Traffic Control Devices Pooled Fund Study

Evaluation of Truncated Arrow-per-Lane Guide Signs

Final Report

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INTRODUCTION

BACKGROUND

Some freeway and expressway interchanges contain an interior option lane in which traffic in that lane can choose to exit or remain on the route at the split. The 2009 MUTCD requires that either the Overhead Arrow-per-Lane or Diagrammatic guide sign designs be used for all multi-lane exits at major interchanges that have an optional exit lane that also carries the through route.[1] The MUTCD advises that the Overhead Arrow-per-Lane guide sign design should also be considered for multi-lane exits with an option lane at intermediate and minor interchanges. However, some practitioners believe that it is cost-prohibitive and unnecessary to install Overhead Arrow-per-Lane guide signs at intermediate and minor interchanges. The MUTCD allows the use of a combination of conventional guide signing and regulatory lane-use signing when the inclusion of the Overhead Arrow-per-Lane guide sign design is not warranted.

Some research has shown that conventional guide signs may produce fewer lane-placement errors and exit lane errors than certain types of diagrammatic signs.[2] Conventional signs, however, lack the ability to display lane-choice configurations. In a 1992 survey, Brackett, Huchingson, Trout and Womack found that modified diagrammatic signs which provided separate arrows for each lane (such as the current Overhead Arrow-per-Lane sign design) were more effective in communicating lane assignment than the original diagrammatic sign.[3] A recent study by Golembiewski and Katz (2008) investigated the usage of an Overhead Arrow-per-Lane sign compared with original Diagrammatic guide signs. The results indicated that the Arrow-per-Lane sign type is appropriate for drivers of all ages, but is especially beneficial for older drivers. Therefore, the researchers concluded that, with regard to decision sight distance and correct lane choice, the Overhead Arrow-per-Lane sign provides superior navigation guidance.[4]

Given the benefits of Overhead Arrow-per-Lane guide signs, a condensed version of an Overhead Arrow-per-Lane guide sign is needed for use where a full Overhead Arrow-per-Lane guide sign is not a reasonable option. For example, sections of highway that have a high number of through lanes would require extremely large signs, and equally large span trusses to support it. A truncated version of Overhead Arrow-per-Lane signs, which could be displayed on existing cantilever structures, would eliminate the expense of installing larger structures, while still reaping the benefits of the arrow-per-lane sign concept. The arrow-per-lane concept might not be a reasonable option where there are closely spaced interchanges, e.g. in urban areas, and the advance guide signs for downstream interchanges must share the same structures as the option lane signing when sign spreading, as recommended in the MUTCD, is not possible due to other constraints. Thus, recommendations have been made for an alternative design, such as a truncated Arrow-per-Lane design.

RESEARCH GOALS

The Traffic Control Devices Pooled Fund Study (TCD PFS) is a continual effort that conducts systematic evaluations of human factors and operations issues associated with novel TCD ideas. As part of this effort, the FHWA Human Factors Team is evaluating five Truncated Arrow-per-Lane sign design alternatives for use on highways where multi-lane exits and option lanes exist.

Objectives

The current research study was designed with the following two objectives in mind:

1. Identify truncated versions of the Overhead Arrow-per-Lane guide sign.
2. Evaluate effectiveness of the Overhead Arrow-per-Lane guide sign and any identified truncated versions compared to allowable MUTCD practices and other common practices.

STIMULI

Five truncated signing alternatives were identified for potential use at minor and intermediate interchanges which have multi-lane exits and an option lane.

Alternative 1: Truncated Arrow-per-Lane

Alternative 1 is a truncated version of the Overhead Arrow-per-Lane guide sign design. This version includes only the up-arrows for the two right-most lanes (i.e., option lane and exit only lane), rather than also showing up-arrows for all adjacent through lanes. An example of alternative 1 is shown in Figure 1.

Figure 1. Alternative 1: Truncated Arrow-per-Lane Guide Sign Series

This sign is part of a three-sign series in which the first sign is located one mile from the exit gore, the second sign is placed approximately one half mile from the gore, and the third sign is placed near the gore.

Alternative 2: Overhead Arrow-per-Lane

Alternative 2 is the Overhead Arrow-per-Lane guide sign design which is currently recommended through guidance statements for minor and intermediate interchanges which have multi-lane exits with an option lane (adapted from Figure 2E-4 in the MUTCD).[1] This design includes one upward-pointing arrow per lane, which in turn indicates to the driver the number of lanes and the direction of each lane. An example of alternative 2 is shown in Figure 2.

