Traffic Control Devices Pooled Fund Study

Evaluation of Combined Lane Use and Destination Sign Alternatives for Overhead-Mounted Guide Signs on Multilane Conventional Road Intersection Approaches

Final Report

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Prepared by:
Gary Golembiewski
Bryan Katz
Erin Dagnall
Mary Anne Bertola

Science Applications International Corporation

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Johnny Bhullar, California Department of Transportation
Fred Heery Sr., Florida Department of Transportation
Kathy Zahul, Georgia Department of Transportation
Larry Gregg, Illinois Department of Transportation
Tim Crouch, Iowa Department of Transportation
Steven Buckley, Kansas Department of Transportation
John Smith, Mississippi Department of Transportation
Julie Stotlemeyer, Missouri Department of Transportation
Dan Waddle, Nebraska Department of Roads
Dave Partee, Nevada Department of Transportation
William Lambert, New Hampshire Department of Transportation
Doug Bartlett, New Jersey Department of Transportation
Pat Ott, New Jersey Department of Transportation
Barbara Abrahamer, New York State Department of Transportation
Ron King, North Carolina Department of Transportation
Ed Fischer, Oregon Department of Transportation
Michael Kimlinger, Oregon Department of Transportation
C. Mark Alexander, Pennsylvania Department of Transportation
Nick Boozer, South Carolina Department of Transportation
Doug Skowronek, Texas Department of Transportation
Tom Notbohm, Wisconsin Department of Transportation
Roger Wentz, American Traffic Safety Services Association
Lee Billingsley, Broward County, Florida (retired)
John Fisher, City of Los Angeles, California, Department of Transportation

Amanda Emo, Federal Highway Administration, Office of Safety R&D
John Seabrook, Federal Highway Administration, Federal Lands Highway
Ed Rice, Federal Highway Administration, Office of Safety
Scott Wainwright, Federal Highway Administration, Office of Operations
Jeff Shaw, Federal Highway Administration, Office of Safety
Bryan Katz, Science Applications International Corporation

The objective of the Traffic Control Devices Pooled Fund Study (TCD PFS) is to assemble a group composed of State and local agencies, appropriate organizations and the FHWA to 1) establish a systematic procedure to select, test and evaluate approaches to novel TCD concepts as well as incorporation of results into the MUTCD; 2) select novel TCD approaches to test and evaluate; 3) determine methods of evaluation for novel TCD approaches; 4) initiate and monitor projects intended to address evaluation of the novel TCDs; 5) disseminate results; and 6) assist MUTCD incorporation and implementation of results.

To join the TCD PFS, or for more information about the TCD PFS

- Contact Amanda Emo at (202) 493-3395 or contact Scott Wainwright at (202) 366-0857
- Visit www.pooledfund.org and search for study # TPF-5(065).

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DISCLAIMER

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INTRODUCTION

BACKGROUND

Based on the results of the FHWA report, "Synthesis of Non-MUTCD Signing" (2005), a number of different practices that various states use to combine lane-use signing and guide-signing for destinations were identified. In response to various geometric and operational considerations – such as complex intersections involving multiple turn lanes, multiple destinations, and service roads – states have chosen to combine this information on a single sign (especially if constrained against using advance signs on urban or arterial streets). At these locations (primarily on urban streets and arterials), the combined information may be more effective than separate signs for lane use and guide signs – especially when conveying information to drivers who are unfamiliar with the area. The usual design in these cases indicates that: 1) certain lane(s) must be used to reach a destination designated by numbered route or destination name; 2) lane(s) are designated for mandatory turns or shared-lane use contrary to normal rules of the road. Current applications attempting to combine this information have resulted in an inconsistent use of colors, layouts, and other sign elements. Figure 1 shows an example of existing guide signs which include information on destination and lane use. The two signs shown in this figure have similar sign elements and implications, applied differently. Finally, although various forms of guidance are given on the basic layout of similar signs, the existing Manual on Uniform Traffic Control Devices (MUTCD) includes guidance for dedicated lanes using separate signs only (2009).

Figure 1. Examples of Existing Guide Signs.

Since the signs currently in use show inconsistency in their application, this project has been designed to help determine which essential sign elements are most effective in conveying the needed information to motorists, with a focus on *arterial roads*. As stated above, the combined lane use and destination sign included in the current MUTCD applies only to dedicated lanes using separate signs, and a number of states seem to have adopted various guidelines from different sections of the MUTCD for different elements and variations. For instance, Section

2E.18, stipulates "arrows for *interchange* guide signs should be pointed upward slanting for all exit direction signs and downward pointing arrows shall be used only for overhead guide signs to prescribe lane assignment for traffic bound for a destination or route that can be reached only by being in designated lanes." Further guidance for guide signs on conventional roads is discussed in Chapter 2D. For purposes of this study, this chapter provided guidance on arrows (Section 2D.08); route sign assemblies (2D.27); advance route turn assembly (2D.29); directional assembly (2D.30); and destination signs (2D.34).

