Influence of Mobile Work Zone Barriers in Maintenance Work Zones on Driver Behavior: A Driving Simulator Study

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ABSTRACT

Highway construction projects often require temporary changes in roadway characteristics, such as the number of operational lanes, lane path, lane width, shoulder width, and posted speed limit. These modifications which are often temporary in nature have the potential to impact driving performance. Many research efforts have focused on developing standards to ensure the safety of drivers and workers in work zones, however comparatively little research has been conducted to better understand the influence of mobile work zone barriers (MWB), a relatively new type of positive barrier designed to protect workers in the activity area of a work zone, on driver behavior. The OSU Driving Simulator was used to evaluate the influence of an MWB on driver behavior in single left lane and right lane drop maintenance work zones on 4-lane, 2-way divided highways. Thirty six drivers traversed 144 work zones. Measures of vehicle trajectory, lateral position and glance patterns were recorded and examined. No statistical differences were observed in the glance patterns of drivers between work zones with and without the MWB, suggestive statistical differences were identified between average speeds in the taper and activity area of right lane closure work zones with speeds slightly slower in the presence of the MWB, and an eight inch shift to the right was observed in the lateral position of vehicles in the activity area of left lane drop work zones in the presence of the MWB. Results suggest that no critical hazards are introduced to drivers from the application of MWBs in maintenance work zones.

INTRODUCTION

Construction and maintenance on America's aging transportation network requires temporary changes to the roadway environment that generally impose restrictions on the facility's capacity. According to the Federal Highway Administration (FHWA), roughly 20% of the National Highway System (NHS) undergoes construction during the peak construction season (*1*). More than 3,000 work zones are expected to be on the NHS during this time, with an estimated 12 billion vehicle miles traveled a year through active work zones. It is, therefore, critical that engineers develop traffic management plans that will minimize additional delay and increase work zone safety, as an estimated 24% of non-recurring delay can be attributed to work zones (*1*), and 578 work zone fatalities were caused by motor vehicle crashes in 2010 (*2*).

Engineers typically use microsimulation or the Highway Capacity Manual (HCM) 2010, to estimate roadway capacity through work zones. Microsimulation requires numerous parameter inputs, which attempt to capture driver behavior under various work zone conditions. For example, VISSIM is based on Wiedemann's car following and lane changing models, with numerous driver behavior parameters incorporated into the car-following model (*3*). The HCM 2010 provides guidance for determination of work zone capacity, identifying standard capacities and several potential influencing factors (*4*). These resources, however, do not capture the apparent effect of driver behavior associated with differing work zone configurations and traffic control devices, as well as regional differences across the country (*5*).

Driving simulators have been used extensively to evaluate the safety implications of various work zone configurations and the associated traffic control elements (*6*, *7*, *8*, *9*). Furthermore, there have been significant efforts to validate results from simulator experiments, reporting mixed results depending on the design of the experiment. It is postulated that driving simulation can be expanded beyond applications related to work zone safety to better understand how variations in driver behavior influence work zone capacity. This research uses a driving simulator as a mechanism to accurately capture driver behavior as they interact with mobile work zone barriers.

BACKGROUND

The literature included in the following background section is not intended to be comprehensive, rather to lay the foundation for the study of MWB in maintenance work zone configurations.

Standard Configuration for Single Lane Closure

Part 6: Temporary Traffic Control of the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) describes the design specifications for temporary traffic control zones. The MUTCD states that there are four main areas in a work zone: the advance warning, transition, activity, and the termination areas. The Oregon Temporary Traffic Control Handbook (OTTCH) incorporates the temporary traffic control described in the MUTCD (Figure 1).

The advance warning area may vary in format from a series of signs up to a mile or more in advance of the work space to a single sign or flashing lights on a work vehicle. In the advance warning area, information regarding the coming temporary traffic control measures is relayed to the road users. The layout of the area should give road users ample time to respond to downstream modifications occurring within the transition area (*10*, *11*).

The transition area diverts traffic from its normal path and into a temporary path through the work zone. The transition area contains tapers arranged out of approved channelizing devices used to shift or close one or more travel lanes or a shoulder (*10*, *11*).

