Focus Group Participants' Understanding of Advance Warning Arrow Displays used in Short-Term and Moving Work Zones

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ABSTRACT

In long-term work zones on multilane highways and/or freeways, the Federal Highway Administration has interpreted the Manual on Uniform Traffic Control Devices (MUTCD) to mean that only one advance warning arrow display can be used to denote the closure of a single lane. Where two or more lanes are closed, a single arrow display is used for each lane to be closed. However, in short-term applications or for moving/mobile work convoys, the MUTCD allows the use of multiple arrow displays to indicate a single lane closure. These disparate uses for arrow displays create the potential for confusion by drivers.

This paper describes the results of four focus group interviews with Midwestern drivers. Participants were shown several mock images of shadow work vehicles with arrow displays and were questioned on how well they understood and/or interpreted the message conveyed by arrow displays, depending on the display type and quantity of displays used, and the researchers looked specifically for potential driver confusion.

Focus group participants generally considered panel displays that included motion (e.g., sequential arrows and sequential chevrons) as implying a more important situation and preferred their use over flashing versions (flashing arrows and flashing chevrons). While participants were receptive to the use of multiple arrow displays on multiple shadow vehicles, a minority indicated that this conveyed a need to move over more than one lane. Participants also indicated that staggering sequential shadow vehicles from the shoulder into the closed lane provided useful information as to the number and location of the closed lanes.

Key Words: arrow display—focus group—traffic control—work zone

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INTRODUCTION

In work zones where the traffic control plans are relatively static, such as at long-term work zones, the use of a single advance warning arrow display, as shown in Figures 1 and 2, to indicate a single closure appears well-standardized and well-understood by the arriving public. In fact, the Federal Highway Administration (FHWA) has interpreted the Manual on Uniform Traffic Control Devices (MUTCD) as meaning that only one arrow display is to be used for each lane closed in long-term situations (FHWA 2003). However, in work zones that are moving or of a very short duration, there is often a desire by highway departments and contractors to use multiple arrow displays to indicate that a single lane is closed. Because these types of work zones often have fewer visual reinforcements to the lane closure message (e.g., no cones, barrels, or other channelizing devices), this desire seems understandable.

In short-term applications or for moving/mobile work convoys, the MUTCD does allow the use of multiple arrow displays to indicate a single lane closure (FHWA 2004). This results in a situation where the same traffic control device (e.g., an arrow display) is used in a slightly different manner depending on the nature of the work zone: in a long-term work zone, two arrow displays mean two lanes are closed, but in a short-term, mobile, or moving work zone, two arrow displays may mean only a single lane is closed. These disparate uses for arrow displays create the potential for confusion by drivers. This research was conducted to determine the extent to which typical drivers are able to understand these uses of arrow displays, to explore any confusion resulting from these different uses, and to make suggestions on how to improve lane changing information to drivers in short-term, mobile, and moving work zones.

Figure 1. Typical advance warning arrow display at a long-term work zone (arrow displayed)

Figure 2. Typical advance warning arrow display at a long-term work zone (chevron displayed)

METHODOLOGY

Focus group meetings were conducted in order to gain a better understanding of the views and opinions of the driving public as to how well they understand the information conveyed from the various displays on an arrow panel, which methods were preferred, and what alternatives might be useful for the driving public. Focus groups have advantages over other survey methods in that they are able to cover a topic in more depth and, due to the open-ended nature of the discussions, the potential exists for innovative concepts to be suggested by participants (University of Texas 2007). Areas of emphasis that were discussed during the focus groups included the following:

- What the various arrow displays mean to the driving public
- How participants interpreted the difference between a single arrow display and multiple arrow displays
- What the various caution displays mean to the driving public
- The driving actions that participants believe they would take when confronted with various arrow panel displays

Additionally, participants were asked what they would prefer to see changed with respect to advance work zone traffic control applications in short-term, mobile, and moving freeway operations.

