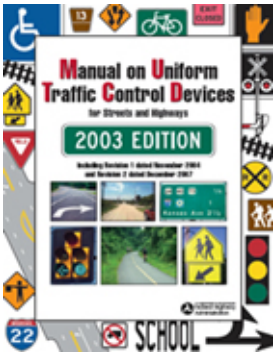
Traffic Control Devices Pooled Fund Study



The main goals of the Traffic Control Devices Pooled Fund Study (TCD PFS) are to address emerging traffic control device research needs and aid in compliance with the MUTCD rule-making process and incorporation of novel TCDs into the MUTCD. The TCD PFS is composed of State and local transportation agencies, the Federal Highway Administration (FHWA), and other relevant organizations.

The objectives of the TCD PFS are to:

- Establish a systematic procedure to select novel TCD concepts and existing concepts to improve upon
- Evaluate concepts through the development of innovative methodology for testing and analysis of selected concepts
- Prepare and disseminate results from evaluations
- Provide information to the MUTCD team for their consideration to incorporate and implement results in future editions of the manual

Research conducted by the TCD PFS employs a consistent process that addresses human factors and operations issues for each TCD ideal. Research needs are identified by local and state jurisdictions, industry, and other relevant organizations. This cutting-edge research provides local and state agencies with a faster response to both their existing TCD needs as well as emerging needs brought on by new technologies.

RESEARCH PROJECTS

- Alternate Flash Patterns for Flashing Beacons
- Countdown Pedestrian Signals: A Comparison of Alternative Pedestrian Change Interval Displays
- Development of Uniform Guide Sign Standards*
- Evaluation of Diagrammatic Freeway Guide Signs
- Evaluation of International Symbol Signs*
- Evaluation of Lane Use and Destination Signing*
- Evaluation of Selected Symbol Signs
- Lane Restriction Signing and Markings for Double Lane Roundabouts
- Navigation Signing for Roundabouts
- Pavement Markings for Speed Reduction

*Research is currently underway

Traffic Control Devices Pooled Fund Study Members

Caltrans, Wayne Henley
Florida DOT, Mark Wilson
Georgia DOT, Kathy Bailey
Illinois DOT, Larry Gregg
Iowa DOT, Tim Crouch
Kansas DOT, Steven Buckley
Mississippi DOT, John Smith
Missouri DOT, Julie Stotlemeyer
Nebraska DOR, Dan Waddle
Nevada DOT, Dave Partee
New Hampshire DOT, William Lambert
New Jersey DOT, Doug Bartlett
New York DOT, Barbara Abrahamer
North Carolina DOT, Ron King
Oregon DOT, Ed Fischer
Pennsylvania DOT, Glenn Rowe
South Carolina DOT, Don Turner
Texas DOT, Doug Skowronek
Wisconsin DOT, Tom Notbohm
ATSSA, Roger Wentz
Broward Co., FL, Lee Billingsley*
City of Los Angeles, John Fisher
FHWA, Scott Wainwright
FHWA, Amanda Emo
FHWA, John Seabrook
FHWA, Ed Rice
SAIC for FHWA, Bryan Katz

* Retired

Countdown Pedestrian Signals

Countdown pedestrian signals (CPSs) can be used to supplement traditional pedestrian signals by means of flashing digits that count down the number of seconds remaining until the end of the pedestrian change interval. These CPS devices use an orange, flashing, upraised hand along with the time countdown displayed during the pedestrian change interval. Previous investigations of CPS effectiveness have generally concluded that CPSs provide pedestrians with useful information to help them cross the street more successfully. However, these studies have also found that pedestrian comprehension concerning the concurrent flashing hand is relatively poor and compliance with the legal meaning of the flashing hand is low. Therefore, removing the flashing hand from the CPS may actually improve pedestrian comprehension and crossing decisions by eliminating one possible source of confusion.

Two studies were conducted to test this hypothesis. Study 1 was a laboratory experiment to investigate pedestrians' comprehension of the experimental CPS (with countdown only), standard CPS (with flashing hand plus countdown), and conventional signal (with flashing hand only). Altogether, 45 research participants were shown pictures of a pedestrian in different crossing situations and with different types of displays. The participants were asked to provide the correct pedestrian behavior for each situation. Results indicate that the experimental CPS produced the fewest instances of confusion, especially for older pedestrians, and the standard CPS performed nearly as well. The conventional signal, however, led to many more instances of confusion than the two CPSs.

Study 2 was a field observational study of pedestrians, comparing behavior where the experimental CPS was in effect vs. where the standard CPS was in effect. At the experimental site, pedestrian behavior was observed during predetermined periods for 1 week with standard CPSs present. Then the standard CPSs were replaced with experimental CPSs, and behavior was observed again for one week. There was also a matched control site. A total of 4,287 pedestrian crossings were recorded over a period of 129 hours of observation. With the experimental CPS there was no increase in the number of pedestrians observed beginning to cross during the pedestrian change interval. However, pedestrians began to cross later during the pedestrian change interval. Very few pedestrian/vehicle conflicts were observed with either CPS display.

In summary, the results of these two studies were not completely consistent, and do not provide strong evidence either for or against the use of the experimental CPS. Until evidence is shown to the contrary, engineers should continue to use the standard CPS with the flashing orange hand and the countdown display. For more information contact Joe Moyer at (202) 493-3370 or at joe.moyer@fhwa.dot.gov.