RESEARCH GOALS

This research project was designed to evaluate several different elements for combined lane-use and destination signing to assess which element or combination of elements was best in terms of comprehension by road users on non-freeway or expressway facilities (i.e., arterials). The sign elements in this study will be evaluated for overhead-mounted guide signs only (as shown on the bottom half of Figure 1), on multi-lane conventional intersection approaches. Recent literature suggests that drivers' understanding of a number of these elements has already been demonstrated. For instance, use of the "Exit Only" message by Chrysler (2004) and Golembiewski and Katz (2007) on highway directional and lane assignment signs, showed the majority of drivers who viewed signs with this element understood the lane "Only" message. In the two studies, more than three-fourths of drivers showed they understood the "Only" message in lane assignments and made appropriate lane choices based on that information. When considering arrow direction, a recent project by Inman (2009, in press) has shown drivers' responses to upward pointing arrows when approaching roundabouts were effective.

The desired outcome of the project is to provide recommendations for a consistent and uniform practice for such signs regarding elements including construction/assembly type, type of information conveyed, and color of arrows and arrow panels. It should be noted the project's goal is to provide general recommendations for the elements tested such that the signs could be applied in across a number of different roadway types. Due to the number and variety of configurations encountered on arterial and urban roadways, this project cannot address each type of design or reflect the contextual and design constraints that might be encountered. However, the results of this project can help to provide guidelines that will lead to a higher degree of consistency and design standards in their use.

RESEARCH APPROACH

The research approach consisted of three major elements: gathering information to develop alternatives, evaluating the alternatives, and developing recommendations on use. The following is a list of specific activities:

- Developed 18 experimental sign alternatives to be evaluated in order to build guidelines specifically for combined-lane use and destination signing.
- Performed a laboratory study to evaluate understanding of the sign alternatives.
- Drafted recommendations regarding the implementation of the alternatives that were evaluated.

STUDY APPROACH

The initial step of this study determined the sign alternatives to be tested. The details and results of this research are outlined in the following section.

EXPERIMENTAL SIGN SELECTION

The research team identified existing MUTCD standards for similar signs or related sign elements which may already be applied by states in order to communicate combined lane use and destination signing. The team also identified any elements which may be relevant but not yet included in the MUTCD. Based on this information, multiple variables which should be examined in order to provide recommendations on guidelines specifically for combined lane use and destination signing were created.

Five sign variables, or sign elements, were selected to be included in this study. The following consists of a brief description on each sign element used.

- Lane Designation – Two types of lane designations were used in this study; shared-lane designations and single-lane designations. A shared-lane designation describes a lane which can be used to reach more than one destination, i.e. a center lane can be shared by both left turns and through traffic. A single-lane designation describes a lane that is used for one specific destination, i.e. right turn only, left turn only, or through only.

- Construction Type – Two sign construction types were used in this study and include a single sign and an assembly. A single sign has all information presented on one sign. An assembly contains separate signs of information for each lane or destination.

- Destination Direction – Three different directions can be used for the target destination: left, right and through.

- Arrow Type – Two arrow types used included regulatory lane-use panel (R3-5 & R3-6) and white lane-use arrow without panels. Regulatory lane-use panels are arrows displayed in a white box, and including the word “Only” for single-lane designations. White lane-use arrows are arrows alone, which are directly applied on the main sign panel.

- Vertical Separator Lines (on single panel signs only) – These are small vertical white lines which can be placed on single panel signs in order to create a separator between different destinations. This is a possible alternative to an assembly which contains separate panels for each destination or lane. In this study vertical separator lines are either present or absent.

Based on combinations of the variables presented above, 18 experimental signs were developed. Each experimental sign and the elements utilized are shown in Table 1.

Table 1. List of Experimental Signs and Elements

Sign	Lane Designation	Construction Type	Destination Direction	Arrow Type	Vertical Separator Lines
1	Shared	Single Sign	Right	Regulatory Lane-Use Panel	Present
2	Shared	Single Sign	Right	Lane-Use Arrow	Absent
3	Shared	Single Sign	Left	Regulatory Lane-Use Panel	Present
4	Shared	Single Sign	Left	Lane-Use Arrow	Absent
5	Shared	Single Sign	Through	Regulatory Lane-Use Panel	Present
6	Shared	Single Sign	Through	Lane-Use Arrow	Absent
7	Single	Single Sign	Left	Regulatory Lane-Use Panel	Absent
8	Single	Single Sign	Left	Lane-Use Arrow	Present
9	Single	Assembly	Left	Regulatory Lane-Use Panel	-
10	Single	Assembly	Left	Lane-Use Arrow	-
11	Single	Single Sign	Right	Regulatory Lane-Use Panel	Absent
12	Single	Single Sign	Right	Lane-Use Arrow	Present
13	Single	Assembly	Right	Regulatory Lane-Use Panel	-
14	Single	Assembly	Right	Lane-Use Arrow	-
15	Single	Single Sign	Through	Regulatory Lane-Use Panel	Absent
16	Single	Single Sign	Through	Lane-Use Arrow	Present
17	Single	Assembly	Through	Regulatory Lane-Use Panel	-
18	Single	Assembly	Through	Lane-Use Arrow	-

RESEARCH METHOD

RESEARCH DESIGN

The study was conducted at the Turner-Fairbank Highway Research Center (TFHRC) in the Highway Sign Simulator. MediaLab software was used in combination with a projector, which displayed the images on a frosted glass screen. The software electronically collected the required data and saved output data files for analysis.

Participants were seated at a table, with their chair positioned approximately 6ft from the screen. Lights were turned off during the study. Participants were shown one image at a time, for a total of 18 images. Each image had a different experimental sign mounted above a 3-lane road. Participants were instructed that they would always be travelling to McLean and would need to report any and all lanes they could use to get to McLean.

