917	40,523	85,064

TABLE 2 Itemized Pooled-Fund Budget (continued).

Item	Evaluation #13 Intellizone - Quixote (WI)	Evaluation #14 Portable Lighting Tower – Tower Solutions (WI)	Evaluation #15 Paddle Pal – Rock Watson Innovations (WI)	Evaluation #16 Driver Recognition of Channelizing Devices (WI)	MATC
Personnel					
Salaries & Wages	7,456	10,090	4,952	24,545	30,617
Fringe Benefits	1,822	3,045	1,309	6,900	7,042
Subtotal	9,278	13,135	6,261	31,445	37,659
Other Direct Costs					
Materials & Supplies	100	100	500	300	1,500
Printing & Copying	100	100	100	200	3,000
Postage				300	500
Telephone & FAX				500	500
Research Equipment		100		1,000	
Travel	640	300	100	500	2,500
Tech Installation					
Tech Maintenance					
Subtotal	840	600	700	2,800	8,000
Total Direct Cost	10,118	13,735	6,961	34,245	45,659
Indirect Cost	4,654	6,305	3,201	15,755	3,766
Total Cost	14,772	20,040	10,162	50,000	49,425

TABLE 3 Pooled-Fund Budget Summary.

Evaluation	Technology	State	Cost
1	Intellizone - Quixote	Iowa	38,185
2	Effectiveness of Extra Enforcement in C&M Zones	Iowa	40,233
3	Dynamic Late Merge System - IRD	Kansas	80,590
4	CALM System - Scientex	Kansas	90,590
5	SHO Fixture Portable Lighting System - Allmand	Kansas	9,709
6	Portable Lighting Tower - Tower Solutions	Kansas	9,709
7	Paddle Pal - Rick Watson Innovations	Kansas	10,510
8	Autoflagger – Safety Technologies	Kansas	7,237
9	Relectorized Sleeves for Barrel Delineators - Reflexite	Kansas	16,008
10	Intellizone – Quixote/Hoosier	Missouri	97,917
11	D-25 Speed Advisory Sign System - MPH	Nebraska	40,523
12	Freeway Speed Advisory System - National ITS	Nebraska	85,064
13	Intellizone - Quixote	Wisconsin	14,772
14	Portable Lighting Tower - Tower Solutions	Wisconsin	20,040
15	Paddle Pal - Rick Watson Innovations	Wisconsin	10,162
16	Driver Recognition of Channelizing Devices	Wisconsin	50,000
MATC			49,425
		Total Cost	**670,674**