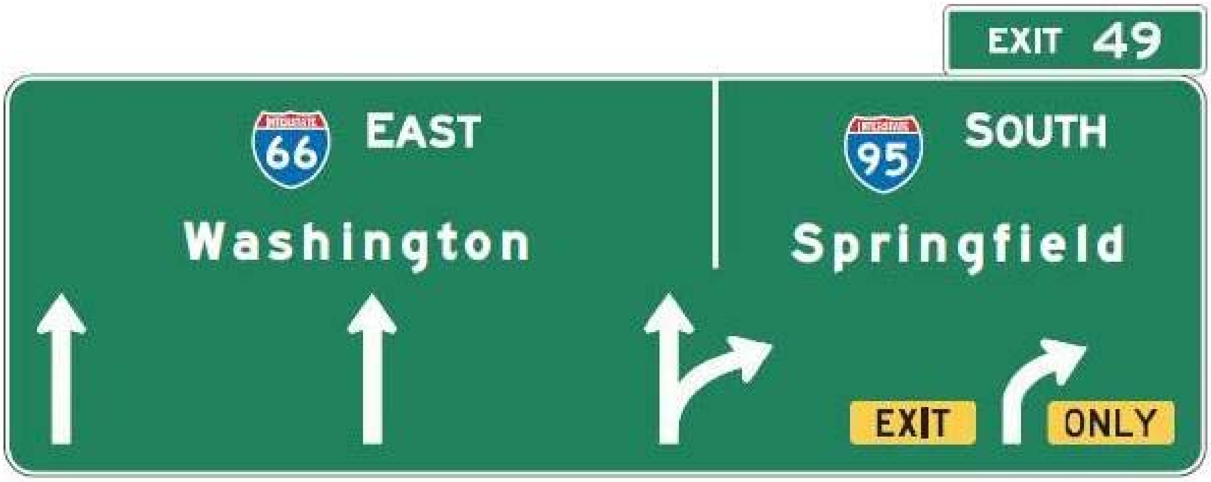


Figure 2. Alternative 2: Arrow-per-Lane Guide Sign Series

This sign is part of a three-sign series in which the first sign is located one mile from the exit gore, the second sign is placed approximately one half mile from the gore, and the third sign is placed near the gore.

Alternative 3: Truncated Arrow-per-Lane with Pull Through

Alternative 3 is a truncated version of the Overhead Arrow-per-Lane guide sign design. This version includes the arrow per lane style signing for the two right-most lanes (i.e., option lane and exit only lane). Instead of including the route shield and cardinal direction for the through destination on the primary sign (as is done in alternative 1), this information is presented on a secondary Pull-Through sign located on the same assembly. An example of alternative 3 is shown in Figure 3.

Figure 3. Alternative 3: Truncated Arrow-per-Lane with Pull Through

This pair of signs is part of a three-sign series in which the first sign is located one mile from the exit gore, the second sign is placed approximately one half mile from the gore, and the third sign is placed near the gore. Both signs shown in Figure 3 were used at each of the three locations in the sign series.

Alternative 4: Minor Interchange

Alternative 4 is the current MUTCD recommendation for signing at intermediate and minor multi-lane exits with an option lane when Overhead Arrow-per-Lane or Diagrammatic guide signing has been determined not to be warranted based such factors as the extent of the need for the option lane and the type of the traffic exiting during high-volume periods (adapted from Figure 2E-11 in the MUTCD).[1] An example of alternative 4 is shown in Figure 4.

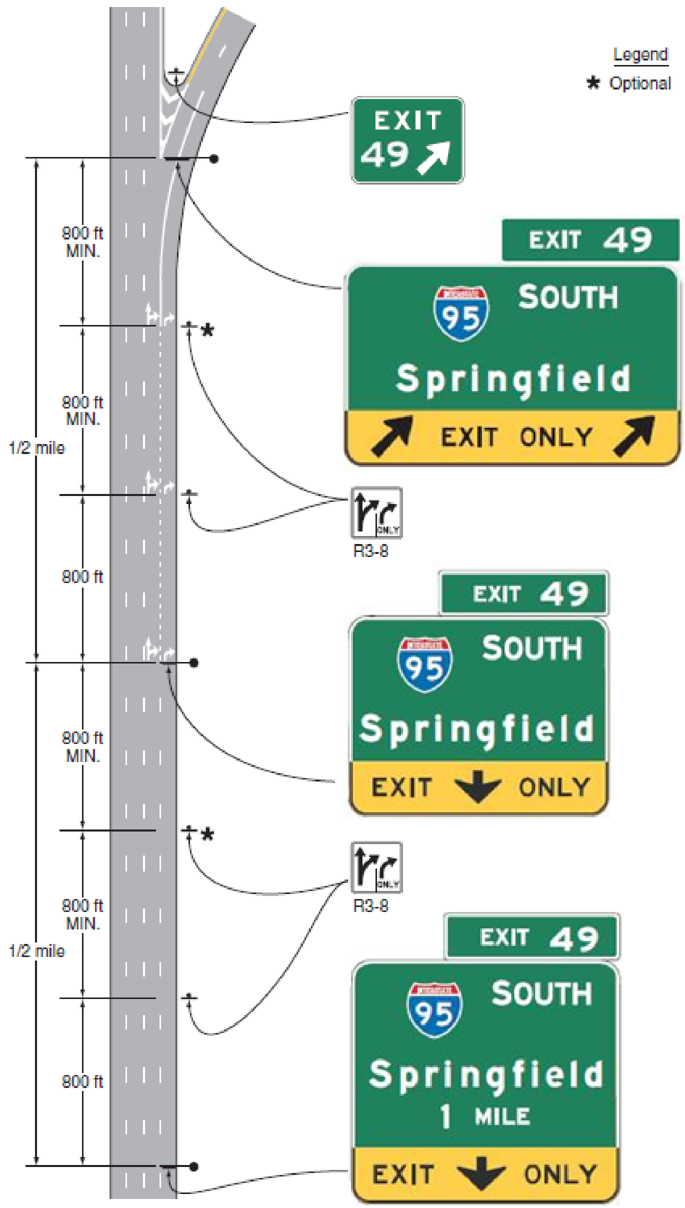


Figure 4. Alternative 4: Minor Interchange Guide Sign Series

This sign is part of a three-sign series in which the first sign is located one mile from the exit gore, the second sign is placed approximately one half mile from the gore, and the third sign is placed near the gore. This sign series is also used in conjunction with a post-mounted lane-use sign (R3-8 Series).