The table in front of the participants held a small stand with an example image as a reminder of lane numbering. The image was identical to the image of the 3-lane road used in the experiment, excluding the experimental signs. Each lane had the appropriate number on it, 1-3 from left to right.

Each sign was shown for 3 seconds before the image disappeared. After the experimental image disappeared, the next screen prompted the participant with the question "Which lane(s) can you use to get to McLean?" Participants announced their lane selections aloud, and the researcher recorded their responses in the MediaLab program.

Participants were shown the 18 experimental signs in a randomized order and the signs were evaluated for comprehension.

PARTICIPANTS

Participants were recruited from the Washington DC metropolitan area. Of 96 participants, half were between 19 and 56 years of age (mean = 37) and half were between 57 and 86 years of age or older (mean = 71). Each age group consisted of equal numbers of males and females. All participants possessed a valid driver's license and passed a vision screening test with a minimum 20/40 acuity in at least one eye (corrected if necessary). Participants were paid upon completion.

RESULTS

The participant responses for each experimental sign are presented separately, followed by comparisons for the major variables of interest. For each sign, comprehension was based on participants' understanding of the intended meaning of the sign, i.e., if they knew the correct lane(s) they could use to travel to McLean.

INDIVIDUAL SIGN COMPREHENSION

Sign 1

Figure 2 shows the image that was displayed for Sign 1. The sign indicates that lanes 2 and 3 can be used to travel to McLean. Comprehension results of the sign are shown in Table 2.

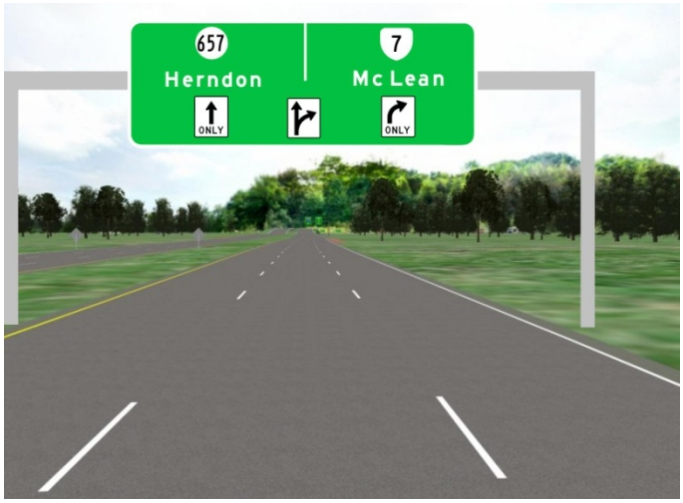

Figure 2. Image of Sign 1 – Correct Lanes = 2, 3

Table 2. Comprehension Results for Sign 1.

	N	%
Correct	69	72
Part Correct – Lane 2 only	-	-
Part Correct – Lane 3 only	27	28
Wrong	-	-

Sign 2

Figure 3 shows the image that was displayed for Sign 2. The sign indicates that lanes 2 and 3 can be used to travel to McLean. Comprehension results of the sign are shown in Table 3.

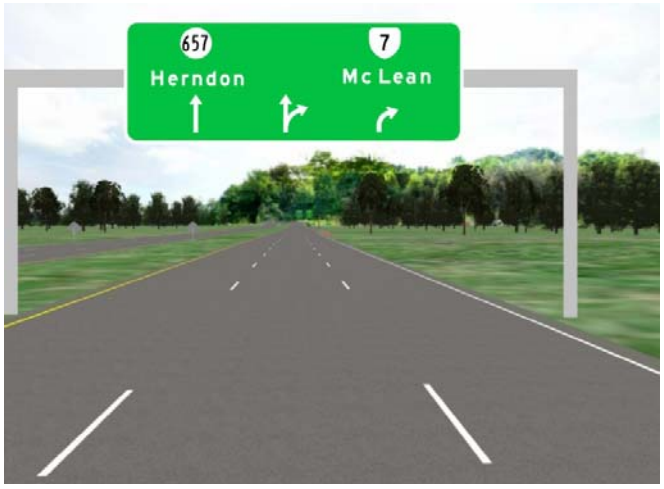

Figure 3. Image of Sign 2 – Correct Lanes = 2, 3

Table 3. Comprehension Results for Sign 2.

	N	%
Correct	79	82
Part Correct – Lane 2 only	1	1
Part Correct – Lane 3 only	15	16
Wrong	1	1

Sign 3

Figure 4 shows the image that was displayed for Sign 3. The sign indicates that lanes 1 and 2 can be used to travel to McLean. Comprehension results of the sign are shown in Table 4.

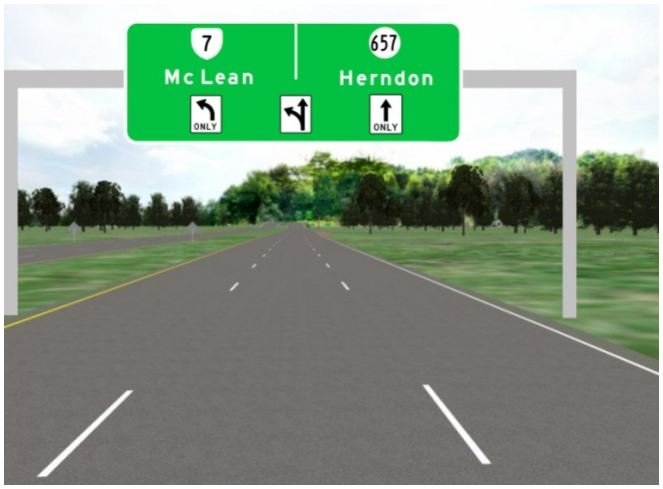

Figure 4. Image of Sign 3 – Correct Lanes = 1, 2

Table 4. Comprehension Results for Sign 3.

