Deployment and Evaluation of ITS Technology in Work Zones

Authors:

Rob Bushman, P.Eng.
University of Saskatchewan
Saskatoon, Saskatchewan, Canada
e-mail: rjb230@mail.usask.ca
phone: (306) 653-6600
fax: (306) 242-5599

Rod Klashinsky
International Road Dynamics Inc.
Saskatoon, Saskatchewan, Canada
e-mail: rod.klashinsky@irdinc.com
phone: (306) 653-6613
fax: (306) 242-5599

ABSTRACT

Highways in rural areas where construction work is taking place experience many of the same traffic problems that are being experienced by large urban areas such as congestion, delays, aggressive driving, and road rage. The effects may be felt even more in construction areas since the problem is concentrated in a smaller area and takes place in locations where motorists are accustomed to a greater degree of mobility. In 2001, more than 1000 fatalities occurred in work zones, with many occurring in the transition area leading up to the actual construction site. Just as ITS is being applied to relieve traffic problems in urban areas, ITS technology is also being used in work zones to provide smoother, safer, and more efficient traffic flow.

The Lane Merger system is one example of ITS technology designed specifically for work zone applications. When construction forces the reduction from two lanes to one lane, drivers are forced to merge into a single lane. Some aggressive drivers stay in the lane that is closed until the final taper before merging into the continuous lane where flow is often uneven, entrance gaps are small, and drivers in the continuous lane are less inclined to cooperation. The result is increased accident potential, disruptions in traffic flow, driver irritation, and increased delays for drivers in the continuous lane. The Lane Merger creates a dynamic “No Passing” zone in advance of the construction area that advises motorists to merge early. The system changes as traffic condition changes so that it is always relevant to the current driving conditions.

A study recently completed by Wayne State University in Michigan showed that the Lane Merger was beneficial in reducing aggressive driving, reducing travel time delay, and decreasing traffic stops and duration of stops. It was also shown to have a favorable benefit to cost comparison.

The Lane Merger is one example of ITS in work zones that has been developed, deployed, and proven successful. Other applications have also emerged such as variable speed limit and travel information systems that provide regulations and information that are based on the current conditions and are relevant and believable to drivers.

INTRODUCTION

Traffic engineers across North America are facing a challenge to meet the ever increasing demand for use of the transportation infrastructure to provide safety and mobility to motorists. The cost of congestion has continued to rise with a recent estimate by Texas Transportation Institute now estimating that lost time and fuel due to congestion in only the major urban centres of United States cost approximately $67.5 Billion. (1) This has led many transportation agencies to apply innovative Intelligent Transportation Systems (ITS) technology such as freeway management systems, congestion pricing, and interoperable payment systems across various travel modes.

The challenge of safety and mobility is also an issue in work zone areas as road repair and construction intensify the issues and focus them in very concentrated areas. A stretch of highway, either in urban or rural areas, that is normally safe and relatively free of congestion can experience the same safety and mobility issues as major urban freeways. Construction zones may actually experience more intensive problems than urban freeways because motorists are accustomed to smooth traffic flow in these areas prior to construction taking place while in urban areas congestion is an expected occurrence for many motorists. The cost of traffic delays caused by construction activities can exceed $50,000 per day on many urban freeway projects. (2)

Accidents in and around work zones account for approximately 2.5% of all accidents that occur on the highway system. Annually more than 40,000 accidents and 1000 fatalities occur in construction areas. (3) In terms of total highway miles this is a disproportionately high number and reflects the concentration of safety issues at construction sites. Two of the contributing factors to this increase in accidents are the aging highway infrastructure which requires more maintenance to sustain an acceptable level of service and the increasing travel demand.

In the State of Michigan there have been approximately 10 work zone related deaths per year over the last 5 years, which is approximately 1% of the national total. (3) Michigan has taken seriously the problem of work zone safety by using both legal and technological approaches. Michigan became the first State to introduce legislation that increases criminal penalties for injuries and deaths caused in work zones compared to traffic accidents on other parts of the highway system with penalties of up to 15 years in prison for causing a fatality and up to 1 year for an injury causing incident. Michigan has also introduced several innovative solutions to apply ITS technology and principles to improve the safety and mobility of work zones. In 2000 Michigan introduced the use of the dynamic lane merge system and based on positive results continue the expansion of the use of this technology. In 2002 Michigan was one of the first in North America to introduce an automated Variable Speed Limit (VSL) and also deployed a portable real time information system.

MERGING TRAFFIC AT WORK ZONES

A high percentage of work zone related accidents occur in the transition area prior to the actual construction area. In the transition area traffic must change from multi-lane free flow conditions to restricted speeds and reduced lanes. Difficulties in making this transition results in a higher distribution of rear end and side swipe occurrences in work zone accidents than non-work zone accidents. (4)

One of the reasons for the increase in side swipe incidents is the lane change and merge that must occur when a lane is closed. As traffic approaches an area with a lane restriction, some vehicles will merge into the single continuous lane and proceed in an orderly fashion through the work zone. However, aggressive drivers will frequently stay in the dropped lane until the last moment in an attempt to get further ahead in the queue. They must then perform a dangerous merge maneuver in congested traffic with limited time and space available.

There are at least three problems that arise from this kind of action. First, there is the risk of accident during the actual lane merge itself since there are few openings in the continuous lane for a vehicle to merge and aggressive driving is often involved. Secondly, if the lane merge is successfully completed, it has likely disrupted the flow of traffic. Someone has had to slow down or stop in order to create an opening for the incoming vehicle, forcing all vehicles behind to adjust speed as well. As the number of traffic disruptions increases, so does the potential for rear-end accidents and other incidents. The third aspect is the perception and attitudes of drivers. Drivers who pass a waiting line of traffic in the continuous lane and then make a merge into the front of the line obtain an unfair time saving over those who stay in the continuous lane. This increases the impatience, anxiety, and anger level of many who must now wait longer. These feelings will linger and may affect the driving habits and aggressiveness of drivers further down the road and divert their focus away from safe driving.

DYNAMIC LANE MERGER

In response to traffic safety and mobility concerns related to aggressive driving and late lane merges, International Road Dynamics worked with Indiana Department of Transportation to develop and deploy a Dynamic Lane Merger System.

Motorists may be discouraged from attempting to enter the continuous lane at the taper location by creating a no-passing zone in advance of the construction zone. This will move all vehicles into the continuous lane before the final merge point, avoiding many of the problems discussed earlier. However, the traffic volumes and congestion will vary greatly throughout the day at the construction zone. As a result, the point at which vehicles can be moved smoothly into a single lane will also vary greatly during the day. As congestion increases and the queue in the continuous lane lengthens, the opportunity for smooth lane changes moves further back from the taper area.

The Dynamic Lane Merger is designed to automatically react to the changing queue length and flow conditions and adjust the length of the no passing zone. As congestion occurs at a certain point, the no passing zone must be moved upstream of this point to provide vehicles with time and space to merge while traffic is still moving and there are sufficient openings. The dynamic no passing zone is created by using a series of trailer mounted traffic signs with flashing beacons. These signs contain the message "LEFT LANE DO NOT PASS WHEN FLASHING". The entire sign and message is in conformance with the MUTCD standards. By turning the beacons on or off, the length of the no passing zone can be adjusted to match the traffic flow characteristics so that it is meaningful and relevant to the motorist and appropriate for the conditions.

The equipment for each control station is mounted on a small trailer so that it is portable. This allows the system to be moved at a site as construction progresses or moved to another site with relative ease. Each control station is equipped with a static sign and flashing beacons. Each station, except the one furthest upstream, is also equipped with a non-intrusive traffic monitoring device to detect vehicle volume, occupancy, and speed.

The information from the sensor is processed to determine the congestion level at that particular point. If congestion is detected a signal will be relayed by radio frequency (RF) communication to the next upstream station. The sign at the upstream station will be activated to extend the no passing zone.

Figure 1: Dynamic Lane Merger Deployed On I-69 Near Lansing, Michigan

EVALUATION OF DYNAMIC LANE MERGER SYSTEM

In December 2001 the final report of an evaluation of the use and effectiveness of the Dynamic Lane Merger system was released by Wayne State University and the Michigan Department of Tranpsortation. The Dynamic Lane Merger was deployed at six different locations through the 2000 and 2001 construction seasons. In Phase I of the study which took place in 2000, the focus was deployment issues and approaches to determine an effective configuration to provide clear and positive guidance to motorists. In 2001 the second phase of the project was conducted to determine the effectiveness of the system in improving traffic flow and reducing aggressive driving.

Data was collected for each test condition using the floating car method where a driver and a timer travel through the work zone with at least 15 runs conducted under each condition. In addition, the location and duration of any stopped time delay through the advanced warning area were recorded along with any observations of aggressive driver behavior.

The general conclusion of the evaluation was that the Dynamic Lane Merger "Can be very helpful in reducing aggressive driver behavior, increasing safety and reducing delay at work zones where lane closures are necessary."

Specific findings of the evaluation included the following:

- The average peak period travel time decreased by over 30% resulting in time savings for drivers.

- The average number of stops and duration of stops were decreased, reducing fuel consumption and emissions.

- The number of aggressive driver maneuvers (late merges) during peak hours were reduced by 50-75%, reducing the potential for accidents and road rage

- Driver understanding through education and awareness, supplementary signing, and enforcement is important for overall effectiveness. Police enforcement has a positive impact on reducing aggressive driving.

- Deployment of the Lane Merger will be economically beneficial and achieve B/C ratios greater than one, if a value of time of $3.80 per person hour is assumed for travel time savings.

- The Lane Merger has been shown effective for reduction from two lanes to one lane with either a right lane or left lane closure, and may also be applicable for reductions from three lanes to two lanes. (5)

OTHER APPLICATIONS OF ITS TECHNOLOGY TO WORK ZONES

In 2002 Michigan continued its deployment of Work Zone ITS technology with the deployment of a variable speed limit (VSL) system and a real time information system, both supplied by IRD.

VARIABLE SPEED LIMIT SYSTEM

The VSL is designed to manage the speed of traffic approaching and traveling through work zones based on the current traffic conditions as well as the current status of the construction site. Static speed reduction signs are often ignored by drivers because they are seen as irrelevant, either because traffic volumes are low and traffic is flowing freely, or because there is no construction activity occurring at the site. When the site is active and higher traffic volumes exist, the transition from high speed free flow traffic conditions to slowed or stopped traffic can be a potentially dangerous situation.

The VSL consists of a series of portable trailers with traffic detection capabilities similar to the Lane Merger. However, rather than directing vehicles to change lanes, the VSL displays the current posted speed limit for that section of highway. The speed limit to be displayed is automatically determined by the system based on the activity level of the work zone, current traffic characteristics, and road conditions such as rain or ice.

The Federal Highway Administration has initiated a project to examine the effectiveness of VSL systems in work zones. In 2002 Michigan DOT and Michigan State University deployed a VSL system under various work zone configurations to gather data that is being used in the evaluation of the effectiveness of this approach to work zone traffic management. Some of the measures used to determine the effect of the system on traffic flow include speed, speed variance, speed limit violation, and travel time. Analyis is still underway to determine the significance of results, but there is indication that the system may reduce travel time and may reduce the percentage of vehicles exceeding 60 mph and 70 mph.

REAL TIME INFORMATION SYSTEM

Also in 2002 Michigan DOT deployed a real time information system to provide messages to motorists of traffic conditions ahead. The system includes a number of data collection trailers using non-intrusive traffic sensors to measure traffic flow approaching and traveling through a work zone. Based on the measured conditions estimated travel times are determined and displayed for motorists on portable changeable message signs in advance of the work zone. Also displayed to the motorist is the physical distance to the end of the work zone. While no formal evaluation was conducted, observations of the operation of the system indicated that the system performed the necessary functions to provide accurate and timely information to motorists.

By providing this type of information to motorists, some of the anxiety and impatience caused by work zone delays may be reduced. The information also gives back to motorists a small measure of control over their situation so they can make an informed decision on whether to continue through the work zone or choose an alternate route. By reducing anxiety and increasing driver control, the information system facilitates motorists focusing their attention on driving safely.

In addition to the driver benefits the travel information system may also have a direct impact on congestion and delay. Informing motorists in advance of the work zone of the delays ahead, especially long delays, will result in some of the motorists choosing alternate travel routes thus reducing demand through the work zone and decreases the delay for subsequent motorists through the work zone.

CONCLUSION

As traffic continues to increase on the highway system and maintenance and construction activities are needed to ensure a reliable highway infrastructure, safety and mobility in work zone areas will continue to be a concern. The cost of maintaining the highway infrastructure in terms of delay costs, injuries and deaths warrant continued attention to finding new and better ways to manage traffic through work zones.

Just as ITS technology is being applied in many urban freeway settings to address traffic concerns there are technologies emerging that can be applied specifically to work zone situations. The dynamic lane merger system has been evaluated in Michigan and has been shown to reduce traffic delay time, reduce traffic stops, and reduce aggressive lane change maneuvers. Other systems such as variable speed limit and real time information also show promise to improve the safety and efficiency of traffic flow through work zones.

ACKNOWLEGEMENTS

The projects discussed in this paper are based on the implementation of work zone ITS systems by Michigan DOT. Results of the evaluation are drawn from an extensive evaluation and report conducted by Wayne State University.

References

1. D. Schrank, T. Lomax, 2002 Urban Mobility Study, (College Station, TX, Texas Transportation Institute) p.20
2. FHWA?? - $50,000
3. Fatality Analysis Reporting System, National Center for Statistics and Analysis, National Highway Traffic Safety Administration, US Department of Transportation
4. Work Zone Facts at a Glance, Oregon Department of Transportation, www.odot.state.or.us/transafety/Workzone.htm
5. T. Datta, K. Schattler, C. Hill, Development And Evaluation Of The Lane Merge Traffic Control System At Construction Work Zones, (Detroit, MI: Wayne State University Department of Civil and Environmental Engineering, 2001) pp. 38-39