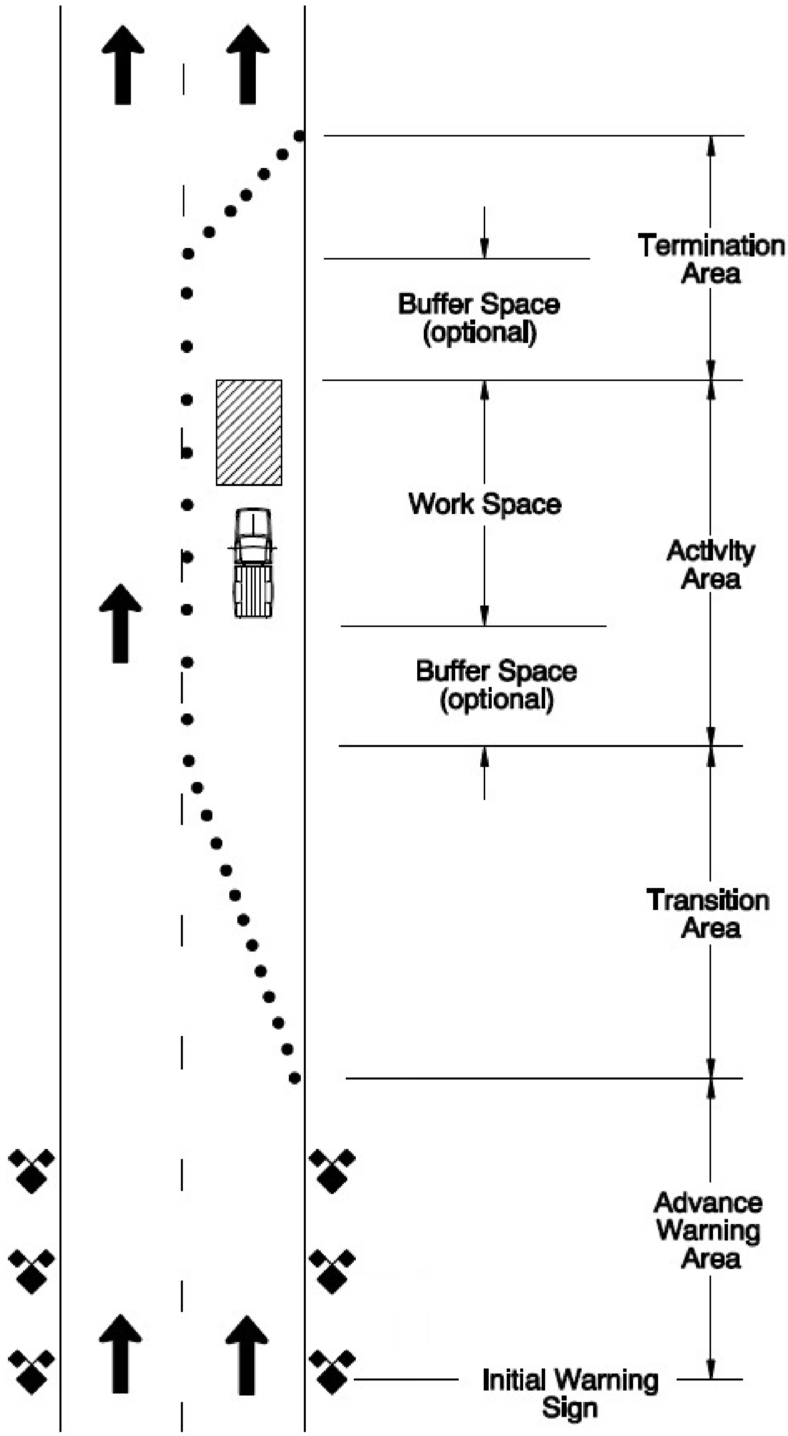

FIGURE 1 Example Work Zone Layout for single right lane drop (OTTCH, 2011)

The area immediately following the transition area is called the activity area. It is comprised of two sections and is typically designated with longitudinal channelizing devices or barriers. The first section of the activity area is the work space, “the portion of the roadway containing the work activity and includes workers, materials, and equipment" (*10*). It is recommended that this area be appropriately delineated and protected. Longitudinal or lateral buffer space(s) make up the second section of the activity area. Buffer space is a closed section of road upstream and adjacent to the work space. It acts to "provide an extra margin of safety for both traffic and workers, and a clear recovery area for errant vehicles" (*10*, *11*). The decision to use and the dimensions of buffer spaces are left to engineering judgment, but should be provided when space is available.

The last work zone section is the termination area. It provides a short, optional buffer space after the workspace and before the tapered distance for traffic to clear the work space and return to its usual path and speed.

Standard Configuration for Mobile Barriers

MWBs provide a moveable, rigid longitudinal barrier between the activity area of work zones and traffic. These attributes, combined with improved safety (*12, 13*) explain why MWBs are emerging as a viable method for protecting construction workers in work zones. However, MWBs are not new; iterations of have been produced since the 1950's (*14*). A variety of barrier systems used in construction were described by Loshe et al. in 2007 (*15*) and by Hallowell et al. in 2009 (*16*).

Perhaps the most notable aspect of an MWB is the fact that one model has been crash tested and approved for use on the NHS by FHWA under the National Cooperative Highway Research Program (NCHRP) 350 and (Test 311) MASH-08 Guidelines. The test utilized a 5,135lb 2002 Dodge Ram 1500 Quad Cab pickup truck at a speed of 100 km/hr and angle of 25-degrees. No structural damage occurred and a maximum dynamic deflection of two feet was observed (*17*).

Driving Behavior in Work Zones

In 2004, Benekohal et al. presented and validated a novel methodology for estimating the operating speed and capacity of work zones on highways. The underlying principle was that operating factors in work zones, such as work intensity, lane width, lateral clearance, and work zone and barrier type (e.g., long-term with concrete barriers, short-term with cones or drums), cause drivers to reduce speed. Results showed that regardless of the work zone activity level, expected speed reductions in short-term work zones are greater than those in long-term work zones (*6*).