	N	%
Correct	84	88
Part Correct – Lane 1 only	11	11
Part Correct – Lane 2 only	-	-
Wrong	1	1

Sign 4

Figure 5 shows the image that was displayed for Sign 4. The sign indicates that lanes 1 and 2 can be used to travel to McLean. Comprehension results of the sign are shown in Table 5.

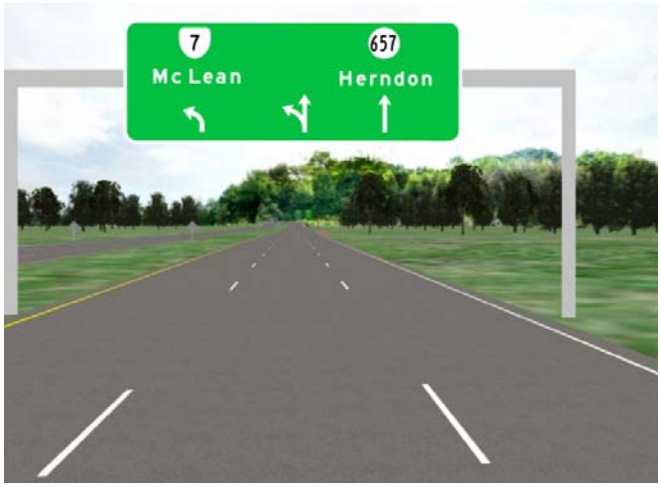

Figure 5. Image of Sign 4 – Correct Lanes = 1, 2

Table 5. Comprehension Results for Sign 4.

	N	%
Correct	80	83
Part Correct – Lane 1 only	15	16
Part Correct – Lane 2 only		
Wrong	1	1

Sign 5

Figure 6 shows the image that was displayed for Sign 5. The sign indicates that lanes 1 and 2 can be used to travel to McLean. Comprehension results of the sign are shown in Table 6.

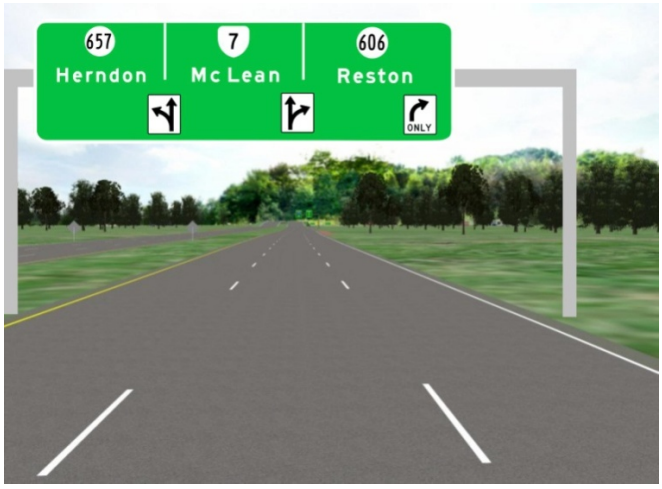

Figure 6. Image of Sign 5 – Correct Lanes = 1, 2

Table 6. Comprehension Results for Sign 5.

	N	%
Correct	16	17
Part Correct – Lane 1 only	3	3
Part Correct – Lane 2 only	45	47
Wrong	32	33

Sign 6

Figure 7 shows the image that was displayed for Sign 6. The sign indicated that lanes 1 and 2 can be used to travel to McLean. Comprehension results of the sign are shown in Table 7.

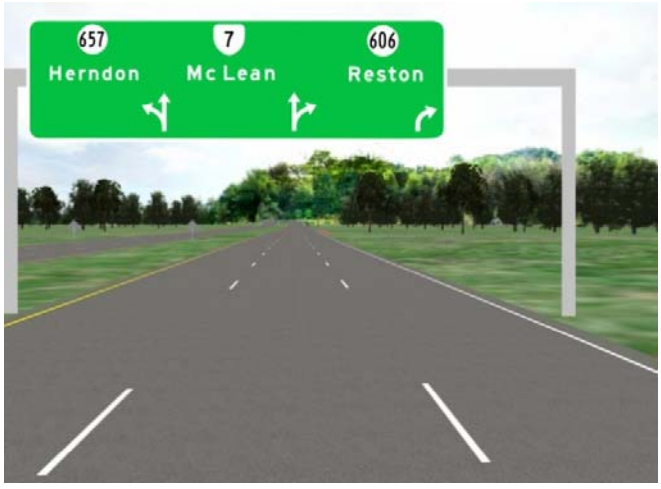

Figure 7. Image of Sign 6 – Correct Lanes = 1, 2

Table 7. Comprehension Results for Sign 6.

	N	%
Correct	7	7
Part Correct – Lane 1 only	2	2
Part Correct – Lane 2 only	58	60
Wrong	29	30

Sign 7

Figure 8 shows the image that was displayed for Sign 7. The sign indicates that lane 1 can be used to travel to McLean. Sign 7 was understood by 99% of participants.

