Variable Speed Limits in Work Zones

Summary of Uses and Benefits

About

The ENTERPRISE Pooled Fund Program initiated a project to document the resources available as well as uses and benefits regarding variable speed limits in work zones. A detailed literature search was conducted to summarize work zone materials available related to variable speed limit technologies. In addition, intelligent work zone (IWZ) representatives from transportation agencies were contacted to provide details on recent related deployments and provide input to the project.

The purpose of the project was to understand the current status of work on IWZ activities by combining the resources gathered through a literature search with the information collected from the transportation agencies on recent deployments. Also included is a summary of variable speed limits in work zones including examples of successes, any guidance possible when technologies are most effective, and the configurations that demonstrated the best results.

While this summary is focused on variable speed limits in work zones, it is important to note that similar summaries were also developed by ENTERPRISE for dynamic merge systems, information describing conditions on alternate routes through work zones; and queue warning systems within work zones. These summaries are available on the ENTERPRISE Project Webpage.

Definition

Variable speed limit technology in work zones typically consists of sensors, Portable Changeable Message Signs (PCMS), and a processing system that calculates the speed limits to be displayed on the PCMS based on measured speed and/or volume data. As congestion begins to form, the PCMS are activated to provide drivers with a safe speed limit through a work zone and to minimize braking as they approach the queue.

VSL Sign installed near Hwy 61 in Minnesota

Resources

The following table includes resources that were reviewed related to variable speed limits. Information was gathered from available online resources (e.g. published reports, agency web pages, news articles) or through coordination with transportation agencies that have deployed variable speed limit systems. For those projects that an online hyperlink was not available, a brief summary of the information gathered for the project is provided at the end of this document.

Variable Speed Limit Related Resources

State/Resource	Report/Deployment Project Summary
Florida	• Online Resource: Evaluating Variable Speed Limits and Dynamic Lane Merging Systems in Work Zones: A Simulation Study[1] (2012) -Study simulating a two-to-one work zone lane closure configuration under different Maintenance of Traffic (MOT) plans and comparing work zone throughputs and travel times across MOTs including early and late Dynamic Lane Merge and VSL combinations. • Online Resource: Implementing Variable Speed Limits in Florida[2] (2007) - Study on plans for Florida that called for the implementation of variable speed limits.
Kansas	• Deployment Summary: I-35/Homestead (2013)
Michigan	• Online Resource: Field Test of Variable Speed Limits in Work Zones[3] (2003) - Report objective was to design and deploy a viable VSL system in a work zone and evaluate the extent to which: speed limit compliance is affected; and how safety as well as traffic flow is improved.
Minnesota	• Online Resource: Field Evaluation of Variable Advisory Speed Limit System for Reducing Traffic Conflicts at Work Zones [4] (2006) - Evaluated effectiveness in reducing traffic conflicts and improving operational efficiency at a work zone on I-494. • Online Resource: Minnesota IWZ Toolbox[5] (2008) - Minnesota strategies for using ITS in work zones and when to appropriately select IWZ systems.
Nebraska	• Report Summary: Evaluation of Work Zone Speed Advisory System (WZSAS)[6] (2001) - Evaluation study to assess the effectiveness of WZSAS in encouraging traffic diversion when there is congestion in the work zone and its applicability as a traffic management tool.
New Jersey	• Deployment Summary: Turnpike 6-9 Widening Project (2013)
Smart Work Zone Deployment Initiative (SWZDI)	• Online Resource: Evaluation of Variable Speed Limits in Work Zones[7] (2013) - Study and evaluation of VSL and Variable Advisory Speed Limit systems and recommendations based on the case studies investigated.
Street Smart Rental	• Online Resource: VSL Deployment Criteria Considerations[8] - Short webpage on deployment criteria and anticipated system effects of variable speed limits.

