

**Working Paper:
Evaluation Criteria and Analysis
May 24, 2004**

TECHNICAL MEMORANDUM

**Project 2003-27:
Identification of Traffic Control Devices for Mobile and Short Duration Work
Operations**

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ABSTRACT

This report documents and summarizes: Task 1 - Develop a proposed methodology and criteria for measuring and evaluating the new technologies and Information systems, and Task 2: Analysis of the current NJDOT practices for short duration and mobile work zone operations, for Phase II – Research Approach of the study, “Identification of Traffic Control Devices for Mobile and Short Duration Work Operations”, for the New Jersey Department of Transportation. Task 1 was conducted by contacting other state agencies and a literature search of the causes of work zone crashes. Task 2 was conducted by interviewing NJDOT Safety personnel from the Bureau of Employee Safety, and reviewing mobile and short duration work zone cites in Region North and Region South.

Based on the literature search and field inspections of mobile and short duration work zones, interviews with NJDOT personnel and the literature search of the cause of work zone accidents, the following conclusions and recommendations are presented:

- Most NJDOT work zone crashes and accidents are caused by careless driving, speeding and motorist inattention which are similar to the causes of crashes in work zones from the literature and other agencies.
- NJDOT mobile and short duration work zones meet of the safety standards for design and application specifications for traffic control during highway maintenance by *Manual on Uniform Traffic Control Devices* (MUTCD).
- Safety devices should be selected to reduce traffic speed through work zones, improve motorists’ recognition of work zone hazards, and improve motorists’ attention to signs and the work zone.
- Any new safety devices for mobile and short duration work zones should be implemented in conjunction with worker safety training, and public safety and education programs.

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INTRODUCTION

This report documents and summarizes: Task 1 - Develop a proposed methodology and criteria for measuring and evaluating the new technologies and Information systems, and Task 2: Analysis of the current NJDOT practices for short duration and mobile work zone operations, for Phase II – Research Approach of the study, “Identification of Traffic Control Devices for Mobile and Short Duration Work Operations”, for the New Jersey Department of Transportation. Task 1 was conducted by contacting other state agencies and a literature search of the causes of work zone crashes. Task 2 was conducted by interviewing NJDOT Safety personnel from the Bureau of Employee Safety, and reviewing mobile and short duration work zone sites in Region North and Region South.

The objective of this research project is to study mobile and short duration work zone safety with particular attention to the identification of work zone safety devices, information systems for the reduction of safety and congestion, and implementation of innovative techniques to reduce delays and crashes due to work zones. The specific objectives are to:

- Identify state-of-the art work zone safety technologies to improve worker safety in mobile work zone and short term maintenance operations,
- Identify information systems for work zone traffic control to reduce delays and crashes,
- Identify “best practices” for the use of law enforcement to improve work zone safety,
- Identify key issues to be considered from public outreach and information systems.
- The identified work zone safety items will provide improvements for maximum protection of the motoring public, protection of exposed workers in the work zone and of workers in the set up of the work zone, and will meet the current standards established by internal policies of the NJDOT.

The research approach will include the identification of potential technologies and information systems, evaluation of the identified devices and systems with appropriate maintenance yards and crews, and the parathion of specifications and Baseline Document Change papers for adoption by the NJDOT. Potential technologies and information systems will be identified from the NJDOT New Technologies and Products database of approved and under evaluation products, Transportation Research Board and National Cooperative Highway Research Program reports, international sources, Strategic Highway Research Program reports, other State DOT correspondence, and manufacturers and vendors. The identified technologies and information systems will be researched to obtain users and technical information on their effectiveness.

PHASE II - RESEARCH APPROACH

Task 1: Develop a proposed methodology and criteria for measuring and evaluating the new technologies and information systems

With the guidance of the Research Project Selection and Implementation Panel, appropriate maintenance yards and crews will be selected to evaluate the selected technologies and information systems. As noted above, maintenance yards and crews will be selected based on the function of the yard and crew.

A research approach will be formulated to determine the guidelines for acceptance of the products and the evaluation criteria for the technologies and information systems. The selected technologies and information system should be evaluated for a 6 week period. Most technologies and systems have been thoroughly evaluated and reported in the literature. Such information may be sufficient for selection and than evaluation by maintenance. Other products such as the speed indicator boards have been tested but the RPSIP may determine that before and after speed studies are necessary for adoption. Such studies will be conducted under this study as required by the panel. In addition, the

presence of police at construction sites has been shown to reduce speed and provide a measure of assurance for the workers. Some DOTs have experimented with dummy police vehicles which may be applicable to maintenance work zones. Such systems may require traffic and speed analysis.