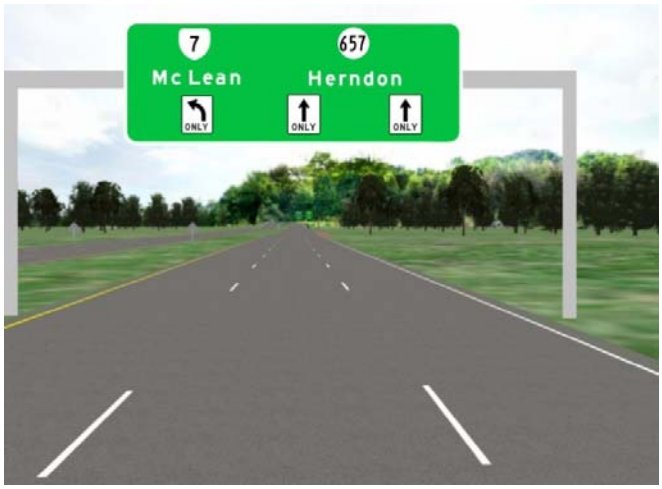

Figure 8. Image of Sign 7 – Correct Lane = 1

Sign 8

Figure 9 shows the image that was displayed for Sign 8. The sign indicates that lane 1 can be used to travel to McLean. Sign 8 was understood by 100% of participants.

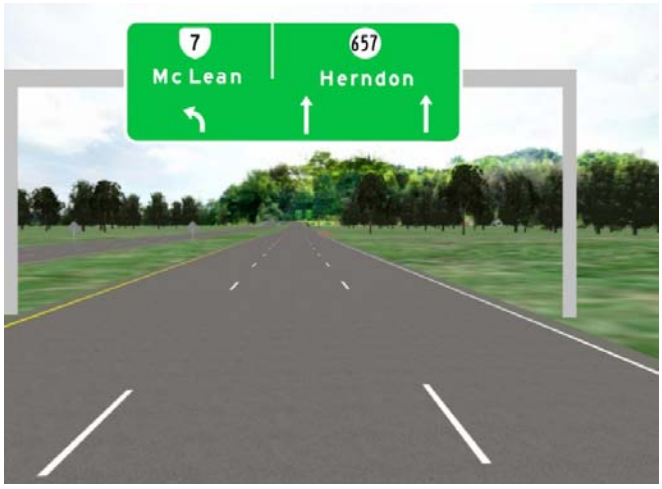

Figure 9. Image of Sign 8 – Correct Lane = 1

Sign 9

Figure 19 shows the image that was displayed for Sign 9. The sign indicates that lane 1 can be used to travel to McLean. Sign 9 was understood by 98% of participants.

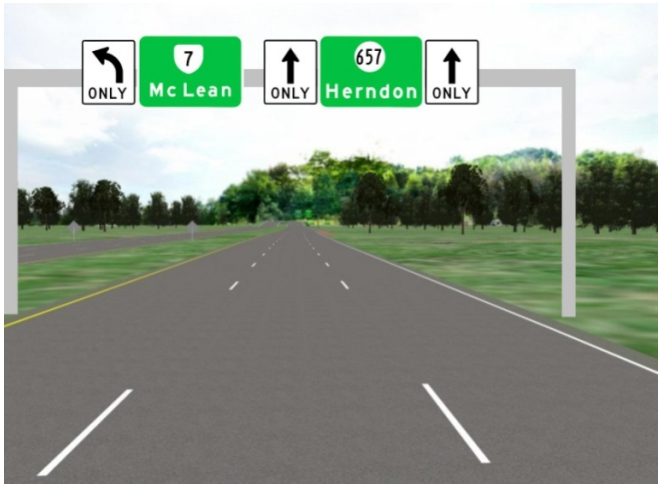

Figure 10. Image of Sign 9 – Correct Lane = 1

Sign 10

Figure 11 shows the image that was displayed for Sign 10. The sign indicates that lane 1 can be used to travel to McLean. Sign 10 was understood by 99% of participants.

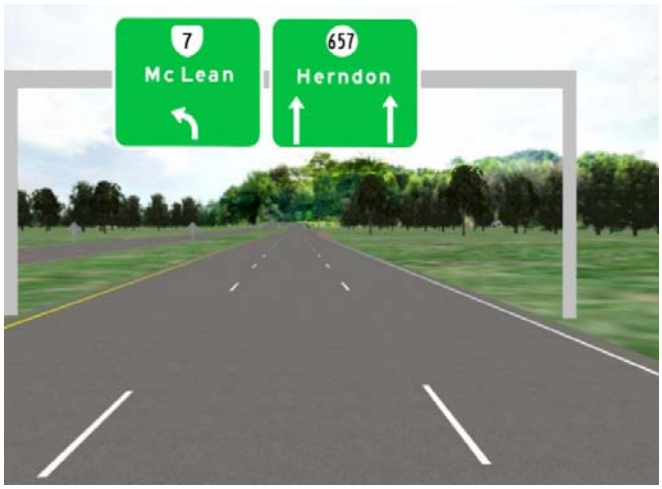

Figure 11. Image of Sign 10 – Correct Lane = 1

Sign 11

Figure 12 shows the image that was displayed for Sign 11. The sign indicates that lane 3 can be used to travel to McLean. Sign11 was understood by 99% of participants.