Texas	• Online Resource: Summary of Treatments to Improve Work Zone Speed Limit Compliance[9] (2005) - Project to determine effective measures to motivate and encourage drivers to observe posted speed limits in work zones.
USDOT Federal Highway Administration	• Online Resource: Work Zone Intelligent Transportation Systems Implementation Guide[10] (2014) - Document to provide guidance on implementing ITS in work zones to assist public agencies, firms, developers, etc. • Online Resource: Work Zone Public Information and Outreach Strategies[11] (2005) - This guide is designed to help transportation agencies plan and implement effective public information and outreach campaigns to mitigate the negative effects of road construction work zones. • Online Resource: Examples of Variable Speed Limit Applications[12] (2000) – Transportation Research Board (TRB) Speed Management Workshop that discusses domestic and foreign examples of VSL applications.
Utah	• Report Summary: Evaluation of the Effectiveness of Variable Advisory Speed System (VASS) on Queue Mitigation in Work Zones[14] (2012) - Study objective was to perform a statistical analysis on performance data to evaluate VASS effectiveness on queue mitigation. • Report Summary: VSL Signs Effects on Speed and Speed Variation in Work Zones[15] (2008) - Research tested the compliance and derived potential advantages from the use of variable speed limit equipment.
Virginia	• Online Resource: Work Zone Variable Speed Limit Systems: Effectiveness and System Design Issues[16] (2010) - Study recommends that Virginia DOT pursue VSL technology, but carefully scrutinize algorithm design and VSL sign placement, and a cost/benefit analysis indicates that VSLs may be most appropriate for long-term applications.

Benefits

There are a number of benefits from the deployment of variable speed limit technology in work zones. If the VSL is deployed far enough ahead of the work zone, it can reduce crashes that could occur as drivers approach the back of the queue. Another benefit of VSL systems is to reduce congestion and ease traffic through a work zone depending on current conditions.

If properly designed, VSL systems have shown to also reduce system travel time through increased uniformity in traffic speeds. A field evaluation conducted by the Minnesota DOT on a VSL System, Field Evaluation of Variable Speed Limit System for Reducing Traffic Conflicts at Work Zones a VSL system[4], in a work zone found that the reduction in speed difference resulted in approximately a 7% increase of the total throughput volume measured.

As another example, according to a study conducted by Utah DOT, VSL Signs Effects on Speed and Speed Variation in Work Zones[15], both the average speed and variation in speeds were reduced by providing drivers real time speed limit information which reacted to the construction conditions in the field.

Typical Use

According to the USDOT FHWA Work Zone ITS Implementation Guide[10] variable speed limit displays should be considered for deployment when any of the following conditions are anticipated:

- Frequent planned lane closures are expected, which will create queues that cause high speed differentials between queued and approaching traffic
- Work activities that will frequently occur for which lower speed limits would be beneficial to have on a temporary basis
- Traffic speeds through the project vary widely due to overstautrated conditions during the peak period, and the timing and extent of congested travel will vary significantly day to day

For example, the Minnesota IWZ Toolbox[5] suggests considering deploying speed information when the work zone will cause additional travel time and the work zone queue is estimated to slow traffic at least 20 mph below the posted speed limit.

A Field Test of VSL in Work Zones In Michigan[3] concluded that a VSL system may have more utility in longer and "simpler" work zones (e.g. long zones with relatively short active work areas).

Typical System Components

Variable speed limit technology in work zones typically consist of sensors and PCMS and are used in conjunction with other ITS technologies. In addition, weather information and road surface condition technology may also be utilized to calculate the appropriate speeds that a driver should be traveling in work zones. The VSL system identifies the average speed of downstream traffic through the sensors and then provides the upstream traffic with an optimum speed to approach the queue.

Sign Messages

There are a variety of messages and signs that may be used to display a safe speed limit to drivers. One example is a static sign used in a Minnesota field evaluation, Field Evaluation of Variable Advisory Speed Limit System for Reducing Traffic Conflicts at Work Zones[4], which states, WATCH FOR SLOW TRAFFIC AHEAD, with a variable changeable message sign to display the speed limit. Another example as shown bleow includes a sign alerting drivers to the beginning of a VSL Zone and a VSL sign posted in a work zone in Virginia, Work zone VSL Systems: Effectiveness and System Design Issues[16].