With the guidance of the Research Project Selection and Implementation Panel, As a major component of the evaluation, each crew will be provided with instructions for the operation of the technologies and information systems. The crews will be given survey sheets for the specific item to be evaluated. The research team will meet with the crews to instruct the crew in the product operation and meet with the crew to discuss the final assessment of the technologies effectiveness. The research team will not limit the number of technologies and systems for evaluation. However, the duration of the project is one which may limit the number of technologies and information systems that can be researched.

Task 2: Analyses of the Current NJDOT Practices for Short Duration and Mobile Work Zone Operations.

A short Term work zone is defined as an activity that requires traffic control, takes less than one period of daylight, and is not performed at night. A mobile work zone is defined as work occurring over a distance of 1000 feet during a fifteen minute period. In this context, the use of new technologies and information systems will be analyzed for incorporation into revised NJDOT maintenance practices with the assistance of NJDOT maintenance engineers. As new technologies and information systems are identified and evaluated on maintenance projects, the current NJDOT maintenance practices will be reviewed and compared to SHRP, TRB and state-of-the art practices by other State DOTs.

DATA COLLECTION

Methodology and Criteria for Measuring and Evaluating the New Technologies and Information Systems

The Texas Transportation Institute¹ conducted a survey of all state transportation agencies to obtain data on safety operations for mobile and short duration maintenance. Information, supporting materials and data were obtained from eighteen agencies. In addition to the survey responses, focus groups of Texas Department of Transportation field and supervisory personnel were assembled to identify hazards and to simulate new ideas and creative concepts that could improve worker and motorist safety through such work zones. The TTI investigators conducted field observations of eleven mobile and eighteen short duration maintenance operations in five districts of Texas.

The TTI survey results indicated the most significant hazards for all responding agencies were high speed traffic, and inattentive motorists which resulted in rear end crashes of safety vehicles and errant vehicles entering the shadow vehicle convey or the work area. Some state agencies approach the solution to these issues by incorporating advance warning devices in addition to the standard MUTCD safety. Such devices and solutions are:

- brighter or fluorescent signs on shadow vehicles,
- trail vehicles with speed display boards below the arrow panel,
- the use of better or additional lighting on shadow vehicles, such as solid light bars, blue lights, or light emitting diode(LED) lights,
- dynamic message boards in advance of the work area, and
- police to enforce traffic laws.

All of these devices provide the motorist with the optimum warning to reduce or eliminate crashes and improve worker safety.

The New York State Department of Transportation² maintains a work zone accident data base to track the causes of crashes in such areas. The annual

analysis of these data indicate that rear end accidents of construction and maintenance vehicles and rear end crashes of motorists by other motorists is the most common crash. Such crashes are indicative of speeding and inattentiveness by motorists. The New York State DOT has identified seven intrusion countermeasures for stationary, mobile and short duration work zones:

- reduced channelization spacing,
- enhanced flagger station,
- rumble strips,
- reduced speed limits
- police enforcement,
- dynamic message signs, and
- drone radar.

The Center for Transportation Studies³ at the University of Virginia studied the characteristics of work zones crashes for all types of work zones. The results indicate that rear end crashes are the predominate type of crash. Although no solutions were proposed in the scope of the study, it clearly indicated that speed and inattentiveness are contributing factors for such crashes.

Analyses of the Current NJDOT Practices for Short Duration and Mobile Work Zone Operations.

The researchers conducted field observations of mobile and short duration work operations to analysis and compare current maintenance work zone operations with the MUTCD and other agencies, as well as interviews with work zone safety personnel. The first group of field observations was conducted in Region South with personnel from the Bureau of Employee Safety.

The mobile pothole patching operation consisted of the automated pothole patching truck, two dump trucks with Truck Mounted Attenuators behind the patching truck, and the foreman's pickup truck ahead of the patching truck. The operation occurred on inside northbound lane of U.S. Route 130 in Haddon

Township. The operation is shown in Figure 1. A flashing arrow board, "Road Work Ahead" sign and a Scorpion TMA were mounted on the rear of both dump trucks. The dump trucks maintained proper distance between the potholing patching and traffic as the operation rounded curves and advanced in the straight roadway. A single warning sign was placed off the right shoulder some distance prior to the operation.

A sweeping operation consisted of the sweeper and a single dump truck on NJ Route 38 in Mount Laurel. The operation was in the right shoulder. The flashing light board and sign were similar to the previous operation. The sweeping operation is shown in Figure 2.

During the inspection of the above mobile operations, the NJDOT inspectors observed an electrical crew preparing for repair work at a traffic intersection. The electrical crew had not placed warning signs ahead of their parked vehicle, and failed to wear safety vests. The NJDOT inspectors discussed safety rules with the crew.