In 2007, Richard Tay and Anthony Churchill set out to find the effects of different median barrier types on driver speed on urban freeways. With guidance from the HCM 2000, expected decreases in speed due to the particular lane width and lateral clearance were estimated for four sites with barriers and an 80km/h speed limit and two sites with a 70km/h speed limit, and analyzed relative to two no barrier configurations, one in each speed limit zone. It was found that the differences in the observed and predicted mean speeds were not as expected. With the exception of one site, the mean speed and 85th percentile speed were generally higher than the control sites. Their findings were consistent with those found in Sweden (*18*). It can be inferred from their results that "drivers perceived the median barriers more as a protective device than as a hazard and therefore adapt to their presence by increasing their speed to compensate for the perceived reduction in risks" (*7*).

In 2010, the Texas Transportation Institute (TTI) tested human comprehension of warning signs and lane closures in a driving simulator. It was found that iterative warning signs with no more than three units of information (with a unit equaling one word or a short line of two words) and orange traffic barrels work best to inform the driver of an upcoming event and guide them to a safe travel path (*8*).

To determine the impact of various factors on work zone crashes and driver performance, McAvoy et al. (2011) conducted driving simulator research. Some of the various independent variables considered in the study included roadway type (divided or undivided), traffic density (low, moderate, and high), and work zone type (lane or shoulder closure). Crash frequency, speed, lane deviation, and deceleration were the primary performance criteria measured and utilized to determine the most hazardous work zone configurations for drivers. It was determined that the most hazardous work zone configuration involved a divided highway with a lane closure during low density traffic conditions (*9*).

Not all driver performance variability in work zones can be attributed to roadway and work zone characteristics. The greatest contributor to speed and headway variability in a traffic stream is most likely the diversity of the driving population and the vehicle fleet. The two most widely used approaches to categorize drivers are by age and gender. An examination of work zone crash data done by Li and Bai (2009) in Kansas showed that looking at these driver characteristics is important. This study looked at 85 fatal crashes between 1998 and 2004, as well as 620 injury crashes between 2003 and 2004 in Kansas highway work zones. Of the 85 fatal crashes, 64 (75%) were caused by male drivers, 24 (28%) were caused by drivers 55 and older, and 61 (72%) were caused by drivers between the ages of 15 and 54 (22 (26%) coming from people age 35-44). Of the 620 injury crashes, 398 (64%) were caused my male drivers, 86 (14%) were caused by drivers 55 and older, and 534 (86%) were caused by drivers between the ages of 15 and 54 (126 (20%) coming from people age 25-34) (*19*).

METHODOLOGY

This research was conducted in a high-fidelity driving simulator. To build the environment, single lane drop maintenance work zone configurations were replicated based on the standards described in the 2009 Manual on Uniform Traffic Control Devices (MUTCD) and the 2011 Oregon Temporary Traffic Control Handbook (OTTCH). All elements of the work zones were replicated faithfully.

The research was focused on driver behavior in the advanced warning, transition, and activity areas of single lane drop maintenance work zones. The following three null hypotheses were developed to address the critical need for research to understand the impact on driver behavior caused by MWB:

1. $\boldsymbol{H_0}$: *There is no difference in vehicle velocity while traversing a single left or right lane closure work zone with a mobile barrier or a sequence of drums positioned in the activity area of a work zone.*

2. ***H_0*: *There is no difference in vehicle trajectory while traversing a single left or right lane closure work zone with a mobile barrier or a sequence of drums positioned in the activity area of a work zone.***
3. ***H_0*: *There is no difference in the driver's glance patterns or fixation points while traversing a single left or right lane closure work zone with a mobile barrier or a sequence of drums positioned in the activity area of a work zone.***

Driving Simulator

The Oregon State driving simulator is a high-fidelity simulator, consisting of a full 2009 Ford Fusion cab mounted on top of a pitch motion system (Figure 2 a and b). The pitch motion system accurately models acceleration and braking events. Three projectors produce a 180 degree front view and a fourth projector displays a rear image for the driver's center mirror. The two side mirrors have LCD displays. The vehicle cab instruments are fully functional and include a steering control loading system to accurately represent steering torques based on vehicle speed and steering angle. The simulator software can record performance measures such as speed, position, brake, and acceleration at a sampling rate of 60Hz.

a b c

FIGURE 2 Views from a) outside the simulator and b) from inside the OSU Driving Simulator and c) subject wearing eye-tracking device.

Eye Tracking

Eye tracking data was collected using the Mobile Eye-XG platform from Applied Science Laboratories (Figure 2 c). The advanced Mobile Eye-XG allows the subject to not only have unconstrained eye movement but also unconstrained head movement, generating a sampling rate of 30 Hz and an accuracy of 0.5 to 1.0 degree. The subject's gaze is calculated based on the correlation between the subject's pupil position and the reflection of three infrared lights on the eyeball. Eye movement consists of fixations and saccades where fixations are points that are focused on during a short period of time and saccades are when the eye moves to another point. The Mobile Eye-XG system records a fixation when the subject's eyes have paused in a certain position for more than 100 milliseconds. Quick movements to another position, saccades, are not recorded directly but instead are calculated based on the dwell time between fixations. The eye tracking data is recorded asynchronously with the driving simulator data, but the files can be merged during the analysis process.