Four focus groups were conducted in four cities in three Midwestern states in order to provide a diverse group of participants. Focus groups were conducted in the following locations:

- Kansas City, Missouri
- Lawrence, Kansas
- Overland Park, Kansas
- West Des Moines, Iowa

Participant Demographics

Focus group participants were recruited with the goal of having a diverse population of licensed drivers. Requirements for individual participants included having a valid driver license, driving at least 8,000 miles per year, and driving on a freeway at least once per month. Additionally, it was desired to match as closely as possible the demographics of the overall driving population with respect to gender, age, and level of education. Table 1 shows the ideal demographic percentages obtained from the U.S. Census Bureau and U.S. Department of Transportation, FHWA, for the population education level and the age of licensed drivers in the three states where focus groups were held (FHWA 2007; U.S. Census Bureau 2007). For the demographic category of age, all of the percentages were calculated based on state licensed drivers instead of the total state population.

Table 2 shows the actual demographic percentages of the 39 participants that took part in the focus groups. The targeted demographic distribution and the overall distribution of actual participants compared reasonably well, although an exact match between them was not achieved due to last-minute cancellations by some participants. Additionally, finding some demographic groups, such as participants with less than a high school education and participants for the oldest demographic group, was problematic. Overall, the actual demographic results indicated that a good cross section of the driving public was achieved; this is an encouraging indication that the comments provided can be considered representative for the areas where the focus groups were conducted.

Focus Group Study Design

Each focus group consisted of five main parts. The first part served as an orientation, where the research team explained the research goals of the project, how the focus group would be conducted, and an explanation of any questions that the participants had. The second, third, and fourth parts of the discussions consisted of explorations of participants' opinions and understanding of the following:

- Individual arrow displays when mounted on a single work vehicle
- Multiple arrow displays when mounted on several work vehicles
- Individual caution displays when mounted on a single work vehicle

The final part of the focus groups consisted of an open-ended discussion about what participants thought could be a way to change the advance warning area traffic control layout for short-term, mobile, and moving work zones.

Table 1. Targeted focus group participant demographics by location

		Kansas City, Missouri	Lawrence, Kansas	Overland Park, Kansas	West Des Moines, Iowa	Average
Gender	Male	49%	49%	49%	49%	**49%**
	Female	51	51	51	51	**51**
	Total	100	100	100	100	**100**
Age	Under 25	15	16	16	15	**15**
	25 – 39	26	26	26	24	**25**
	40 – 64	44	42	42	44	**43**
	Above 65	15	16	16	17	**16**
	Total	100	100	100	100	**100**
Education Level	No High School Degree	15	12	12	11	**13**
	High School	34	30	30	36	**32**
	Some College	29	32	32	31	**31**
	College Degree	22	26	26	22	**24**
	Total	100	100	100	100	**100**

Source: U.S. Census Bureau and the Federal Highway Administration.

Table 2. Actual focus group participant demographics by location

		Kansas City, Missouri	Lawrence, Kansas	Overland Park, Kansas	West Des Moines, Iowa	Average
Gender	Male	43%	43%	44%	45%	**44%**
	Female	57	57	56	55	**56**
	Total	100	100	100	100	**100**
Age	Under 25	14	28	33	0	**19**
	25 – 39	43	43	45	64	**49**
	40 – 64	43	29	11	18	**25**
	Above 65	0	0	11	18	**7**
	Total	100	100	100	100	**100**
Education Level	No High School Degree	0	0	0	18	**2**
	High School	14	0	33	0	**14**
	Some College	14	57	22	27	**30**
	College Degree	72	45	45	55	**54**
	Total	100	100	100	100	**100**

The arrow displays presented as part of this research are shown in Figure 3. Each arrow display was presented within a conceptualized image of a rural freeway scene showing one or more work vehicles meant to represent the advance warning shadow vehicles for a short-term, mobile, or moving work convoy equipped with arrow displays. The images were intentionally conceptualized to prevent participants from seeing extraneous levels of detail that would inevitably occur if real photographs had been used. The images were intended to show the vehicles just upstream from the crest of a hill, and this was explained at length to the participants; this meant that participants had to rely solely on the advance warning to know what lay ahead. Participants were told that they were approaching the work vehicle(s) from the right lane of a six-lane freeway. The images were displayed to the participants on a projection screen for several minutes while discussions about the specific arrow display(s) took place. The arrows

and chevrons in the images flashed and moved sequentially as appropriate when presented to the participants.