The second group of field observations was conducted in Region North with personnel from the Bureau of Employee Safety. The observations consisted of a litter pick up operation which consisted of a dump truck and dump truck with small TMA, and a landscape spraying operation with the truck mounted sprayer and a dump truck with a Scorpion TMA on Route I-280 in West Orange. Both operations were being conducted on the shoulder. This operation is shown in Figure 3. A second landscape spraying operation was observed on Route I-78, Scotch Plains in the insider shoulder. The operation consisted of the sprayer and two dump trucks each with a Scorpion TMA. The Shadow vehicles rode in the inside lane to protect the spraying vehicle with straddled the shoulder and lane. This is shown in Figure 4.



Figure 1. U.S. Route 130 Northbound Haddon Township Pothole Patching Operation.



Figure 2. NJ Route 38 Eastbound Right Shoulder Sweeping Operation in Mount Laurel



Figure 3. Landscape spraying operation on Route I-280, West Orange on the outside shoulder



Figure 4. Landscape spraying operation on Route I-78, on the inside shoulder.

A short duration work zone was observed on Route I-287, Basking Ridge. The operation consisted of a pothole patching crew that was filling a pothole with hot mixed asphalt. Three dump trucks with the Scorpion TMA were located behind two workers who were shoveling the material from a dump truck. A foreman's pick up truck was in front of the dump truck. The two workers were exposed to traffic for a distance of 40 feet between the attenuator truck and material truck. Traffic was backed up for a mile or more behind the operation and was moving slowing past the operation, which precluded taking pictures.

In interviews with the NJDOT personnel from the Bureau of Employee Support, it was noted that most work zone accidents in New Jersey are caused by errant motor vehicles. Few work zone intrusions or crashes are caused by trucks. In their opinion, these accidents at NJDOT work zones were caused by careless driving, speeding, and inattentiveness of the motorists to the work zone, other vehicles and signs. The personnel emphasized the importance of police for all work zone operation because police encourage motorist to reduce their speed.

The NJDOT personnel emphasized the importance of public education – outreach and safety programs – to inform the public on the importance of work zone safety, and the need to show that workers have families and need their considerations. Safety programs should include work zone safe driving instructions in driver's manuals, posters and education for truck drivers at rest stops, and CB notification for truckers and in-car notification for motorists in the event of a work zone. Such items will be discussed in subsequent working papers and tasks for this project.

NJDOT personnel suggested improved advanced warning such as signing ahead of the work zone, improved lighting such as LED, variable strobes, and arrow boards that "follow" traffic, and improved work zone planning to reduce conflicts between various maintenance operations.

CRITERIA FOR DEVICE FUNCTIONALITY IN MOBILE OPERATIONS

These evaluation criteria for certain devices will provide assistance in selecting appropriate traffic control devices for worker safety, and the safe and efficient movement of traffic through mobile and short duration work zones. From the devices and equipments identified in the literature report and, depending on the utility and effectiveness, the device functionality can be classified into five categories as follows:

Reduce exposure to the motorists/crew

Along work zones, the changing driver habits and traffic patterns cause safety concerns. The device should keep the road users and workers safe, while at the same time inhibiting traffic flow as little as possible. The ultimate goal of this criterion is to prevent worker injuries, motor vehicle accidents, and personal injury to motorists and/or pedestrians.

Warn motorists/crew to minimize likelihood of crash

Maintenance crews in short-term work zones have a frightening job. Short-term/mobile work zones present special challenges in providing safe conditions for work crews. In short duration or mobile work zones, which are only in one place for a short period of time, motorists have very little chance to develop any expectations about the presence or layout of the work zone. Workers must perform their repair work while on constant alert for drivers who disregard or fail to notice the warning signs to slow down. This study is attempting to identify devices that would effectively alert drivers to work zone conditions and motivate them to change the way they drive within the work zone. The traffic control devices should be able to warn as well as minimize the likelihood of crash in order to improve worker and driver safety.

Minimize severity of crashes once they occur

An effective traffic control device in a short-term work zone must be easy to set up and remove without compromising the safety of the workers. Even though no one device can eliminate all, crash severity can be minimized by using devices that could absorb the major impact and reduce exposure to workers. Truck mounted attenuators, crash cushions and balsa beam can serve as devices which satisfy this criterion. The devices should also provide sufficient visibility to gain driver attention.

Provide separation between work crew and traffic

Separating traffic from work activities by the use of temporary traffic barriers, shadow vehicles with truck-mounted attenuators, or similar devices minimizes risk for both workers and travelers. The need for positive separation should be based on work zone factors including:

- Traffic speed and volume
- Distance between workers and traffic
- Duration and type of work operations
- Physical hazards present

Improve work zone visibility/presence

Visibility issues for motorists approaching and driving through highway work zones is a major concern. Ninety percent of a driver's reaction depends on vision, and vision is severely limited at night or in inclement weather conditions. Depth perception, color recognition, and peripheral vision are all compromised after sundown. Conditions such as fog, rain, snow and dusk also hinders visibility to drivers, therefore decreasing worker safety. Therefore it is important to provide good visible traffic control devices and sufficient lighting to the work zones.