Experimental Factors

Two experimental factors were tested, the position of the lane drop and the presence of the MWB in the activity area of the work zone. Within the simulated environment, subjects were presented with combinations of the independent variables. These combinations included both left and right lane drops as well as activity areas with and without the MWB. These options resulted in a two by two factorial design or four experimental scenarios to be analyzed.

Subject Recruitment and Sample Size

Participants in this study were recruited from the OSU student population and the surrounding community of Corvallis, Oregon. Participants were required to possess a valid driver's license, not have vision problems, and be physically and mentally capable of legally operating a vehicle. Participants also needed to be deemed competent to provide written informed consent. This study targeted an enrollment of 40 participants with a balance of gender which was not screened until the quota for either males or females had been reached, at which point only the gender with the unmet quota was allowed to participate. In total, 36 drivers (17 male, 19 female) with an average age of 36 (range of 18 to 75) completed the experiment. Subjects were compensated for their participation —a $20 payment was given to those who participated. The research design was reviewed and approved by the Institutional Review Board.

Scenario Layout and Intersection Control

The experiment was designed using simulator software (Internet Scene Assembler, SimCreator, and Google Sketch-Up) and the OSU Driving Simulator was used to project the virtual environment around the driver. The purpose of this environment was to put drivers in situations in which observations could be made and measurements taken in a controlled and repeatable laboratory setting to help answer our exact experimental questions. The course was designed to take the subject 10 to 15 minutes to complete. The entire experiment, including the consent process and post-drive questionnaire, lasted approximately 45 minutes. In an effort to reduce the chances of simulator sickness, the driving scenario was built with no stops and no ambient traffic.

Four types of work zones were presented to the subjects. These included a right lane closure with a mobile barrier (work zone 1), a right lane closure without a mobile barrier (work zone 3), a left lane closure with a mobile barrier (work zone 2), and a left lane closure without a mobile barrier (work zone 4). Each work zone was located on the tangent section of a four-lane, divided, rural highway with travel in both directions. In order to test one of the most hazardous work zones involving a divided highway with a lane closure during low density traffic conditions, the ambient traffic in the environment was set to zero (*9*). Figure 3, shows a plan view of the experimental test track. Each of the four work zones are identified as well as the four billboard locations. The start location was rotated to four positions, between each work zone to minimize the potential for errors of confounding.

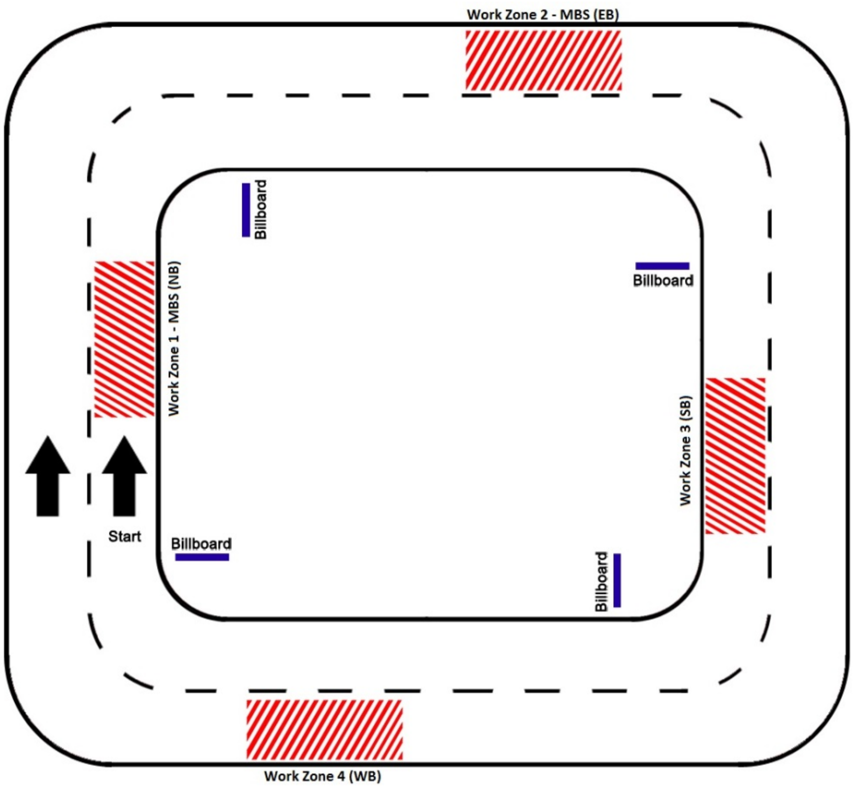

FIGURE 3 Example Aerial View of One Simulated Test Track.

Figure 4 illustrates a typical right lane closure for a work zone containing a mobile barrier (left panel), as well as a work zone that does not contain a mobile barrier (right panel).