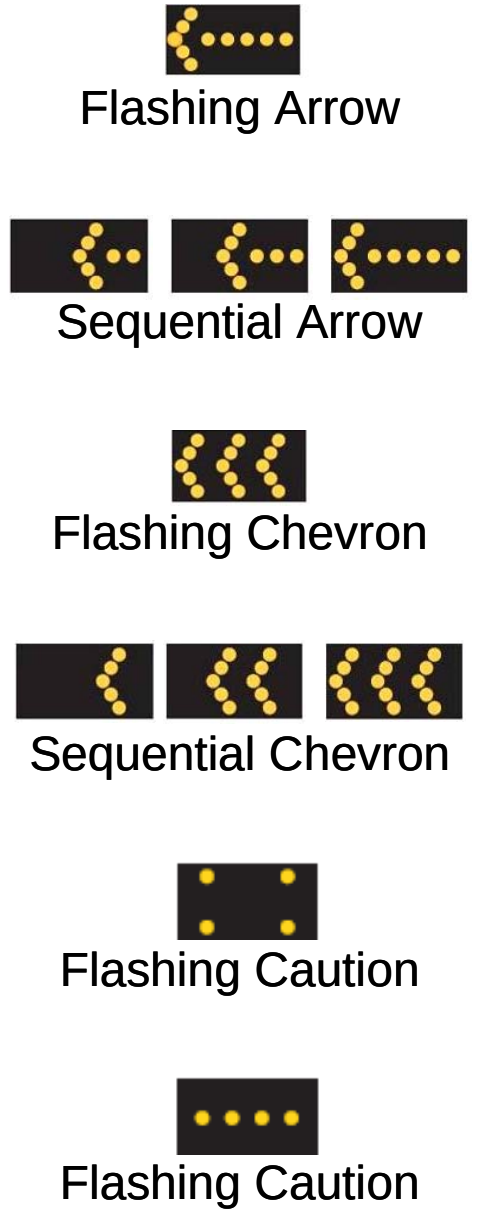


Figure 3. Advance warning arrow and caution displays presented to focus groups

KEY FINDINGS

Individual Arrow Displays when Mounted on a Single Work Vehicle

Figure 4(a) shows the first image shown to the participants: a representation of a shadow vehicle equipped with a flashing arrow display and moving slowly on the shoulder of a rural freeway. Participants were asked what they thought was happening and what they were being told to do by the traffic control devices. The same questions were asked of participants when the same image was shown with a sequential arrow (Figure 4(b)), flashing chevron (Figure 4(c)), and sequential chevron arrow (Figure 4(d)) displayed instead. These cases were designed to examine whether the driving public would associate the specific image on the arrow display with a closed lane, as well as the participants' preference.

Participants' Understanding of Single Arrow Displays

Participants generally understood that they were being directed to move over when shown the image in Figure 4(a). This did not change when participants were shown subsequent images of the sequential arrow (Figure 4(b)), flashing chevron (Figure 4(c)), and sequential chevron displays (Figure 4(d)). However, when asked specifically how many lanes, participants did not universally understand that they were to move over one lane. A minority of participants in each focus group indicated that they were being told to move all the way to the left.

Some participants indicated that, even through they were being told to move over one lane, they were not likely to comply for varying reasons.

- A few participants indicated that they would move all the way to the left lane, not because of the arrow display, but because they were uncomfortable driving near a large work vehicle.
- A small minority of participants in each focus group also admitted that they would not move from the right lane regardless of the arrow display unless they were presented with additional information or were forced to do so.

Interestingly, in all four focus group locations participants indicated that the sequential displays seemed to indicate a more important or critical situation due to the movement within the display.