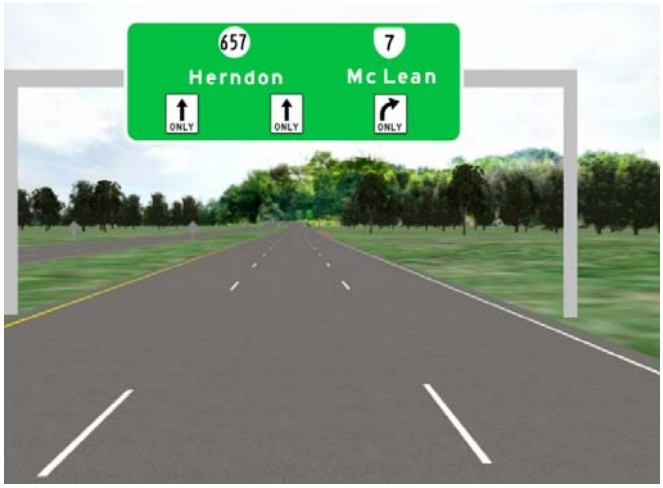

Figure 12. Image of Sign 11 – Correct Lane = 3

Sign 12

Figure 13 shows the image that was displayed for Sign 12. The sign indicates that lane 3 can be used to travel to McLean. Sign 12 was understood by 98% of participants.

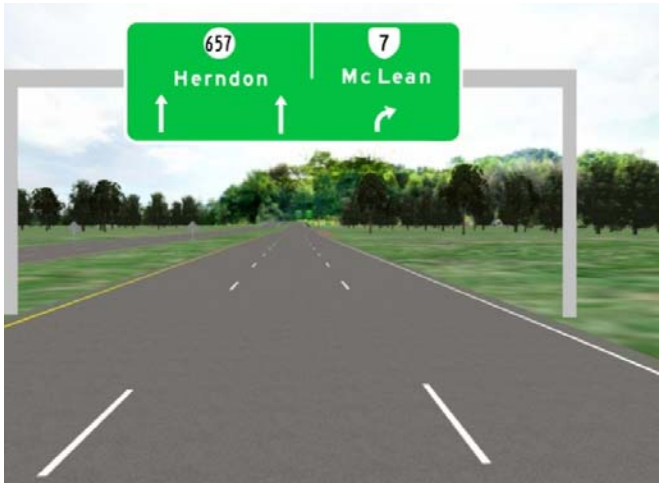

Figure 13. Image of Sign 12 – Correct Lane = 3

Sign 13

Figure 14 shows the image that was displayed for Sign 13. The sign indicates that lane 3 can be used to travel to McLean. Sign 13 was understood by 95% of participants.

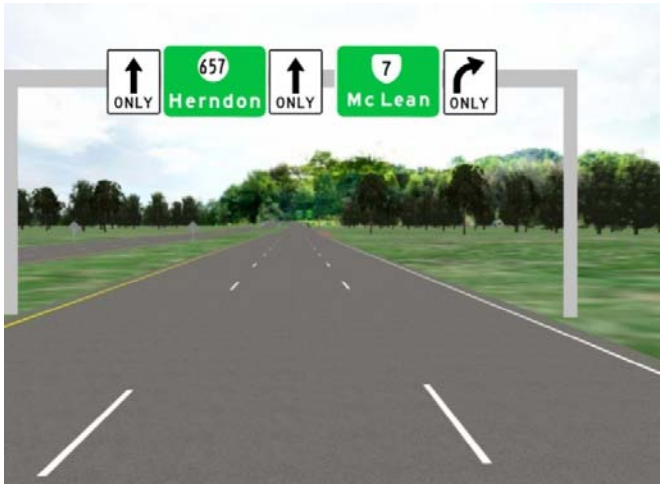

Figure 14. Image of Sign 13 – Correct Lane = 3

Sign 14

Figure 15 shows the image that was displayed for Sign 14. The sign indicates that lane 3 can be used to travel to McLean. Sign 14 was understood by 99% of participants.

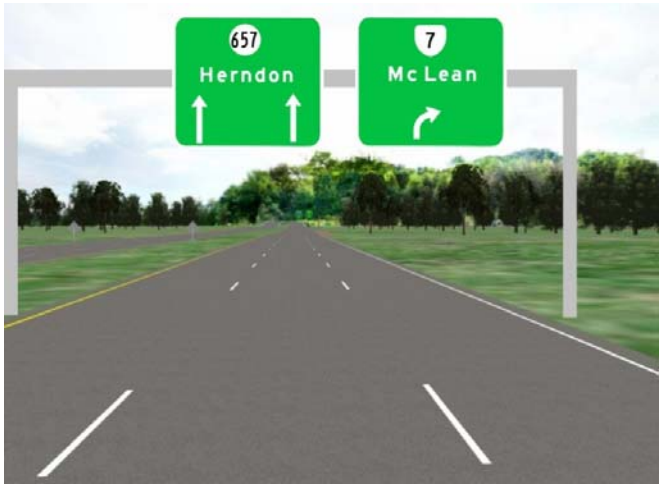

Figure 15. Image of Sign 14 – Correct Lane = 3

Sign 15

Figure 16 shows the image that was displayed for Sign 15. The sign indicates that lane 2 can be used to travel to McLean. Sign 15 was understood by 99% of participants.