Alternative 5: Conventional Arrows

Alternative 5 is commonly used by many agencies to convey the presence of option lanes. An example of alternative 5 is shown in Figure 5.

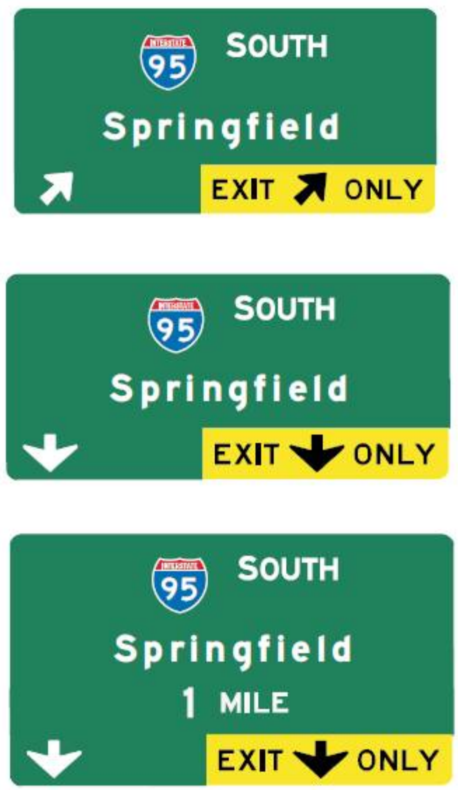


Figure 5. Alternative 5: Conventional Arrows Guide Sign Series

This sign is part of a three-sign series in which the first sign is located one mile from the exit gore, the second sign is placed approximately one half mile from the gore, and the third sign is placed near the gore.

METHOD

The research was conducted in the Washington, D.C. metropolitan area. Participants were seated at a table in front of a laptop computer. Participants viewed videos of signs played on the laptop and were given worksheets for recording their responses. Each video displayed one of the five signing series alternatives. A researcher was seated next to the participant in order to run the videos and ensure the participants were recording their responses properly.

Each participant was exposed to only one of the five signing conditions. Prior to viewing the videos, participants were instructed that they were traveling to Interstate 95 South toward Springfield, and were given instructions to indicate which lanes they could use to reach their destination, and which lanes they could not use to reach their destination. Each participant viewed two videos; one video had Interstate 95 South/Springfield as the exiting destination, and the other video had it as the through destination. Interstate 66 East toward Washington was always used as the alternate destination, i.e., the destination other than their target destination. The presentation order of the videos was randomized.

The videos contained 4 visible travel lanes, and ran at a simulated speed of 55 mi/h. In each video, the lane point-of-view was from the left center lane. After passing the first sign in the series, the video was paused with the sign just out of view. Participants then marked on their response sheets which lanes they could and could not use to continue to Interstate 95. Lanes they could use were circled and lanes they could not use were marked with an "X." The video continued in this manner, pausing after each sign in the series so the participant could record their response.

PARTICIPANTS

The study employed a sample of 100 research participants (50 male and 50 female). Males ranged from 18 years to 71 years (M = 31.4 years) and females ranged from 18 years to 90 years (M = 38.3 years). Each participant possessed a valid state driver's license. Including instructions, signing of informed consent, and debriefing, the evaluation took about 15 minutes to complete. Each participant was paid $10.

RESULTS

Table 1 and Table 2 show the percentage of participants who selected each lane at each sign in the series for exiting destination directions and through destination directions, respectively. Correct lane selections are highlight in red italics. For example, Table 1 indicates that, when considering participants who viewed Alternative 1, after viewing the first sign in the series 25% reported that they could use Lane 1 to reach their destination, 25% reported they could use Lane 2 to reach their destination, 50% reported they could use Lane 3 to reach their destination, and 75% reported they could use Lane 4 to reach their destination. As Table 1 represents the exiting destination condition, only Lanes 3 and 4 could have actually been used to reach their destination, thus they are highlighted in red.

Table 1. Percentage of participant selections for each lane at each sign in the series for exiting destination directions.

Sign Alternative	Order in Series	Lane 1 Through	Lane 2 Through	Lane 3 Option	Lane 4 Exit
Alternative 1	1st Sign	25.0	25	*50.0*	*75.0*
	2nd Sign	10.0	20	*60.0*	*85.0*
	3rd Sign	10.0	15	*45.0*	*90.0*
Alternative 2	1st Sign	9.5	14.3	*90.5*	*90.5*
	2nd Sign	14.3	14.3	*85.7*	*85.7*
	3rd Sign	9.5	9.5	*90.5*	*90.5*
Alternative 3	1st Sign	4.8	00.0	*90.5*	*95.2*
	2nd Sign	4.8	00.0	*90.5*	*95.2*
	3rd Sign	4.8	00.0	*85.7*	*90.5*
Alternative 4	1st Sign	15.0	20.0	*35*	*80.0*
	2nd Sign	20.0	20.0	*50*	*80.0*
	3rd Sign	15.0	15.0	*70*	*85.0*
Alternative 5	1st Sign	21.1	26.3	*68.4*	*68.4*
	2nd Sign	26.3	31.6	*63.2*	*57.9*
	3rd Sign	26.3	31.6	*57.9*	*63.2*

Table 2. Percentage of participant selections for each lane at each sign in the series for through destination directions.