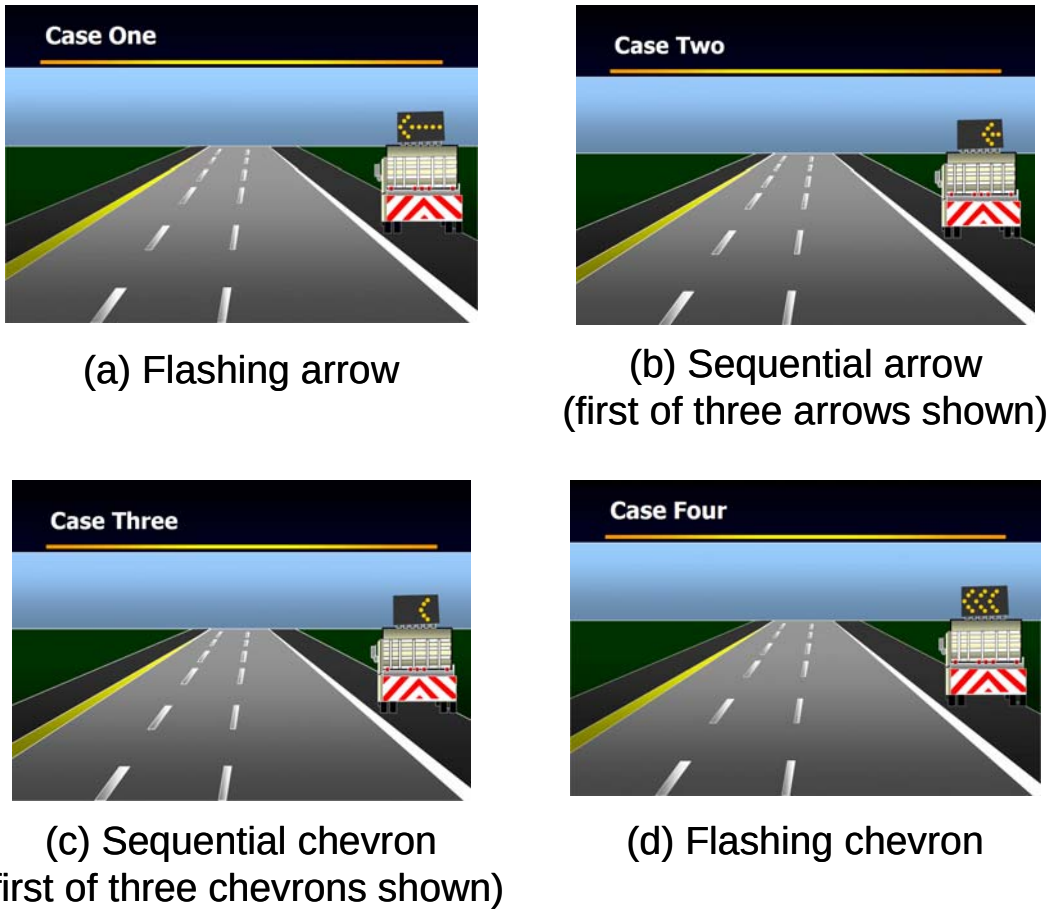


Figure 4. Focus group images showing single work vehicles equipped with arrow display

Comparison of Sequential Chevron Display with Curve Warning Chevrons

In two of the focus group locations, participants pointed out that the sequential chevron display (Figure 4(c)) seemed to be indicating that there was a sharp curve just over the hill rather than a lane closure. This potential discrepancy in meaning is a point of concern for the use of chevron displays compared to arrow displays. Participants did not have this reaction from the flashing chevron display or either of the arrow-type displays.

Participants' Preference of Arrow Display Based on Perceived Effectiveness

Participants were also asked to rate which arrow display they preferred to see based on which one they believed was most effective in conveying a lane closure. The participant preferences included the following:

- Sequential arrow (49% considered this display the most effective)
- Sequential chevron (28%)
- Flashing arrow (19%)
- Flashing chevron (2%)

As noted above, participants were more likely to rate sequential displays as more effective than their flashing counterparts.