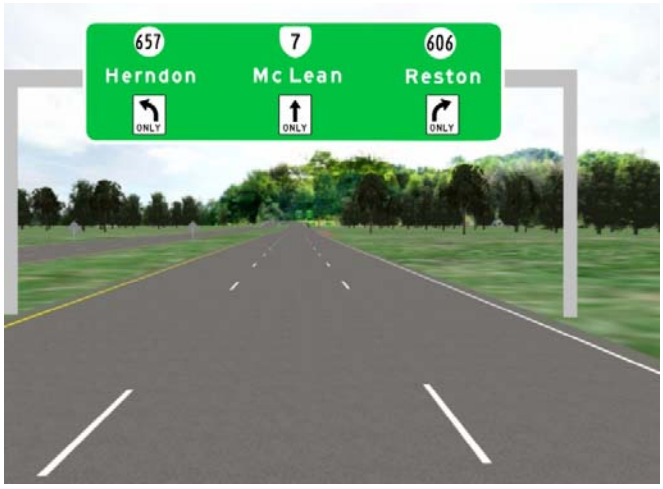

Figure 16. Image of Sign 15 – Correct Lane = 2

Sign 16

Figure 17 shows the image that was displayed for Sign 16. The sign indicates that lane 2 can be used to travel to McLean. Sign 16 was understood by 100% of participants.

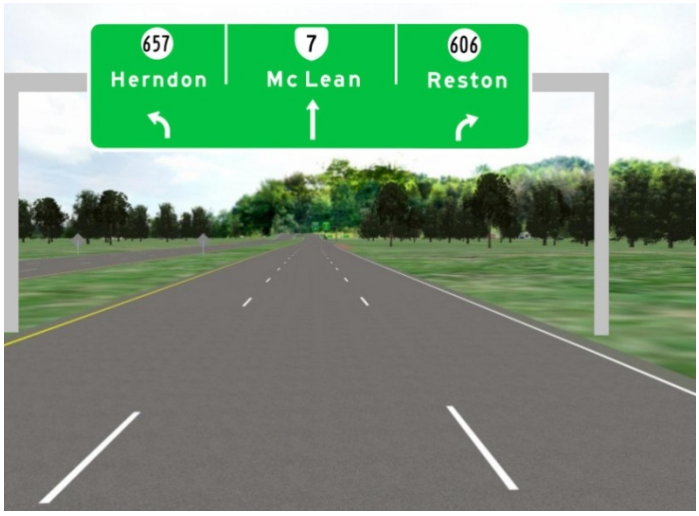

Figure 17. Image of Sign 16 – Correct Lane = 2

Sign 17

Figure 18 shows the image that was displayed for Sign 17. The sign indicates that lane 2 can be used to travel to McLean. Sign 17 was understood by 95% of participants.

Figure 18. Image of Sign 17 – Correct Lane = 2

Sign 18

Figure 19 shows the image that was displayed for Sign 18. The sign indicates that lane 2 can be used to travel to McLean. Sign 18 was understood by 100% of participants.

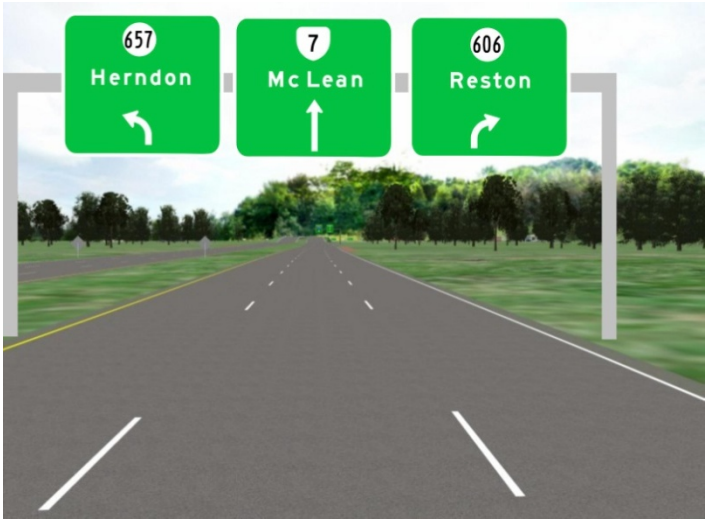

Figure 19. Image of Sign 18 – Correct Lane = 2

ANALYSIS OF SIGN ELEMENTS

Analysis of the main factors assumed a fully correct criterion for comprehension, ie. *all* correct lanes must have been identified to be considered "correct"; partial understanding is not correct.

Some sign elements could not be used in conjunction with other sign elements, therefore multiple analyses were performed which may include only the signs that encompass the variables of interest. Explanations of these instances are given in each of the sections below, where necessary. All tests were evaluated with maximum probability of Type I error of 0.05.

Lane Designation

Of the 18 signs examined, signs 1 through 6 had shared-lane designation with more than one lane which could be used to reach the target destination. Signs 7 through 18 had single-lane designation with only one lane which could be used to reach the target destination.

As shown in the results for each sign, participant responses to the signs with a single-lane designation showed almost perfect comprehension, with correct responses ranging from 95% to 100%. The signs with shared-lane designation showed a decrease in comprehension, with correct responses between 72% and 88%.