Sign Alternative	Order in Series	Lane 1 Through	Lane 2 Through	Lane 3 Option	Lane 4 Exit
Alternative 1	1st Sign	*65.0*	*70.0*	*60.0*	5.0
	2nd Sign	*65.0*	*65.0*	*65.0*	5.0
	3rd Sign	*65.0*	*75.0*	*50.0*	5.0
Alternative 2	1st Sign	*90.5*	*95.2*	*90.5*	4.8
	2nd Sign	*85.7*	*90.5*	*90.5*	9.5
	3rd Sign	*90.5*	*90.5*	*95.2*	9.5
Alternative 3	1st Sign	*85.7*	*85.7*	*71.4*	14.3
	2nd Sign	*85.7*	*95.2*	*71.4*	9.5
	3rd Sign	*85.7*	*90.5*	*76.2*	9.5
Alternative 4	1st Sign	*50.0*	*60.0*	*60.0*	35.0
	2nd Sign	*55.0*	*55.0*	*65.0*	40.0
	3rd Sign	*55.0*	*55.0*	*55.0*	40.0
Alternative 5	1st Sign	*52.6*	*57.9*	*52.6*	26.3
	2nd Sign	*63.2*	*68.4*	*47.4*	26.3
	3rd Sign	*63.2*	*68.4*	*42.1*	15.8

Data were considered as one set of responses per participant. Each set consisted of three questions, corresponding to each of the three signs in the series. If the participant selected all of the correct lanes, and only correct lanes, then he/she received a score of "1" for the question. Conversely, if the participant did not select all of the correct lanes and/or selected one or more incorrect lanes, then he/she received a score of "0" for the question. Thus there were eight possible outcomes for each set of responses – (0,0,0), (0,0,1), (0,1,0), (0,1,1,), (1,0,0), (1,1,0), (1,0,1), and (1,1,1) – where the position in the set corresponded to the question following that sign number (e.g., a "1" in the first position corresponded to answering correctly on the question following the first sign in the series).

Frequencies and row percentages (i.e., percentage of responses for a given sign alternative) are presented in Table 3 and Table 4 below for exiting and through destination directions, respectively. Generally speaking, the majority (75%-95%) of responses for each alternative and destination combination were either (0,0,0) or (1,1,1). In other words, participant responses were usually either all incorrect (incorrect for all three signs in the series) or all correct (correct for all three signs in the series). However, this was not the case for Alternative 4 for the exiting destinations. In this condition, only 35% of participants were either all correct or all incorrect, meaning that 65% of participants changed their responses at some point in the sign series.

Three possible outcomes contained situations where the participant's responses were correct at some point during the sign series, but ultimately changed to incorrect by the end of the series; these outcomes were either (0,1,0), (1,0,0), or (1,1,0). Columns corresponding to these outcomes are highlighted in red in Table 3 and Table 4. When considering all alternatives, these correct-to-incorrect changes constituted about 8% of the responses for the exiting destinations and about 10% of the responses for the through destinations. The remaining three possible outcomes contained situations where the participant's responses were incorrect at some point during the sign series, but ultimately changed to correct by the end of the sign series; these outcomes were either (0,0,1), (0,1,1), or (1,0,1). Columns corresponding to these outcomes are highlighted in green in Table 3 and Table 4. Such incorrect-to-correct changes constituted about 18% of the responses for the exiting destination directions and about 8% of the responses for the through destination directions. Also, it should be noted that about 46% of such incorrect to correct changes occurred when using Alternative 4 for the exiting destination directions. Additionally, of all incorrect-to-correct changes when using Alternative 4 for the exiting destination, approximately 58% of these changes came from the (0,1,1) outcome.

Table 3. Frequencies (first row in cell) and row percentages (second row in cell) of each outcome of the set of responses by sign alternative for exiting destination directions.

Sign Alternative	(0,0,0)	(0,0,1)	(0,1,0)	(0,1,1)	(1,0,0)	(1,0,1)	(1,1,0)	(1,1,1)
Alternative 1	50.00	5.00	5.00	5.00	0.00	0.00	10.00	25.00
Alternative 2	14.29	0.00	0.00	4.76	0.00	4.76	0.00	76.19
Alternative 3	9.52	0.00	0.00	0.00	0.00	0.00	9.52	80.95
Alternative 4	25.00	20.00	0.00	35.00	5.00	5.00	0.00	10.00
Alternative 5	47.37	5.26	0.00	0.00	10.53	5.26	0.00	31.58

Table 4. Frequencies (first row in cell) and row percentages (second row in cell) of each outcome of the set of responses by sign alternative for through destination directions.

Sign Alternative	(0,0,0)	(0,0,1)	(0,1,0)	(0,1,1)	(1,0,0)	(1,0,1)	(1,1,0)	(1,1,1)
Alternative 1	60.00	0.00	0.00	5.00	5.00	0.00	10.00	20.00
Alternative 2	14.29	4.76	0.00	0.00	0.00	0.00	0.00	80.95
Alternative 3	23.81	9.52	0.00	4.76	4.76	0.00	4.76	52.38
Alternative 4	60.00	0.00	0.00	5.00	5.00	5.00	5.00	20.00
Alternative 5	57.89	0.00	0.00	5.26	10.53	0.00	5.26	21.05

Data were then analyzed using Generalized Estimating Equations (GEE), which is an appropriate methodology for categorical data when each participant contributes more than one measurement. A binomial response distribution and logit (log odds) link function were assumed. Variables included in the model were sign *condition* (Alternative 1, Alternative 2, Alternative 3, Alternative 4, or Alternative 5), destination *direction* (exiting destination or through destination), sign *view* (after first sign in series, after second sign in series, or after third sign in series), and all corresponding second- and third-order interactions. Table 5 presents the Type III statistics for this analysis. *Condition* was the only significant effect; χ^2 (4) = 28.32, $p < 0.01$.