Multiple Arrow Displays when Mounted on Several Work Vehicles

Participants were shown several images of two or three work vehicles in various configurations. Each of these images is shown in Figure 5. These images were shown one at a time to participants for several minutes, starting with the image shown in Figure 5(a) and ending with Figure 5(e).

Generally, participants agreed that they were approaching a larger and/or more extensive work zone operation when two work shadow vehicles could be seen instead of one. At each of the four focus group locations, participants noted that for the images shown in Figure 4 they thought it possible that the entire work zone might consist of just the one truck that was visible and could be a single worker collecting trash from the roadside, for example; the presence of two trucks meant that this was not the case. This finding could mean that when a convoy crosses the crest of a vertical curve there may be some advantage in leaving more than a single vehicle behind to alert traffic that they are approaching a work zone. Other findings are discussed in the following subsections.

Participants' Understanding of Multiple Arrow Displays

When shown Figures 5(a) and 5(b), the majority of participants indicated that they would move over at least one lane.

- When asked whether they were being asked to move over one lane or two, most indicated they were being directed to move one lane; a minority indicated two lanes.
- Among those who believed that one lane was being closed, some also commented that they thought this would be an ineffective way of closing two or more lanes.
- As with the images showing a single shadow vehicle, a small minority of participants indicated that they desired to move over two lanes regardless of what was being shown because they disliked driving next to large work vehicles.
- A small portion of participants misinterpreted this to indicate multiple lanes were closed.

These responses remained consistent when shown all of the images shown in Figure 5 for all four focus groups. This indicates that most motorists are likely to correctly interpret multiple arrow displays in a moving convey as indicating that one lane is closed.