VSL Alerting Drivers to the Beginning of VSL Zone in Virginia

VSL Sign Posted in a Work Zone in Virginia

Compliance

One of the difficulties of implementing VSL is motivating drivers to comply with the traffic regulations within a work zone. Providing more accurate and real time speed restrictions based on the level of construction activity can offer more information to motorists and can encourage drivers to comply with the posted speed while improving safety in the work zone.

The USDOT's Guidelines on Managing Speeds in Work Zones[13] states that "drivers reduce their speeds through the work zone only when they perceive a need to do so, based on conditions in the work zone or the perception of enforcement activities."

The potential voluntary speed reduction in a work zone with a reduced speed limit sign is 0 to 3 mph where operating speeds upstream of the work zones ranged from 60 mph to 77 mph. When normal operating speeds on the roadway are high, these voluntary speed reductions alone may not reduce driver's speeds through a work zone. Drivers reduce their speeds through the work zone only when they perceive a need to do so, which is based on the conditions in the work zone or the perception of enforcement activities.

While there are a wide variety of available improvement methods for work zone speed limit compliance, implementing these treatments appropriately, along with consistent presentation of realistic work zone speed limits, can help motivate drivers to comply, which can reduce speeds and improve safety conditions for workers and drivers. The USDOT's Guidelines on Managing Speeds in Work Zones[13] also recommends that other speed management technologies can be used to encourage compliance if law enforcement is not available, such as speed display trailers; PCMS with radar; citizen band radio information systems; transverse rumble strips; drone radar; narrowing lanes with channelizing devices; and transverse pavement markings.

According to the Texas Department of Public Safety documented in a study from the Texas Transportation Institute, Summary of Treatments to Improve Work Zone Speed Limit Compliance[9]9, more than 9,500 crashes occurred in work zones on the state highway system in 2000 and speed was cited as a contributing factor in approximately 42 percent of these crashes. State's procedures for improving compliance vary widely but enforcement, flagging, speed display trailers, and changeable message signs consistently have shown measureable positive results. The study also found that to avoid work zone speed limits that are ignored or disobeyed, limits should be posted at realistic values and should be confined as much as possible to the specific area where the work is taking place.

Public Outreach

FHWA developed a guide, Work Zone Public Information Outreach Strategies[11], to help transportation agencies plan and implement effective public information and outreach campaigns to mitigate the negative effects of work zones. It may benefit the project and lead to improved compliance rate if the public is educated on the benefits of VSL through a work zone construction project prior to the start of the construction.

Contracting

There are many different contracting options for IWZ projects. Some projects may include the IWZ component as a bid item in an overall construction project and some projects may retain an IWZ vendor with a standalone contract.

In the USDOT FHWA Work Zone ITS Implementation Guide[10], an overview of procurement approaches (direct or indirect) are provided as well as information to consider to determine the procurement award mechanism, issuing a request for proposals, and selecting the preferred vendors, consultant or contractor.

Variable Speed Limit System Deployment Examples

Following are variable speed limit system deployment example project summaries.

Variable Speed Limit Deployment Summary: I-35 Smart Work Zone – Kansas City, Kansas

The project on I-35 required the construction of a new interchange. The goals of the project were to retain equipment at the conclusion of the project and improve safety and reduce congestion. Technologies used included 18 PCMS, 6 portable cameras, 21 portable traffic sensors and 8 portable VSL signs. A low bid contract was utilized and a low bid vendor was tied to the construction project.

Variable Speed Limit Deployment Summary: Turnpike 6-9 Widening Project – New Jersey

During 2010 to 2013 a 25 mile segment of the Pennsylvania Turnpike was widened from 6 lanes to 12 lanes under 14 separate contracts. The goal of the project was to provide a turn-key temporary ITS replacement systems from the New Jersey Turnpike's old legacy system of Variable Message Signs and Variable Speed Limit Signs. Technologies used included 27 portable VSL signs, 31 PCMS and 25 traffic sensors. All temporary devices were managed from the NJTPAN/NJDOT TMC headquarters, but operated automatically based on prevailing downstream traffic conditions.

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