Table 5. Type III statistics for GEE model analyzing participant responses by condition, direction, view, and corresponding interactions.

	Df	Chi-Square	Pr > ChiSq
Condition	4	28.32	<0.0001
Destination	*1*	*0.07*	*0.7985*
View	*1*	*0.28*	*0.5983*
*Condition*Destination*	*4*	*8.12*	*0.0872*
*View*Destination*	*1*	*1.80*	*0.1799*
*View*Condition*	*4*	*9.32*	*0.0536*
*View*Condition*Destination*	*4*	*8.80*	*0.0663*

Based on the information presented in Table 5, the order of responses in the set did not significantly affect how the participant would answer. Also, the majority of participant responses were either all correct or all incorrect for a given sign series. This means that regardless of how many times a participant viewed a sign in a series, his/her initial response after viewing the first sign typically did not change. However, as there were situations where a participant changed responses from incorrect to correct during the series, researchers decided to use the response on the last sign in the series to determine which sign alternatives were the best and whether participant performance was dependent upon the destination direction.

For the remaining statistical analyses, "overall correctness" was defined by participant responses after viewing the third sign in the series. In other words, if the participant selected all (and only) the correct lanes that he/she could use to reach Interstate 95 South toward Springfield after viewing the last sign in the series, then he/she was considered correct. The entire series of responses were not analyzed because, theoretically, as long as the driver understood which lanes they could use by the third sign, they should be able to make the appropriate lane maneuvers to reach their destination.

Chi-squared tests were performed on contingency tables to examine the relationships between sign alternative, destination direction (exiting or through), and overall correctness. Likelihood ratio chi-squared statistics are reported.

OVERALL CORRECTNESS BY SIGN ALTERNATIVE

A chi-squared test indicated that overall correctness and sign alternative are associated; $\chi^2\,(4) = 40.64$, $p < 0.001$. Table 6 shows the percentage of correct responses by sign series alternative.

Table 6. Percentage of overall correctness by sign series alternative (N = 20 for each sign alternative).

Sign Alternative	Correct Responses
Alternative 1	30.00
Alternative 2	85.71
Alternative 3	73.81
Alternative 4	47.50
Alternative 5	36.84

Alternative 1, Alternative 4, and Alternative 5 yielded more incorrect responses than correct responses. Alternative 2 and Alternative 3 yielded more correct responses than incorrect responses, with Alternative 2 yielding the highest percentage of correct responses.

When comparing Alternative 2 and Alternative 3 (the alternatives which resulted in the high percentages of correct responses), there was no significant difference in the proportion of correct responses. Therefore, responses from these two sign alternatives were combined (M = 79.76%) for comparison with the remaining sign alternatives.

When comparing Alternative 4 and Alternative 5 (the alternatives which resulted in the two next highest percentages of correct responses, though both were below 50%), there was no significant difference in the proportion of correct responses. Therefore, responses from these two sign alternatives were combined (M = 42.31%) for comparison with the remaining sign alternatives.

When comparing the Alternative 4/Alternative 5 combination with Alternative 1, there was no significant difference in the proportion of correct responses. Therefore, the responses from these sign alternatives were also combined. The resulting percentages of correct responses for the two groups are shown in

Table 7.

Table 7. Percentage of overall correctness for combined sign series alternatives.

Sign Alternative	Correct Responses
Alternative 2/Alternative 3	79.76

Alternative 1/Alternative 4/Alternative 5	38.14

When considering the comparison of Alternatives 2 and 3 combined against Alternatives 1, 4, and 5 combined, there was a significant difference in the percentage of correct responses; $\chi^2(1) = 36.14$, $p < 0.001$.

OVERALL CORRECTNESS BY DESTINATION DIRECTION

Results were analyzed to determine if destination direction (i.e., through or exit) was associated with correct responses. A chi-squared test indicated that overall correctness and destination direction are associated; $\chi^2(1) = 5.15$, $p < 0.023$. The estimated odds of answering correctly was about 91% higher for exiting directions than for through directions. Table 8shows the percentage of correct responses by sign alternative.

Table 8. Percentage of overall correctness by destination direction.

Destination Direction	Correct Responses
Exit	63.37
Through	47.52

OVERALL CORRECTNESS BY SIGN ALTERNATIVE WITHIN DESTINATION DIRECTION

Because destination direction had a significant effect on overall correctness, the sample was analyzed by sign series alternative within each direction. Table 9 shows the percentage of correct responses by alternative, within each destination direction.

Table 9. Percentage of correct responses by sign series alternative within each destination direction.

Sign Alternative	Correct Responses	
	Exiting	Through
Alternative 1	35.00	25.00
Alternative 2	85.71	85.71
Alternative 3	80.95	66.67
Alternative 4	65.00	30.00
Alternative 5	47.37	26.32

When considering only exiting destinations, overall correctness and sign alternative were significantly associated; χ^2 (4) = 16.95, p = 0.002. Overall correctness and sign alternative were significantly associated when considering only through destinations as well; χ^2 (4) = 26.98, $p <$ 0.001. Alternative 2, Alternative 3, and Alternative 4 yielded more correct responses than incorrect responses for exiting destinations. Similarly, Alternative 2 and Alternative 3 resulted in more correct responses than incorrect responses for through destinations; however, for through destinations, Alternative 4 yielded more incorrect responses than correct responses. For both destinations, the highest percentage of correct responses occurred under Alternative 2 and the lowest percentage of correct responses occurred under Alternative 1.