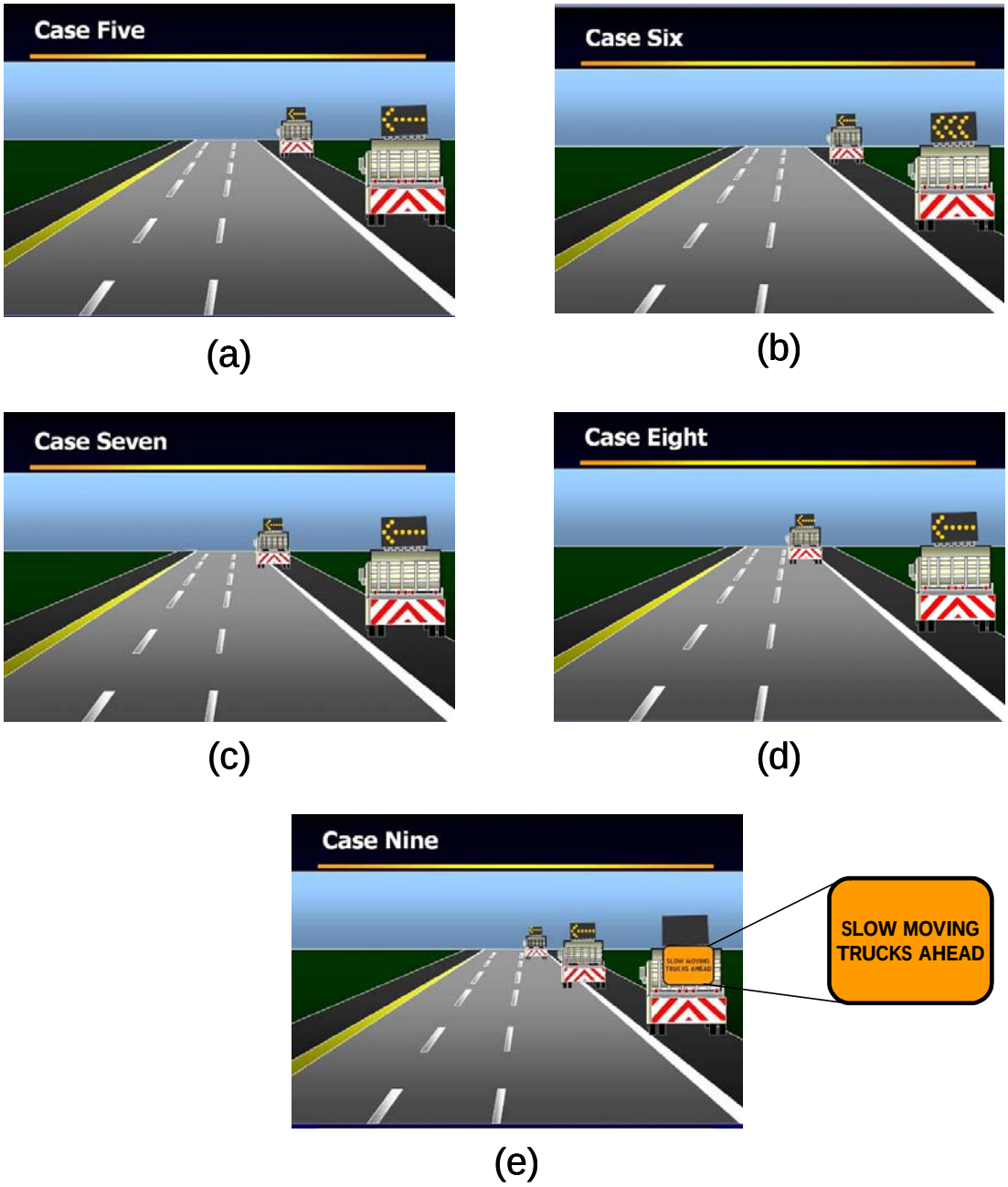


Figure 5. Focus group images showing multiple work vehicles equipped with arrow displays

A small minority of participants in each focus group indicated that they would not vacate the right-hand lane, as they would prefer to drive over the crest of the vertical curve and see for themselves that the lane is actually closed. As expected, this was not an issue for the images shown as Figures 5(c), 5(d), and 5(e). Indeed, participants generally approved of this staggered approach, indicating that this gave positive information regarding the lane closure and would get compliance from even aggressive drivers that would have preferred to remain in the right-hand lane.

Participants' Opinions on Mixing of Multiple Arrow Displays

When shown Figure 5(b), participants were universal in their dislike of displaying different arrow types on two vehicles.

- Example comments by participants were that if they saw this on a real highway they might be inclined to wonder if these two vehicles were part of the same operation or if they were two unassociated individual vehicles that just happened to be in the same vicinity.
- Many participants also commented that at a minimum it appeared that the two truck operators were "not on the same page," and that this reduced the credibility of the message they were conveying to drivers.

These are important statements because in short-term, mobile, and moving work zones the limited traffic control provided by the shadow vehicles is often the only effective safety device protecting workers. If the credibility of this message is degraded, it could correlate to an increased safety risk to workers. While presenting multiple arrow types in a single work area is not disallowed by the MUTCD, many individual states have policies stating that only one arrow type be used statewide or that only one type be used for any given work zone.

Static Signing on Work Vehicles

One final issue discussed in this section of the focus groups was the sample text sign shown in Figure 5(e). Participants were generally in favor of having additional information about the work zone they were approaching. When asked what information would be appropriate to show on such a sign, participants were divided in their opinions at each of the focus group locations.

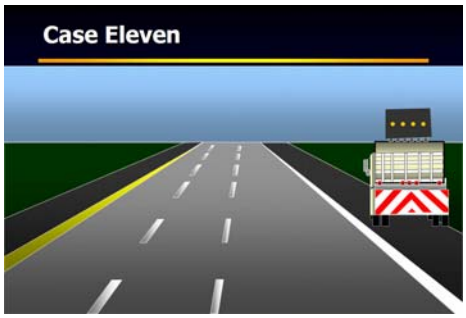
- One group of participants wanted to know what activity was taking place. These participants were interested in what was going on with the work: were they approaching a painting operation that might spray paint on their vehicle? Were they approaching a work area where workers would be out of vehicles and near the traveled lanes?
- Another group of participants wanted to know what they were supposed to do. These participants were less interested in what was happening and stated a preference for positive directions, such as "MOVE OVER," "RIGHT LANE CLOSED," or "MOVE LEFT."