As stated previously, shared-lane designations do not allow for assembly construction types, therefore, an analysis was performed to examine the difference between shared-lane designation and single-lane designation within the single sign construction signs only. A logistic regression analysis showed that there is a significant difference in comprehension between single and shared-lane designations, $\chi^2 = 75.18$, $p < .001$. Arrow type was also included in this model. There was no significant difference between arrow types, and no significant interaction between lane designation and arrow type.

Construction Type

As signs with shared-lane designations, signs 1 through 6, did not allow for assembly construction, construction type was examined for single-lane designation signs (signs 7-18) which allow for both single sign construction and assembly construction. A logistic regression analysis comparing the percent of correct responses indicated that there is no significant difference in comprehension between single sign and assembly construction types, ($\alpha = .05$). Arrow type was also included in this model. There was no significant difference between arrow types, and no significant interaction between construction type and arrow type.

Arrow Type

As discussed in the two previous sections, arrow type was examined as a part of two different models. Neither model showed a significant difference in comprehension between the regulatory lane-use panel and white lane-use arrows.

Vertical Separator Lines

The use of vertical separator lines is only practical on single sign construction types which might need information to be distinguished between different lanes. Therefore, an analysis of vertical

separator lines included only signs with single sign construction types. A logistic regression model, including vertical separator lines and lane designation, showed that there is no difference in comprehension based on the presence or absence of a vertical separator line. There was also no significant interaction between lane designation type and vertical separator line.

Observations

Participants' performance dramatically declined for two of the signs – Sign 5 and Sign 6. Only 17% and 7%, respectively, were able to correctly identify both lanes that could be used to travel to McLean. Furthermore, 33% and 30%, respectively, were not able to correctly identify any lane that would take them to McLean.

Both are shared-lane designation signs, which corresponds with the findings that there is a significant difference in comprehension between shared-lane and single-lane designations. However, these two signs are markedly lower in comprehension than signs 1, 2, 3, and which also have shared-lane designation. These signs had 72%, 88%, 83% and 82% comprehension, respectively. One possible explanation is that signs 5 and 6 share two lanes, while the others only have one shared-lane. Another possible factor is the number of destinations included on the signs. Signs 5 and 6 have three destination names, while the others have only two destination names.

When comparing the comprehension of the single-lane designation signs, signs 7, 8, 9, 10, 11, 12, 13 and 14 (99%, 100%, 98%, 99%, 99%, 98%, 95%, and 99%) have two destinations on each sign and signs 15, 16, 17 and 18 (99%, 100%, 95% and 100%) have three destinations on each sign. There does not seem to be such a drastic change in percentages based on the number of destinations on the sign. These specific results are limited to instances with the number of destinations (in addition to route markers) limited to one per movement, i.e. one destination name assigned to each lane/travel direction for single-lane designations. This study did not examine the use of multiple destination names per movement.

Signs 5 and 6 were more complex than the other 16 signs in that they had shared-lane designation, had *two* lanes which were shared, and had three possible destinations on the sign. Thus it is possible that the severe drop in comprehension is due to the overall complexity of these two signs, rather than one particular variable.

CONCLUSIONS

In this study, most alternatives were well understood by research participants. Signs with single-lane designations were understood significantly more than signs with shared-lane designations. Signs with only one shared-lane had fairly high comprehension with 72% to 88% of participants identifying both correct lanes, and 98%-100% that identified the dedicated lane as a valid response to reach their destination. Complex signs that show multiple shared-lanes and three destinations proved to be more difficult for participants where approximately one-third of participants could not identify at least one correct lane and very few (7% and 17%) identified the two correct lanes when one was an option lane.

The study shows that when designing combined lane use and destination signs for overhead-mounted guide signs on multilane conventional road intersection approaches, it is important when possible to keep the amount of information and sign complexity low. This is especially true of shared lanes, where having multiple shared-lanes instead of one shared-lane is confusing to drivers.

As regulatory lane-use panels and lane-use arrows proved to be equally effective for combined lane use and destination signs for overhead-mounted guide signs on multilane conventional road intersection approaches. Therefore, either arrow type may be appropriate under these signing circumstances. For uniformity, it may be appropriate to select an option to further improve driver comprehension.

The study shows no difference in comprehension based on the presence or absence of vertical separator lines; however, there may be situations where these designs can easily become complex when the destination names are longer, when cardinal directions are added to route markers, or when street names are used instead of route markers. The legends can run together visually and become disassociated from their corresponding arrow. In these cases, the vertical separator line may be necessary.

There are many different ways of communicating destination and lane use information to motorists which can involve various designs using a system of overhead and ground-mounted signs. This study solely looked at various overhead sign alternatives and did not look at the effects that adjacent signs may have in driver comprehension. It was assumed that in many settings, the signs tested may be the only information that drivers would be using to make a decision, and thus the signs were tested independently. Additionally, black-on-yellow ONLY panels are used in freeway signing and could potentially be used in a similar way to the options used in this study to communicate a mandatory turn lane. Because the intent of the study was to investigate combining destination information with lane use arrows on guide signs, only upward pointing arrows were used. This implementation does not suggest that down arrows on freeway and other types of guide signs are not effective or valid where appropriate.

Future opportunities include the determination of effective ways to sign for complex situations where there are multiple shared-lanes, guidance on when vertical separator lines should be used on guide signs, and how combined lane-use and destination signs can compare to other methods using systems of ground-mounted signs to communicate lane use and destination information.

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