When comparing Alternative 2 and Alternative 3 (these alternatives resulted in relatively high percentages of correct responses for each destination) there was no significant association between overall correctness and sign alternative within exiting destinations. There was also no significant association between overall correctness and sign alternative within through destinations. Therefore, the results from these alternatives were combined for further comparison to other sign alternatives within each respective destination.

When comparing Alternative 4 and Alternative 5 (resulting in the next two highest percentages of correct responses for each destination) there was no significant association between overall correctness and sign alternative within exiting destinations. There was also no significant association between overall correctness and sign alternative within through destinations. Therefore, the results from these alternatives were combined for further comparison to other sign alternatives within each respective destination.

When comparing the Alternative 4/Alternative 5 combination with Alternative 1, there was no significant association between overall correctness and sign alternative within exiting destinations and within through destinations. Therefore, the responses from these sign alternatives were also combined. The resulting percentages of correct responses are shown inTable 10.

Table 10. Percentage of overall correctness for combined sign series alternatives within each destination direction.

Sign Alternative	Correct Responses	
	Exiting	Through
Alternative 2/Alternative 3	83.33	76.19
Alternative 1/Alternative 4/Alternative 5	49.15	27.12

Finally, when considering the comparison of Alternatives 2 and 3 combined against Alternatives 1, 4, and 5 combined, there was a significant association between overall correctness and sign alternative within exiting destinations;χ^2 (1) = 13.09, $p < 0.001$. The significant association was also present for through destinations; χ^2 (1) = 24.70, $p < 0.001$. When considering the distribution of correct to incorrect responses within each destination direction, Alternatives 2 and 3 resulted in distributions of approximately 75/25 for each direction, whereas Alternatives 1, 4, and 5 resulted in correct to incorrect response distributions of approximately 50/50 for exiting destinations and 25/75 for through destinations.

For exiting destinations, the estimated odds of responding correctly were significantly higher for Alternative 2 and 3 than for Alternatives 1, 4, and 5. For through destinations, the estimated odds of responding correctly were significantly higher for Alternatives 2 and 3 than for Alternatives 1, 4, and 5.

The extreme difference between the increases in odds is logical given the lack of similar response distributions between the two destination directions for Alternatives 1, 4, and 5. In other words, there is a larger increase in odds for the through destinations since more participants under Alternatives 1, 4, and 5 responded incorrectly compared to the number of participants under Alternatives 2 and 3 who responded incorrectly.

DISCUSSION AND CONCLUSIONS

The results indicated that the majority of participants either responded always incorrectly or always correctly throughout the sign series. In other words, there was not much variation between signs 1, 2 and 3 in the series; most participants who started correct, remained correct throughout the series, and most that started incorrect, remained incorrect throughout the series. However, this was not the case for Alternative 4 for the exiting destinations. In this condition, 65% of participants changed their responses at some point in the sign series. The majority of these responses (92%) were incorrect-to-correct changes, meaning that the participant was incorrect at some point during the sign series, but ultimately changed to a correct response by the last sign in the series.

One explanation of this may be the limited information provided by the first two signs in this series; these signs simply indicate “Exit Only” for Lane 4 (right lane), and provide no additional guidance information regarding an option lane or the through destination and only a regulatory lane-use sign (R3-8) is used. Thus, when participants have the through destination, they may have seen the “Exit Only” information for Lane 4, and easily deduced that they could use the other three lanes to reach their destination. However it’s not surprising that participants would be more likely to change their minds for the exiting destinations, as more interpretation of the “Exit Only” information may be required in order to respond. It is interesting to note that, when considering the exiting destinations for Alternative 4, approximately 58% of incorrect-to-correct changes occurred after viewing the second guide sign. This implies that the R3-8 regulatory lane-use sign may have given participants the additional information they needed to make a correct decision, as they were exposed to this sign after giving their response to the first overhead guide sign. The remaining 41% of incorrect-to-correct changes occurred after viewing the third guide sign in the series. This is also not surprising, as participants were exposed to another R3-8 sign between the second and third guide signs, and were also given additional information on the exit lanes on the third guide sign.

Because there was little variation between signs within a signing series for the majority of the alternatives, and because there were some participants who changed from incorrect to correct within a series, the remaining analyses looked at correctness based only on participant responses for the third sign in a signing series. It was found that the odds of understanding all lanes which can be used to reach a destination (when using either the exit or through direction) were significantly higher under Alternatives 2 and 3 than under Alternatives 1, 4, and 5. Alternatives 2 and 3 had comprehension rates of approximately 86% and 74%, respectively. In contrast, Alternatives 1, 4, and 5 all had comprehension below 50%, with approximately 30%, 48%, and 37% correct responses, respectively.

It is also important to consider sign alternative within destination direction. When participants were intending to exit, the odds of understanding all lanes which could be used to reach the destination were significantly higher for Alternatives 2 and 3 than for Alternatives 1, 4, and 5. When participants needed to use the through lanes, the odds of understanding all lanes which could be used were significantly higher for Alternatives 2 and 3 than for Alternatives 1, 4, and 5. These results are not surprising as Alternatives 4 and 5 provide no information on the through destination. Although Alternative 1 does provide some information on the through destination, participants may have misinterpreted the arrows indicating the option lane. Thus, without this additional information, it is possible that motorists may not understand if the sign is indicating that they should exit for 95 South/Springfield, or that the entire road is 95 South toward Springfield, except for the “exit only” lanes, which lead somewhere else.