Traffic control devices and delineation treatments need to be effective in meeting the needs of motorists on various types of highway facilities under various traffic and lighting condition. Lighting should be used on traffic control devices such as

flashing lights or arrow panels. Glare must be controlled so as not to interfere with the visibility of the work zone by drivers and workers.

The work area and its approaches should also be lighted to provide better visibility for drivers to safely travel through the work zone. Illumination should be provided wherever workers are present to make them visible.

The summary of the criteria and initial device performance are shown in Table 1.

Table 1. Showing criteria satisfied by selected work zone devices/equipment

WORK ZONE DEVICE	CRITERION				
	1	2	3	4	5
Truck Mounted Attenuator	Yellow	Green	Yellow	Yellow	Green
Vehicle Intrusion Alarm	Red	Green	Yellow	Red	Red
Rumble Strips	Red	Green	Red	Red	Red
All Terrain Sign and Stand	Red	Green	Red	Red	Yellow
Directional Indicator Barricade	Red	Green	Red	Red	Green
Flashing Stop/Slow Paddle	Red	Green	Red	Red	Green
Opposing Traffic Lane Divider	Red	Green	Red	Red	Yellow
Queue Detector	Yellow	Green	Red	Red	Yellow
Remotely Driven Vehicle	Yellow	Green	Yellow	Yellow	Green
Portable Crash Cushion	Yellow	Red	Green	Yellow	Red
Cone Shooter	Green	Red	Yellow	Red	Yellow
Pavement sealers	Green	Red	Yellow	Yellow	Yellow
Debris Removal Vehicle	Green	Red	Red	Green	Yellow
Balsi Beam	Green	Yellow	Green	Green	Yellow
Robotic Highway Safety Marker	Green	Red	Red	Yellow	Red

Does not satisfy
 Partly Satisfy
 Fully Satisfy

From the above table it is seen that none of the devices fully satisfies the entire five criteria. But devices such as Truck mounted attenuator, remotely driven vehicle, and Balsi beam at least partly satisfies all the criteria.

CRITERIA FOR EVALUATION OF THE EFFECTIVENESS OF DEVICE

Before and after accident studies, and before and after traffic studies are important tool for evaluating the cost effectiveness and the general effectiveness for reducing crashes, speed and improve driver attentiveness as they go through work zones. However, such studies are costly and time consuming, and furthermore, most devices have been evaluated for such effectiveness by other agencies and manufacturers. Unless the NJDOT has unique traffic and motorists' behavior, this study will use existing agency studies and manufacturers to develop an approval process for selected devices and NCHRP testing data from the manufactures for NJDOT approval of devices.

With the assistance of the NJDOT's project advisory committee, the researchers will select and purchase specific devices for testing by selected maintenance crews. The crews will be surveyed by the researchers for their perception of the effectiveness of the new devices. The crews will evaluate the devices for their ease of set-up and handling, perceived cost effectiveness, apparent reaction by traffic, need for training in the use of the device and maintenance frequency. The researchers will provide surveys to the crews and follow-up with personal interviews. In addition, surveys will contain information on the device's functionality, such as visibility for motorists, minimization of crash severity for exposed workers, ample warning for crews in the event of a vehicle intrusion, and reduction of worker exposure.

CONCLUSIONS AND RECOMMENDATIONS

Based on the literature search and field inspections of mobile and short duration work zones, interviews with NJDOT personnel and the literature search of the cause of work zone accidents, the following conclusions and recommendations are presented:

- Most NJDOT work zone crashes and accidents are caused by careless driving, speeding and motorist inattention which are similar to the causes of crashes in work zones from the literature and other agencies.
- NJDOT mobile and short duration work zones meet of the safety standards for design and application specifications for traffic control during highway maintenance by *Manual on Uniform Traffic Control Devices* (MUTCD).
- Safety devices should be selected to reduce traffic speed through work zones, improve motorists' recognition of work zone hazards, and improve motorists' attention to signs and the work zone.
- Any new safety devices for mobile and short duration work zones should be implemented in conjunction with worker safety training, and public safety and education programs.

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APPENDIX

Proposed Survey of new work zone safety devices.

New Device or technology: _____ Date _____

Ease of set-up and handling:

Perceived cost effectiveness:

Apparent reaction by traffic:

Need for training in the use of the device:

Maintenance frequency :

Functionality

Reduce exposure to the motorists/crew:

Warn motorists/crew to minimize likelihood of crash:

Minimize severity of crashes once they occur:

Provide separation between work crew and traffic:

Improve work zone visibility/presence: