

Safety Effects of a Work Zone Intelligent Transportation System

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Abstract

Over the last few years, work zone safety has become an issue of increasing concern for transportation agencies and the public in North America. Intelligent Transportation Systems (ITS) technologies applied in work zones, commonly referred to as Smart Work Zones, have the ability to monitor real time traffic conditions approaching the work zone. Portable roadside signing is used to advise drivers of reduced speeds ahead and expected delays, as well as suggesting the use of alternate routes. The primary purpose of the ITS work zone safety system is to reduce delays and queues, reduce driver frustration and increase driver awareness and comfort of upcoming conditions.

A Smart Work Zone was deployed on a construction project on Interstate 95 in North Carolina in 2003. Crash occurrences with and without the Smart Work Zone operating from April 29th to September 30th, 2003 were considered. Results indicate that the time between crash events does not follow a normal distribution and is highly

variable. Due to the limited number of crash occurrences and the variability of time between crashes no conclusive results could be drawn. Although no conclusions were drawn the frequency and variability results may be useful for the experimental design to determine appropriate study approaches and periods to obtain significant results in future evaluations.

Résumé

Depuis ces dernières années, la sécurité en zone de travaux est devenue un problème d'une inquiétude croissante pour les compagnies de transport et la population d'Amérique du Nord. Les technologies Systèmes de Transport Intelligent (STI), appliquées en zones de travaux et communément appelées Zones de Travaux Astucieuses, ont la capacité de contrôler en temps réel les conditions du trafic approchant la zone de travaux. Un panneau de signalisation portatif en bord de route est utilisé pour aviser les conducteurs que les vitesses sont réduites en avant et que des retards sont attendus, leur suggérant alors d'utiliser d'autres itinéraires. Le principal objectif des systèmes STI liés à la sécurité en zone de travaux est de réduire les retards et les files d'attente des véhicules, réduire le mécontentement du conducteur, et développer la sensibilisation et le confort de ce dernier face aux conditions routières à venir.

Une Zone de Travaux Astucieuse a été déployée lors d'un projet de construction sur l'Autoroute 95 en Caroline du Nord, en 2003. Des données relatives aux accidents furent prises en compte, avec et sans la Zone de Travaux Astucieuse opérant entre le 29 avril et le 30 septembre. Les résultats indiquent que le temps entre l'occurrence des accidents ne suit pas une distribution normale et varie beaucoup. Dû au nombre limité d'accidents et à la variabilité du temps entre les accidents, aucun résultat concluant n'a pu être formulé. Bien qu'aucune conclusion n'ait été établie, la fréquence et la variabilité des résultats peuvent être utiles pour la conception expérimentale pour déterminer des approches et périodes d'étude appropriées en vue d'obtenir des résultats significatifs dans des évaluations à venir.

Introduction

An efficient and well maintained transportation system is a key component of a healthy economy and standard of living. Unfortunately, maintaining transportation infrastructure is costly in dollars and in significant personal suffering and loss of life, as every year more than 1000 people are killed in work zone related crashes and thousands more are injured in North America.

Agencies are now beginning to deploy Intelligent Transportation Systems (ITS) to improve safety and efficiency of travel through and around work zones. ITS can be used in work zones to monitor and manage traffic, provide traveller information, manage incidents, enhance safety, increase capacity, plan future work zones, and enhance enforcement (Federal Highway Administration¹).

The focus of this study is specifically on the safety aspects of deploying ITS in work zones. A summary of previous research regarding the effects of work zone safety systems is presented. New research from a field deployment of work zone ITS is then presented, including the methodology and results. This study is based on the use of a Smart Work Zone system on I-95 in North Carolina during the 2003 construction season.

Technology and Safety in Work Zones

The application of ITS technology to work zones, commonly referred to as a Smart Work Zone is one that is still emerging and developing. References to the use and evaluation of portable traffic management systems date back to 1995 (SRF Consulting Group Inc.²). The basic goals of deploying ITS technology are to improve safety and mobility by providing accurate and timely information to drivers to guide them more efficiently through work zones.

A Smart Work Zone typically consists of a number of data collection trailers using non-intrusive traffic

sensors to measure traffic flow approaching and travelling through a work zone.

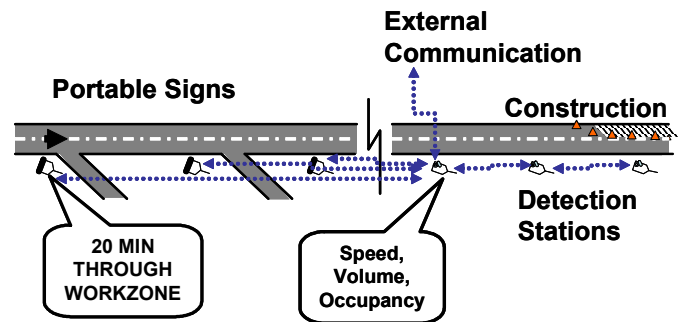


Figure 1 Typical Smart Work Zone Layout

As seen in Figure 1, motorists are provided with advisories of current conditions, and in some cases recommended alternate routes, based on the measured conditions. Travel time and alternate route advisories are posted on portable changeable message signs in advance of the work zone. Information on current conditions is often available from a publicly accessible information web-site which may show graphically a map page and camera images from the site (Bushman and Berthelot³).

Research conducted in Ohio examined collisions on the approach and through work areas to determine the link between characteristics of the work zone and the number of crashes that occur within the work zone (Tarko and Venugopal⁴). The result was a prediction model that can be used to determine expected crash rates approaching the work area and in the work area based on various input parameters including project duration, project intensity, traffic volume, project length, and closure type. However, this prediction model did not consider the type of traffic control used and therefore does not provide information on the impact of ITS in work zones.

Previous research was conducted in Arkansas on a Smart Work Zone system which provided travel time information (Tudor, Meadors, and Plant⁵). The crash rate at the site with the Smart Work Zone was compared with two other control sites with similar

characteristics, using collisions per 100 million vehicle miles traveled as the unit measure. The fatality rate was 2.2 for the site with a Smart Work Zone, compared to 3.2 and 3.4 at the sites without a Smart Work Zone, an average reduction of 33 percent. The rate of rear-end crashes was 33.7 per 100 million vehicle miles traveled for the site with a Smart Work Zone, compared to 29.5 and 43.2 at the sites without a Smart Work Zone, an average reduction of seven percent.

A Dynamic Lane Merger system was evaluated by Wayne State University and the Michigan Department of Transportation (Datta, Schattler, and Hill⁶). The Dynamic Lane Merger is an application of ITS, but differs from the description of a Smart Work Zone provided earlier in that it directs drivers to merge earlier when a queue develops in advance of a work zone. The number of aggressive driver manoeuvres (late merges) during peak hours was reduced by 50 to 75 percent, thereby reducing the potential for crashes.

Safety Assessment of I-95 Smart Work Zone Deployment

During the 2003 construction season, North Carolina Department of Transportation deployed Smart Work Zone systems on several projects, including a resurfacing project on Interstate 95 in the vicinity of Rocky Mount, as illustrated in Figure 2.

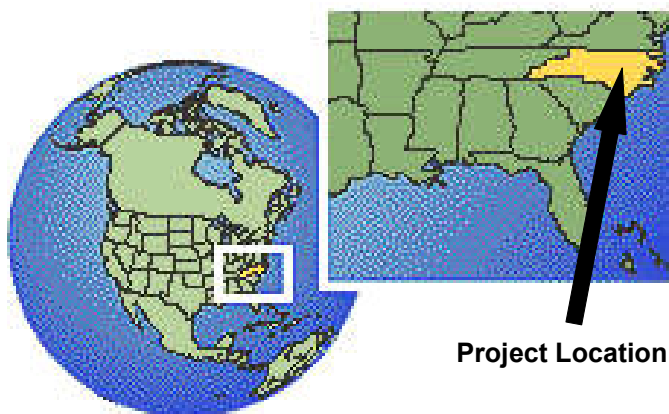


Figure 2 Smart Work Zone Project Location

The Smart Work Zone was deployed from April 29th to November 10th 2003 and is basis of the research into the effect of a Smart Work Zone on traffic safety.

While work zones at any location result in increased safety concerns, Interstate 95 in North Carolina has some characteristics that compound the safety problem. Approximately 57 percent of all drivers on Interstate 95 reside outside of North Carolina, compared to only five percent of drivers on other North Carolina highways. Driver familiarity can be a factor in work zone safety and mobility and in this case a large portion of drivers will be unfamiliar with the work taking place and the traffic control measures being used. The fatal crash rate on Interstate 95 is 1.05 fatal crashes per 100 million vehicle miles traveled, 62 percent higher than the state-wide crash rate on rural Interstates of 0.65 fatal crashes per 100 million vehicle miles traveled (North Carolina Department of Transportation⁷).

The project on which the Smart Work Zone system was deployed covered approximately 15 km in both Southbound and Northbound directions, with an actual lane closure length of two to four kilometres at any time. The base case without the Smart Work Zone consisted of advance static signing, reduced speeds, and Portable Changeable Message Signs (PCMS) advising of a work zone ahead with pre-programmed messages.

The Smart Work Zone deployment included all traffic control of the base case, with additional components added to create the Smart Work Zone.

As part of the Smart Work Zone, three sensor trailers were positioned upstream of the work area to monitor traffic conditions. A typical road side message is illustrated in Figure 3. Three message signs were positioned on I-95 upstream of the work area with at least one sign prior to the alternate route exit. Three additional message signs were positioned to provide route guidance to motorists on the alternate route.



Figure 3 Smart Work Zone Message Sign

Three levels of messages were provided to motorists, depending on the traffic conditions. Messages were displayed on three lines and up to three frames in sequence. Generic messages informing motorists of a work zone ahead, such as “Traffic Slowing Ahead / Prepare To Merge” and Real Time Traffic Info / No Delay Exits 150-141”, were displayed when no delays were detected. When short delays were detected, but not long enough to warrant the use of the alternate route, the current delay estimate was displayed with a message such as “Traffic Stopped Ahead / 15 Minute Delay”. When delay time reached the point where the alternate route would offer a shorter travel time, the amount of delay and the suggested alternate route were displayed using a message such as “Traffic Stopped Ahead / 20 Minute Delay / Use Exit 141 As Alt.”.

Crash information was obtained from North Carolina Department of Motor Vehicle reports completed for this area over the duration of the study period. Lane closure status was obtained from copies of the project inspector log books provided by NCDOT. Smart Work Zone operational status was obtained from electronic log files automatically maintained by the system.

In 2003 the Smart Work Zone was deployed but there were intermittent periods of time when closures took place without the operation of the Smart Work Zone. Lane closures took place without the operation of the Smart Work Zone due to project scheduling and system down time. The project included work on both Northbound and Southbound directions and work locations were sometimes changed with limited advance notice. The result of frequent and rapid relocations was short periods where the Smart Work Zone was not active while road closures took place.

Safety Impacts of Smart Work Zone on I-95

The Smart Work Zone system was first deployed at the end of April 2003 and was used until project completion in November 2003. Crash records were analyzed up to the end of September 2003, as incidents after that period had not yet been recorded in the database. The study period therefore covers April 29 to September 30, 2003. The normal closure schedule for the project was Monday to Friday from 6 am to 6 pm. Any crashes that occurred outside this time window were not considered. Crashes that were coded as occurring in a construction or maintenance work area and that occurred in the same direction as the closure were considered.

The Smart Work Zone system was operational for approximately 92 days when lane closures were in place. 22 crashes were recorded when the Smart Work Zone was in operation. During the study period there were also approximately 13 days when lane closures were in place but the Smart Work Zone was not in operation. This provides a comparison period with and without the use of the Smart Work Zone. Two crashes were recorded when the lane closures were in place without a Smart Work Zone.

One possible measure of the impact of a Smart Work Zone is the average days per crash. With the Smart Work Zone in place, crashes occurred at a

rate of one crash every 4.2 days, while without the Smart Work Zone in place, crashes occurred at a rate of one crash every 6.7 days. However, two things should be noted about these results. First, given the small sample size the outcome is highly sensitive and even a single crash event could significantly alter the results. With only two crashes occurring without the Smart Work Zone in place, a single additional crash would represent a 50 percent increase. Second, using the average days per crash provides no way to quantify the variability of results, such as the standard deviation.

Another measure of a Smart Work Zone's impact is to look at each crash as a unique event and consider the time of operation since the last crash. The time between crashes when the Smart Work Zone was in operation is illustrated in the histogram in Figure 4.

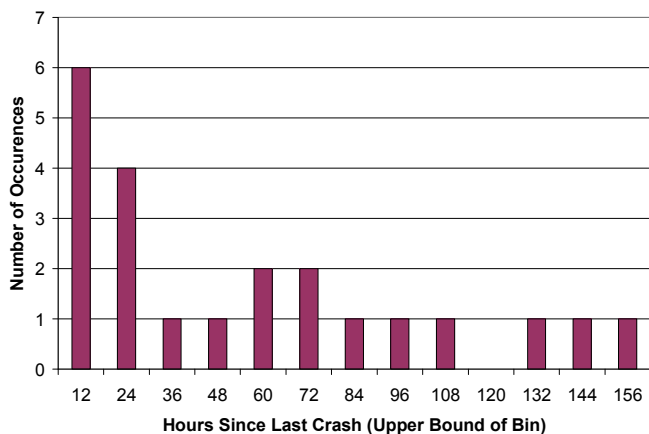


Figure 4 Time Between Crashes with Smart Work Zone in Operation

Using this approach, the variability and distribution of crash times can be considered. Considering the 22 crash events that took place when the Smart Work Zone was in place, the average operating hours between crashes was 50.2 hours with a standard deviation of 43.9, a minimum value of 1.2 hours and a maximum of 145.4 hours. The time between crashes does not follow a normal distribution.

Since there were only two crashes that occurred when the Smart Work Zone was not operating,

analyzing time between crashes is problematic. With only two crash events, there is only one true time between crash measurement, which was 27.7 hours. However, there was a period of 55.2 hours from the start of the study period until the first crash occurred and a period of 77.2 hours after the last recorded crash until the end of the study period. Assuming that the beginning and end time periods represented between crash times would alter the results. Given the low number of crashes and the variability of time between crashes, it appears there is not enough evidence to determine the effects of a Smart Work Zone on safety. Understanding something of the distribution and variability of crash times may be useful in the design of future evaluations to yield results with significance. This may require longer study periods or the use of other approaches such as a conflicts analysis.

Summary and Conclusions

Intelligent Transportation Systems are one tool that is available to agencies to improve safety and mobility in work zones. Previous research, although limited, has indicated an average of 33 percent reduction in fatalities and seven percent in rear-end crashes when ITS is deployed in work zones. Due to the high value placed on having the system operating and in place, resulting in limited time periods for comparison without the Smart Work Zone, the research conducted in this study was inconclusive as to the effects of a Smart Work Zone on safety. The study did show that time between crashes does not follow a normal distribution and provided insight into the frequency of crashes and the variability of time between crashes.

Under a continuation of this research effort, a second site from North Carolina will be analyzed as well as the complete deployment period for the site referenced in this paper. The research will also look at travel time delay, emissions reductions, and a user survey of use, acceptance and reaction to the Smart Work Zone. As crashes are at least partially

a stochastic event and each project is unique further research of other deployments of ITS in work zones is recommended to build a larger body of evidence and to investigate various scenarios of operation and deployment.

7. North Carolina Department of Transportation, Traffic Safety Services Management Unit, Unpublished

Acknowledgements

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