Of those participants who viewed Alternative 1, the percentage of correct responses for exiting destinations (35%) and through destinations (25%) indicates that participants do not understand all lanes which can be used for either destination direction. When considering lane selections for exiting destinations (see Table 1) after viewing the third sign in Alternative 1, there was a 45% difference between the option lane (Lane 3) and the adjacent correct lane (Lane 4). This is a much greater difference than those seen for Alternative 2 (0%), Alternative 3 (4.8%), Alternative 4 (15%) and Alternative 5 (5.3%). While the difference between selections of the option lane (Lane 3) and the adjacent correct lane (Lane 2) for Alternative 1 was not as high for through destinations (25%; see

Table 2), it was still higher than the corresponding difference for most other alternatives. This indicates that, even though Alternative 1 does provide information on the through destination, the concept of the option lane is not adequately conveyed by the signing alternative.

It is important to recognize that participants in the Washington, DC area are familiar with Alternative 5 as it is in common use in the area; however, participants were still unable to understand the intended meaning of the sign.

Based on these results, Alternatives 1, 4, and 5 are not recommended as suitable options for option lane signing, as they do not effectively convey all lanes which can be used when there are multi-lane exits with an option lane. Alternatives 2 and 3 both had high comprehension and were much more effective in conveying the intended information. Therefore, of the alternatives tested, Alternative 3 would be the best option for a truncated version of the Overhead Arrow-per-Lane guide sign at intermediate and minor interchanges which have multi-lane exits and an option lane. Additional testing would be required to determine the effect of adding pull-through signs to Alternatives 1, 4, and 5 when compared with Alternatives 2 and 3. However, such a modification of those alternatives would preclude the use of cantilevered mountings and would require a full overhead span across the highway. Since one of the goals of this project was to consider alternatives that did not require full overhead spans, the feasibility of this additional research should be evaluated compared with the expected benefits.

REFERENCES

1. *Manual on Uniform Traffic Control Devices for Streets and Highways*. FHWA, U.S. Department of Transportation, Washington, D.C., 2009.
2. Gordon, D.A. (1972). "Evaluation of Diagrammatic Guide Signs." Highway Research Record, 414, pp. 30-41
3. Brackett, Q., Huchingson, R.D., Trout, N.D., and Womack, K. (1992). "Study of Urban Guide Sign Deficiencies." Transportation Research Record, 1368.
4. Golembiewski, G. & Katz, B.J. *Diagrammatic Freeway Guide Sign Design.* Final Report. Traffic Control Device Pooled Fund Study*, May 2008.*

APPENDIX A

Instructions to Participants

I am going to show you two brief videos; each video is about 2 minutes long. As you view each video, please imagine that you are driving on this 4-lane road shown in the video.

You are driving to Interstate 95 South toward Springfield. When the video pauses, you will be asked to state which lanes you can and cannot use to continue to Interstate 95 South toward Springfield. You will mark the lanes you CANNOT use with an “X” and circle the lanes you CAN use.

Do you have any questions?

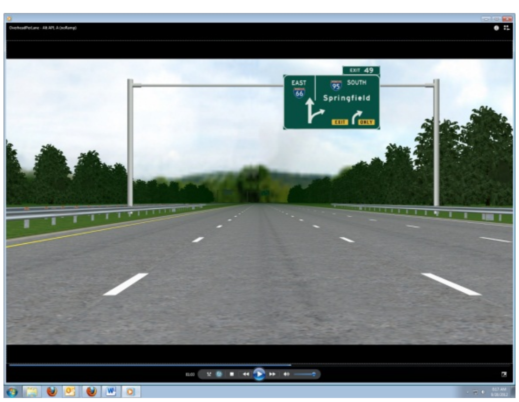
APPENDIX B

Screen Shots from Test Videos
CONDITION 1 (VIEW A)

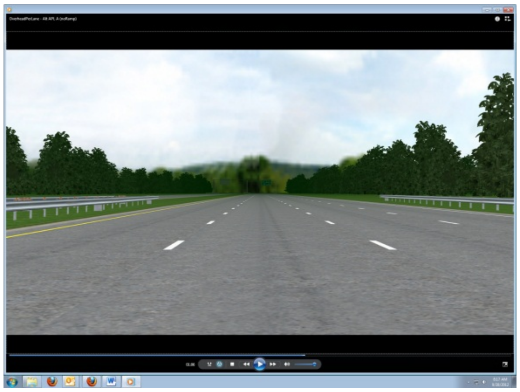
SIGN 1

QUESTION 1

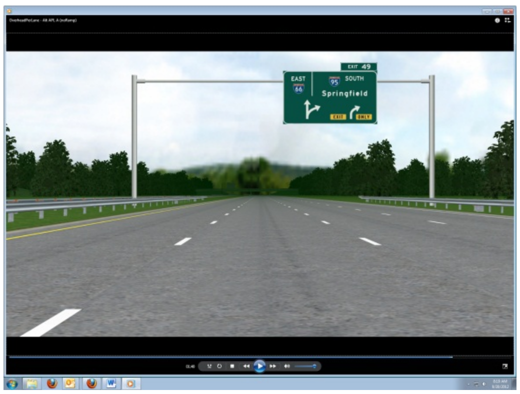
SIGN 2



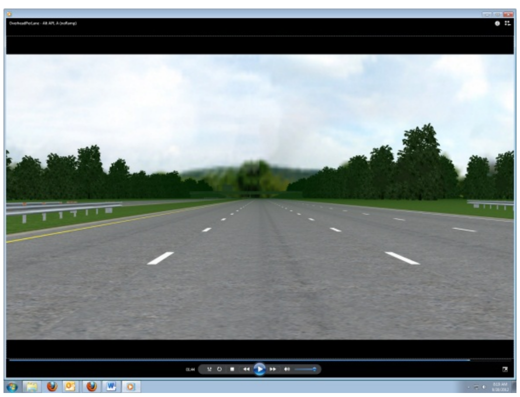
QUESTION 2



SIGN 3



QUESTION 3



CONDITION 2 (VIEW A)

SIGN 1

QUESTION 1

SIGN 2

QUESTION 2

SIGN 3

QUESTION 3

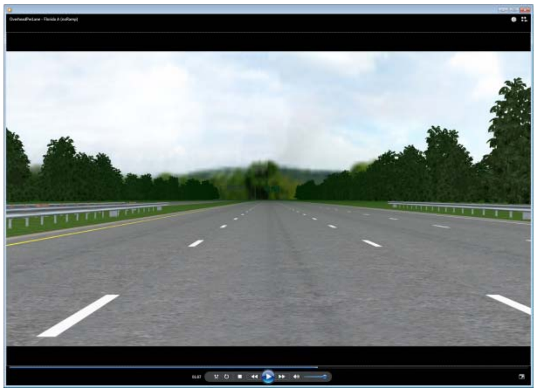
CONDITION 3 (VIEW A)

SIGN 1

QUESTION 1

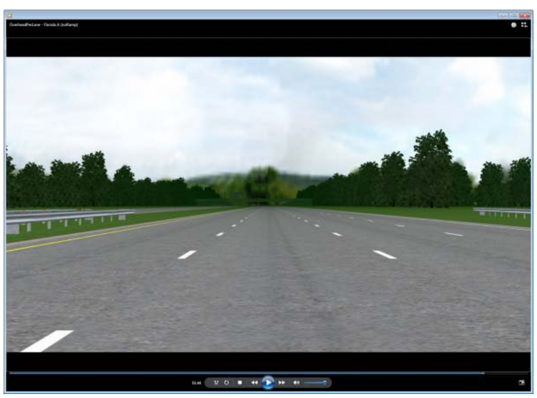
SIGN 2

QUESTION 2



SIGN 3

QUESTION 3

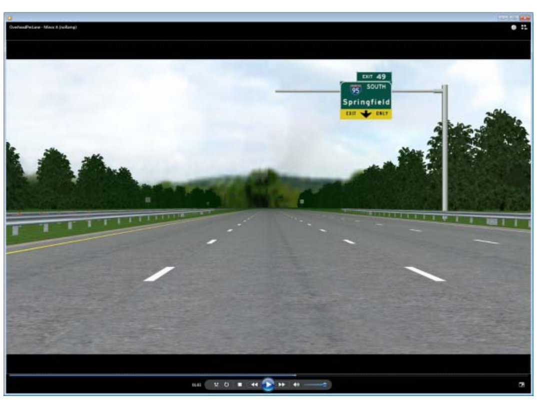


CONDITION 4 (VIEW A)

SIGN 1

QUESTION 1

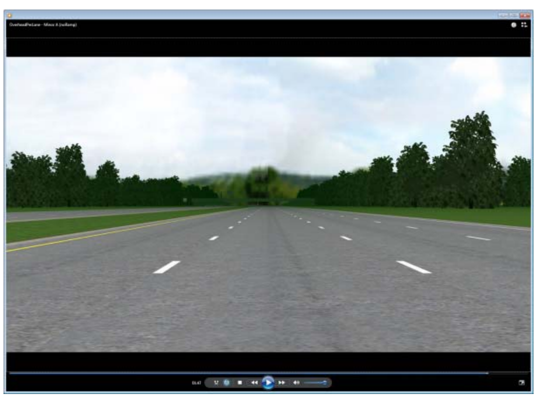
SIGN 2



QUESTION 2

SIGN 3

QUESTION 3

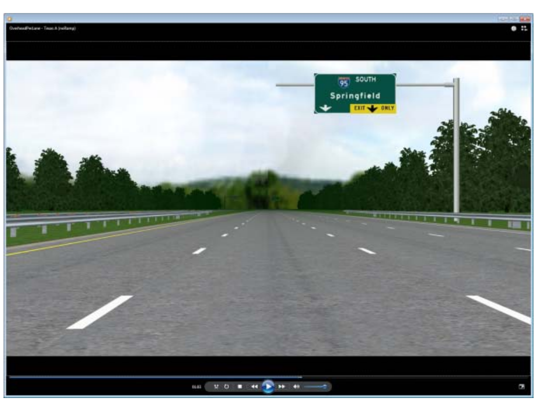


CONDITION 5 (VIEW A)

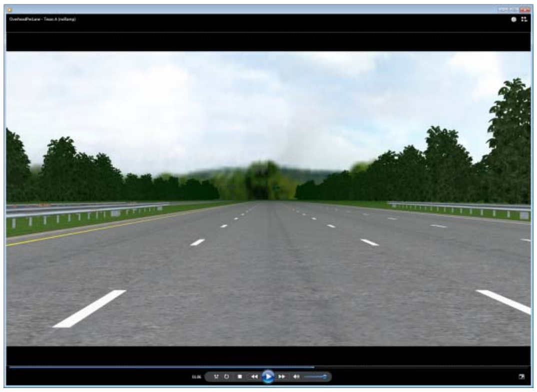
SIGN 1

QUESTION 1

SIGN 2



QUESTION 2



SIGN 3

QUESTION 3