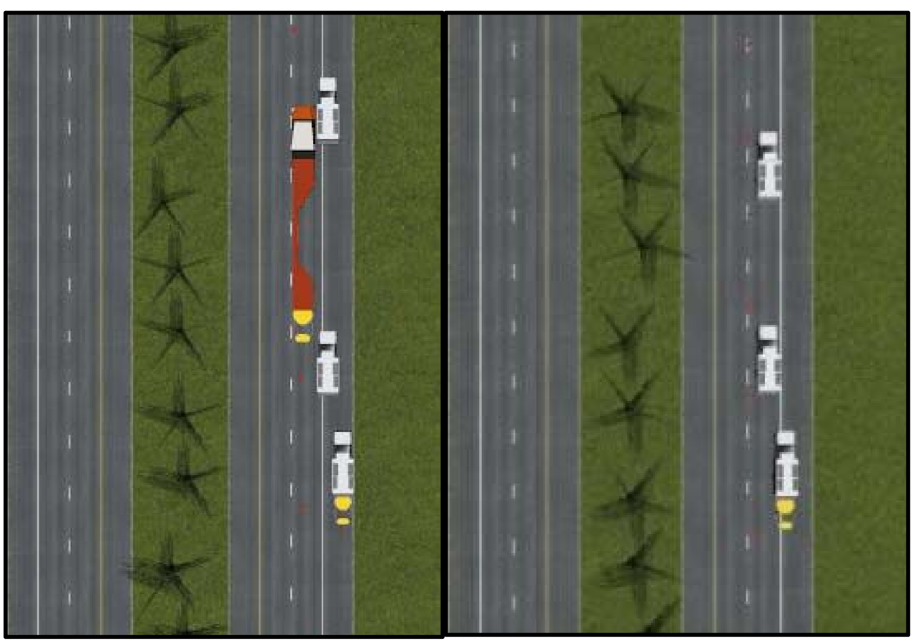

FIGURE 4 Right Lane Closure with Mobile Barrier (left) and Without (right)

A data collection sensor was placed over the advance warning, transition, activity, and termination areas of each work zone. The instantaneous velocity, position, and acceleration were recorded with time stamps at roughly 15 Hz (15 times a second).

A new text file was created each time the test vehicle triggered a sensor in the advanced warning area of the next work zone. This allowed for an organized and efficient transfer of data to a spreadsheet application for further analysis.

Experimental Procedure

Upon arrival at the OSU Driving simulator participants completed the informed consent process, responded to demographic questions, participated in a 3 minute calibration test drive, were outfitted and calibrated with the mobile eye tracker, and then completed the experimental drive. During the experiment participants were instructed to drive as they normally would from one of four start location.(Figure 3). The subject was also instructed not to change lanes unless necessary which required each subject to initially respond to each work zone by changing lanes.

Distractors

To reduce the likelihood that participants deduced the primary research questions of the study, thereby potentially altering their driving behavior, they were asked to complete several texting tasks while traversing the experimental route. As driver's approached the horizontal curves, they were presented with a picture on a billboard. The participants were asked to send a text message containing the name of the animal they saw on a billboard to a phone number they were given prior to experimentation. Participants navigated a total of four horizontal curves each requiring a short response. The texting events were separated from the work zones by several minutes of driving to mitigate any interaction between the scenarios. In post experiment debriefing, nearly every driver supposed that the experiment was concerned with texting while driving.

DATA ANALYSIS AND RESULTS

Of the 38 subjects who participated in the experiment, 2 could not complete the experiment due to simulator sickness, and 16 subjects could not be calibrated for eye tracking data. This resulted in the collection of velocity and position data for 36 subjects, and eye tracking data for 22 subjects. In total, 144 work zones were traversed by 36 subjects, all of which were deemed acceptable for further analysis of the velocity and position data. Additionally, 88 of these work zones were deemed acceptable for eye tracking analysis.

Trajectory of Vehicles

Several time-space diagrams were developed to help understand driver responses to the presence of an MWB in the activity area of a single lane drop maintenance work zone. Figure 5 shows vehicle trajectories, with each line representing the path of a single vehicle proceeding through the work zone. In this figure, distance is mapped on the vertical axis and time on the horizontal axis, meaning that the slope of a line represents the velocity of a single vehicle and curvature indicates acceleration/deceleration.