Individual Caution Displays when Mounted on a Single Work Vehicle

Participants were shown two images of single work vehicles with caution displays. These images are shown in Figure 6. These images were shown one at a time to participants for several minutes. Participants were unsure when asked what information the displays were conveying to drivers, and indeed initial reactions by several participants was that the first display shown (Figure 6(a)) did not mean anything. Upon further consideration, the participants began to believe that the message indicated that they would approach the situation with caution, just as if the vehicle were sitting on the shoulder with hazard lights or a flashing amber light. While this is the correct answer, the participants admitted to being less confident in their answers than in earlier sections of the focus group. When told that these were caution displays, comments were given by participants, included the following:

- If the work vehicle has a flashing amber light, is the caution display even necessary?
- There was the possibility that the flashing caution display shown in Figure 6(b) could be confused with an arrow display with several light bulbs burned out

(a) Flashing caution display



(b) Flashing caution display

Figure 6. Focus group images showing single work vehicles equipped with caution displays

CONCLUSIONS

Several interesting findings were uncovered through the focus group meetings. These include the following:

- A few subjects indicated that the sequential chevron display looked more like a curve ahead warning than a lane closure warning.
- A large majority of participants indicated that they preferred sequential displays over flashing displays. Reasons given were that the sequential movement of these displays indicated a more important or critical situation compared to the flashing alternatives.
- The majority of focus group participants understood that multiple arrow displays in a work convoy indicate a single lane closure. Only a small minority of participants misunderstood the message to mean multiple lane closures.
- Participants were generally favorable of staggering work vehicles into the closed lane (as shown in Figures 5(c) through 5(e)), indicating that this provided positive reinforcement of the lane closure message.
- Participants were universal in their disapproval of mixing arrow displays within the same work convoy. The reaction of the participants to mixing arrow display types seems to reinforce state-level decisions in place to prevent this and indicates that national-level consideration of such a prohibition is needed.
- Participants liked the idea of including additional information in the form of static signing on the back of the shadow vehicles, but there was no agreement on the nature of the information. Some participants wanted to know more about the nature of the work being performed, while others were only interested in directions on what they were supposed to do.
- Caution displays were ultimately understood by participants, but participants were less confident in their responses than for other focus group questions, and there was some discussion about whether such displays were even needed if other devices such as flashing amber lights were present.

Each of these findings represents avenues for additional field research into improving the use and understanding of arrow displays. Improved driver understanding of these devices could result in a beneficial improvement in worker safety and is worthy of additional effort.

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REFERENCES

FHWA. 2003. *Interpretation of the Number and Placement of Arrow Displays for Lane Closure*. Washington, DC: Federal Highway Administration, U.S. Department of Transportation. http://mutcd.fhwa.dot.gov/documents/pdf/6-191-I-VA-S.pdf.

FHWA. 2004. *Manual on Uniform Traffic Control Devices*. Washington, DC: Federal Highway Administration, U.S. Department of Transportation. http://mutcd.fhwa.dot.gov/pdfs/2003r1/pdf-index.htm.

FHWA. 2007. *Highway Statistics 2005*. Office of Highway Policy Information, Federal Highway Administration, U.S. Department of Transportation. http://www.fhwa.dot.gov/policy/ohim/hs05/index.htm

University of Texas. 2007. *Focus Group How-To*. Division of Instructional Innovation and Assessment, The University of Texas, Austin. http://www.utexas.edu/academic/diia/assessment/iar/how_to/methods/focus_groups.php

U.S. Census Bureau. 2007. *American FactFinder*. U.S. Census Bureau, U.S. Department of Commerce. http://factfinder.census.gov/home/saff/main.html?_lang=en.