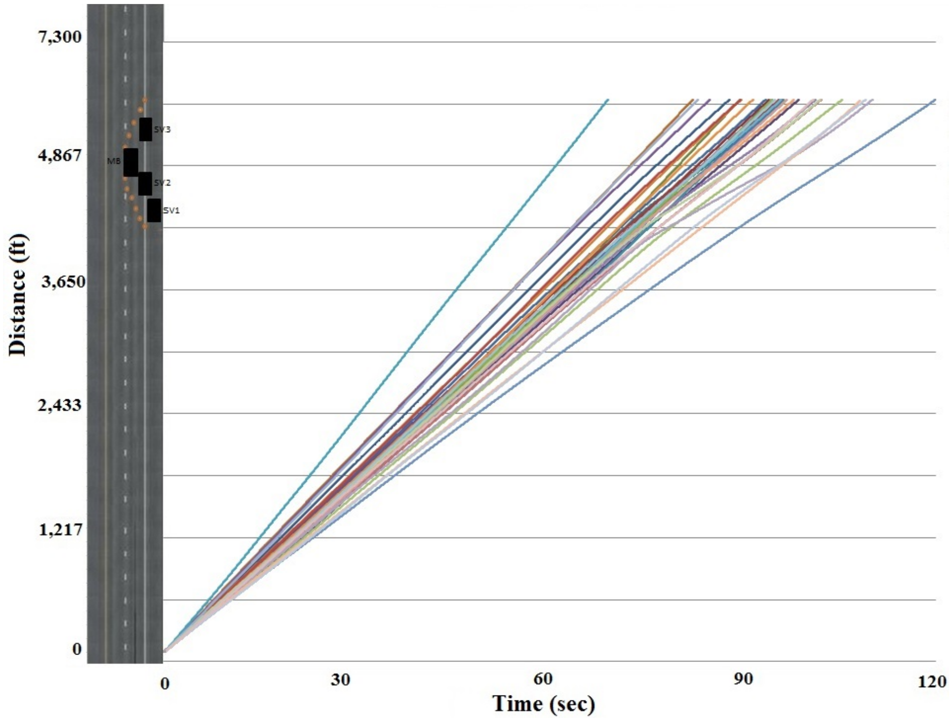

FIGURE 5 Space-Time Diagram for All Subjects – Work Zone 1

The time space diagrams allowed for the consideration of the work zones in sections (Advanced Warning, Taper, and Activity Area) and four work zones (1, 2, 3, and 4). The time space diagrams isolated the impact of individual variable levels. For example, one possible test could determine the difference between the mean velocity of vehicles in the activity areas of work zones 1 and 4. To find out if the mean velocity is in fact different between specific work zones, paired t-tests were conducted. Table 1 presents the results of these paired t-tests. For two variables to be identified as statistically different with 95% confidence, the resulting p-values should be less than 0.05.

TABLE 1 Statistics Summary Table Comparing Mean Velocity of Different Roadway Sections between Work Zones (n = 36).

Work Zone	Work Zone Section	Mean Velocity (MPH)		Paired T-Test	
		WZ 1	WZ 3	p-value	Significant
1 vs 3	Advanced warning	58.47	58.79	0.647	NO
	Taper	55.41	56.93	0.105	Suggestive
	Activity Area	54.40	55.95	0.112	Suggestive
Work Zone	**Work Zone Section**	**WZ 2**	**WZ 4**	**p-value**	**Significant**
2 vs 4	Advanced Warning	59.44	59.46	0.976	NO
	Taper	56.71	56.91	0.742	NO
	Activity Area	55.90	56.21	0.642	NO

Between work zones 1 and 3, as well as 2 and 4, no statistically significant differences were found with respect to velocity. This suggests that the mean velocity of vehicles traversing the different sections of a work zone do not change depending on the presence of the MWB However, it can be said that there is suggestive evidence of a difference in mean velocity in the taper and activity areas of work zones 1 and 3 in which the speed is slightly greater without the MWB present.

Lateral Position of Vehicles

Visualization can be a useful tool when examining any data set. One way to visualize this type of data is to display the trajectories for all of the drivers on a single plot. By making each figure represent a single work zone, the entire spectrum of driver responses to a single scenario can be visually inspected. For example, Figure 6 provides trajectory data for all 36 drivers in work zone 1.

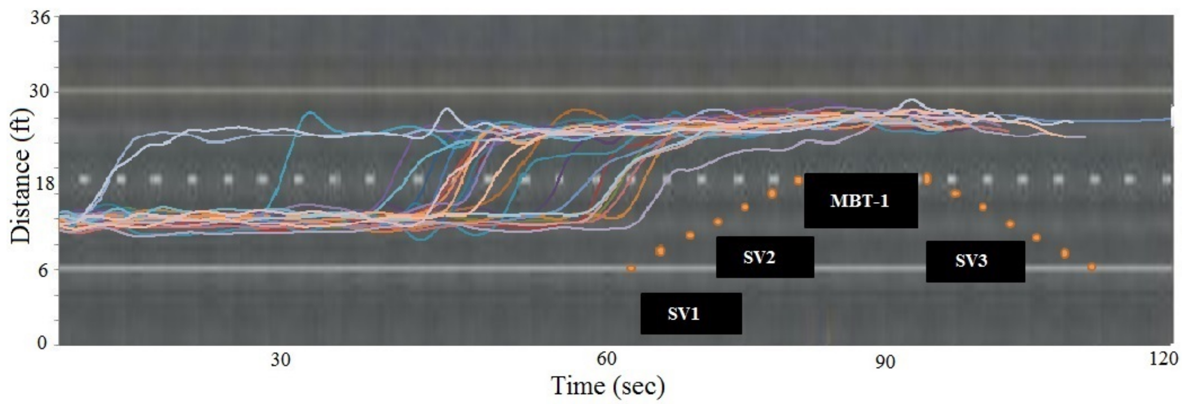

FIGURE 6 lateral Position for All Subjects (Centroid) – Work Zone 1

The average lane position, as measured from the centroid of the vehicle to the centerline of the roadway section, of all vehicles passing through the work zones were compared with paired t-tests (Table 2).

TABLE 2 Statistics Summary Table Comparing Average Lane Position through the Activity Area between Work Zones (n = 36)

Roadway Section	Mean Position (Feet)				Work Zone	Paired T-Test	
	WZ 1	WZ 3	WZ 2	WZ 4		p-value	Significant
Activity Area	8.63	8.73	6.63	5.97	1 vs 3	0.419	NO
					2 vs 4	0.0056	YES

Statistically significant differences (with 95% confidence) were found between the average lane position of vehicles passing through the activity areas of work zones 2 and 4. This suggests that lane position does change, shifting eight inches further away from the MWB, on a left lane drop with a mobile barrier present compared to when there are only drums. No statistically significant difference was found between the average lane position of vehicles passing through the activity areas of work zones 1 and 3.

Visual Search Task of Drivers

Using the ASL Results Plus software suite provided with the ASL Mobile Eye-XG equipment, each subject's fixations were analyzed using Area of Interest (AOIs). This process required researchers to watch each activity area section of roadway video that was successfully collected (4 per subject) and draw AOI polygons on a sequence of individual video frames separated by intervals measuring approximately 5 to 10 frames. Once each AOI was moved manually, an "Anchor" is created. The change in distance and size of AOIs between these Anchors is interpolated to ensure that all fixations on the AOIs, in this case the activity area of the work zone, are captured (Figure 7).

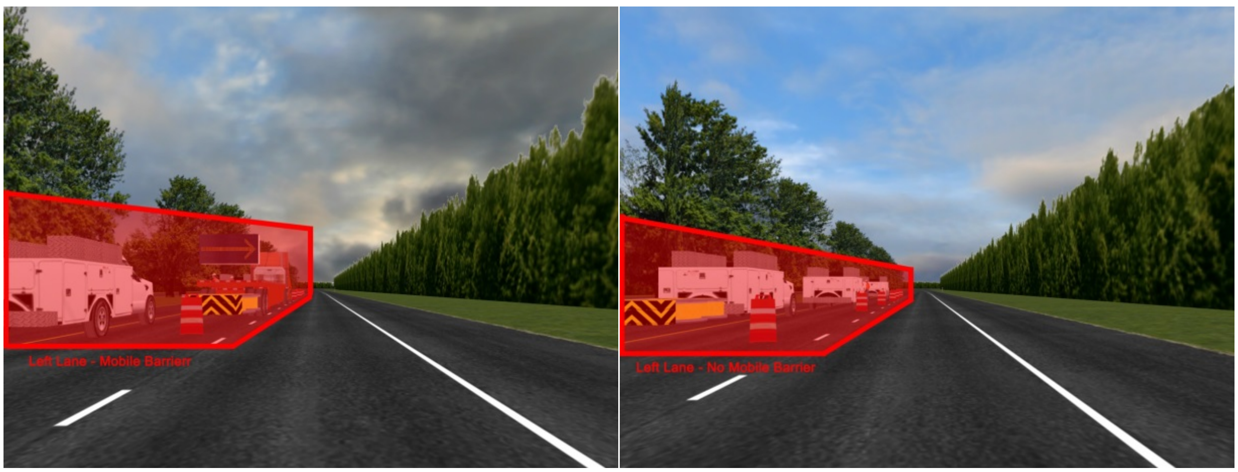

FIGURE 7 Work Zone 2 (left) and Work Zone 4 (right) with AOIs in the Activity Area.

Once the AOIs have been coded for each individual video file, ASL Results Plus is used to output spreadsheets showing all of the fixations and their corresponding AOIs. Fixations outside of coded AOIs were collectively defined as OUTSIDE and were not used further in this analysis. Researchers exported these .txt spreadsheets into different software such as Microsoft Excel and R for further analysis. A portion of one subject's fixation data set can be found in Table 3. This table is a summary of the fixations during four 12-second videos and includes the number of fixations, total fixation durations, average fixation durations, and time of first fixation within each AOI created while passing through all four work zone scenarios on four separate tangent segments of roadway. Saccades, quick eye movements where no fixations are made by the subject, were not exported and analyzed.

Table 3 Example of Raw Fixation Data Output

AOI Name	Fixation Count	Total Fixation Duration (sec)	Average Fixation Duration (sec)	First Fixation Time (sec)
Right Lane - Mobile Barrier	11	3.88	0.353	275.49
Right Lane - No Mobile Barrier	10	2.36	0.236	642.26
Left Lane - Mobile Barrier	11	4.03	0.366	457.99
Left Lane - No Mobile Barrier	12	5.01	0.418	827.03

AOIs include the activity areas of a work zone with a mobile barrier requiring a right lane closure, without a mobile barrier requiring a right lane closure, with a mobile barrier requiring a left lane closure, and without a mobile barrier requiring a left lane closure.

For each scenario, average total fixation duration (ATFD) and fixation counts were collected for each AOI. Figure 8 shows the ATFD for each AOI. 95% confidence intervals were calculated for the ATFDs, and are included in Figure 9. The 95% confidence interval defines an interval that contains the true mean with a statistical confidence of 95%.

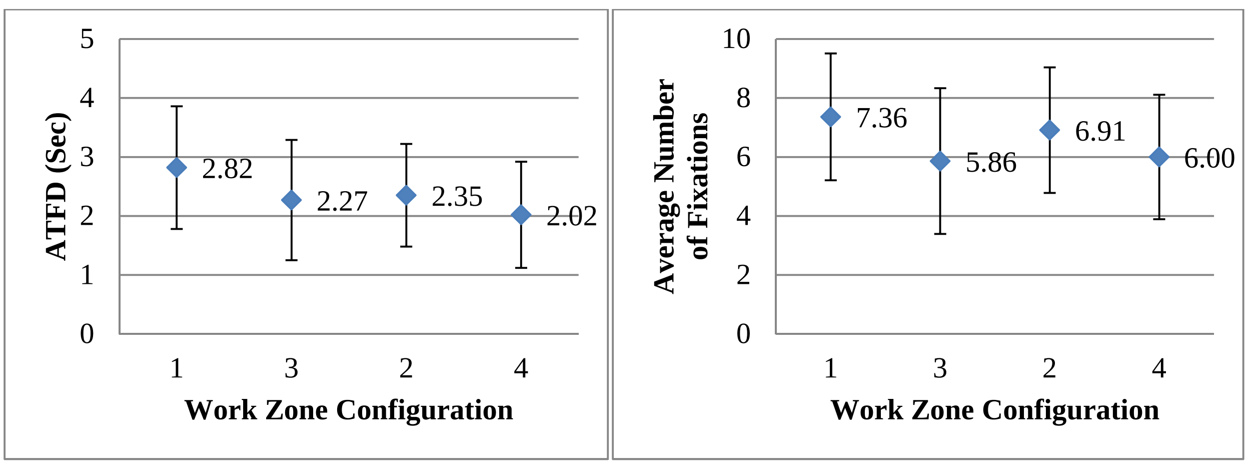

FIGURE 8 ATFD (left) and AFC (right) with 95% CIs for all Four Work Zones.

Figure 8 also shows the average fixation counts (AFC) from all subjects traversing each of the four work zone scenarios. Again, 95% confidence intervals are displayed.

Useful graphical comparisons can be performed based on the ATFD, AFC, and the corresponding 95% CIs. For example, Figure 8 shows the ATFD on AOIs for four experimental scenarios. The graphical comparison between work zones 1 and 3, as well as 2 and 4, show that, with 95% confidence, the ATFD on the activity areas of the work zones do not significantly differ with the presence of a mobile barrier. To confirm this visual inspection, a paired t-test assuming equal variances (verified by two-sample F-tests) resulted in p-values of 0.201 and 0.375 when comparing work zones 1 and 3, and 2 and 4, respectively. While there is no statistical difference between work zones 1 and 3, and 2 and 4, it is interesting to note that some drivers continuously fixated on the MWB in zones 1 and 2 for as long as 5.67 and 4.37 seconds, respectively. Drivers continuously fixated on the work zone area in work zones 3 and 4 for as long as 5.27 and 5.71 seconds, respectively. The mean continuous fixation on work zones 1, 2, 3, and 4 was 1.93, 1.10, 1.63, and 1.39 seconds, respectively.

CONCLUSIONS

This research was aimed at better understanding how drivers behave while traversing a work zone with an MWB. More specifically, research investigated how a driver's velocity, lateral position, fixation duration, and number of fixations are affected by the presence of the MWB. Three null hypotheses were tested using the OSU Driving Simulator.

A driving simulator experiment was conducted in which driver behavior data was collected from 36 drivers representing 144 work zone incursions. The following descriptions highlight the most meaningful research findings.

Results compare the average vehicle velocity in the three roadway sections of all four work zones, which include a right lane drop with an MWB, a left lane drop with an MWB, a right lane drop without an MWB, and a left lane drop without an MWB. Findings include:

- No statistically significant differences were found in 8 of the 12 roadway sections.
- Evidence suggestive of a difference in mean velocity was found between the tapers and activity areas of work zone 1 and work zone 3.

These results suggest that drivers do not change their velocity when traversing a work zone using an MWB when compared to work zones without an MWB.
Findings related to vehicular lateral position include:

- A statistically significant difference ($p\text{-value} < 0.05$) was found in the lateral positioning of vehicles traversing work zones 2 and 4.
- No statistically significant difference was found in the lateral positioning of vehicles traversing work zones 1 and 3.

Results suggest that when drivers are required to change lanes due to a left side lane drop, the presence of an MWB results in an 8 inch shift away from the barrier as compared to a work zone without an MWB. This is possibly due to the additional proximity of the driver to the barrier in a left lane drop.

Results related to glance patterns (ATFD and AFC) of drivers as they traversed work zones both with and without an MWB longitudinal barrier include:

- No statistically significant difference was found in the average total fixation duration of drivers in work zones with and without an MWB longitudinal barrier.
- No statistically significant difference was found in the average fixation counts of drivers in work zones with and without an MWB longitudinal barrier.

The number of subjects who failed to fixate on any part of the activity area was also collected. It was found that 5% of the subjects did not fixate on the MWB in their first encounter with the longitudinal barrier; that number increased to 14% on their second encounter. These findings suggest that driver attention is not diverted from the roadway by the MWB.

Acknowledgements

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