	Pedestrian Change Interval	Solid Don't Walk
Standard CPS		
Experimental CPS		

Standard CPS Pedestrian Change Interval / Solid Don't Walk Phases

This study was conducted by Westat. For more information about the study, or for a copy of the full research report:

- Visit http://www.pooledfund.org/documents/TPF-5_065/ped_countdown-12-2004.pdf
- Contact Bryan Katz at (202) 493-3388 or by email at bryan.katz@fhwa.dot.gov

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 Joe Moyer at (202) 493-3370 or email joe.moyer@fhwa.dot.gov or contact Scott Wainwright at (202) 366-0857 or email scott.wainwright@fhwa.dot.gov.
• Visit www.pooledfund.org and search for study# TPF-5(065).

Traffic Control Devices Pooled Fund Study Members

Caltrans, Greg Edwards	Nevada DOT, Scott Thorson*	Broward Co., FL, Lee Billingsley
Florida DOT, Mark Wilson	New Jersey DOT, Doug Bartlett & Patt Ott	City of Los Angeles, John Fisher
Georgia DOT, Keith Golden	New York DOT, David Woodin	FHWA, Scott Wainwright*
Illinois DOT, Larry Gregg	North Carolina DOT, Lori Cove	FHWA, Joe Moyer
Iowa DOT, Tim Crouch	Pennsylvania DOT, Glenn Rowe	FHWA, John Seabrook
Kansas DOT, Steven Buckley	South Carolina DOT, Don Turner	FHWA, Debra Chappell
Mississippi DOT, John Smith	Texas DOT, Greg Brinkmeyer	SAIC/FHWA, Bryan Katz
Missouri DOT, Julie Stotlemeyer	Wisconsin DOT, Tom Notbohm	SAIC/FHWA, Heather Howard
Nebraska DOR, Randy Peters	ATSSA, Roger Wentz	

*Co-Chairs

FHWA Publication No: FHWA-HOP-06-086

Navigation Signing for Roundabouts

Background

The Traffic Control Devices Pooled Fund Study (TCD PFS) identified the need for navigational signage that is intended to assist motorists with anticipating the correct roundabout exit, selecting an appropriate approach lane for that exit, and recognizing the correct exit upon reaching it. The Navigation Signing for Roundabouts study was initiated by the TCD PFS to meet that need.

The objective of the Navigation Signing for Roundabouts study was to support recommendations on double-lane roundabout signage to the Federal Highway Administration's (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) Team and to the National Committee on Uniform Traffic Control Devices (NCUTCD).

With increasing use of modern roundabouts, issues have arisen regarding the variety of signing used at roundabouts. An evaluation of alternatives was needed to suggest how best to communicate the lane drivers should choose for a given destination in advance of a multi-lane roundabout. Varied guide signing and pavement marking solutions have been suggested, and a number of sign and marking combinations are used by various jurisdictions.

Two tasks were undertaken in the study. In one task, the available information lead time was combined with field observational data and reading time requirements to estimate the maximum amount of information that may be put on roundabout exit signs.

The second task addressed the advance navigational signage needs of drivers. Because those who are unfamiliar with a particular roundabout are the drivers most likely to attend to navigational signing, this task focused on the needs of unfamiliar drivers. Standard lane restriction markings were used in combination with alternative navigation signs to provide these drivers with the information they would need to identify the appropriate roundabout exit and to select the appropriate lane for that exit.

Objective

The overall objective was to obtain data and perform analyses on double-lane roundabout navigation signage to support recommendations to the FHWA MUTCD Team. Two tasks were directed toward development of consistent and effective design standards for roundabout navigation signing that would work well in concert with roundabout pavement marking concepts recommended by the NCUTCD.

- Task 1 was to provide recommendations on the maximum amount of information that is appropriate for round about exit signs.
- Task 2 was to provide recommendations for standardized advance navigational guide signs for roundabouts.

Task 1

To estimate the maximum amount of information that is appropriate for a roundabout exit sign, an estimate is needed of the amount of time drivers have to process the information on the sign. Processing time is affected by operational conditions (merge and lane-change requirements), and sign placement. The time available must be adequate for drivers to both read and make the appropriate decision, e.g., whether or not to exit. Reading time is constrained by legibility distance, vehicle speed, and sight distance. Other factors may impact information processing time, such as the competing demands of merge activity, conflict avoidance, and the curved path tracking requirements posed by the roundabout geometry.

To provide data on the time available to drivers for reading exit signs, observations were made at two roundabouts in Vail, Colorado.

Operational observations confirmed that operational speed closely correlated to the R_4 (left turn movement radius) design speed. Sign information lead time, the time available for detecting and reading a sign, can be estimated from R_4 design speed and detection distance to a roundabout exit sign. The required time needed to read sign information and to make the appropriate choice was derived from the literature. Available sign reading and decision time in roundabouts was assumed to be the difference between total sign information lead time and an estimate of the time consumed by competing tasks.

Task 1 Findings

Table 1 shows the recommended maximum exit sign information load based on the Task 1 analysis.

			Number of Information Items			
			Exit Sign on Splitter Island		Exit Sign, Advance of Splitter Island	
Inscribed Circle Diameter, ft	R_4 Path Radius, ft	Operating Speed, mph	No Lane Change Design	Lane Changes Permitted	No Lane Change Design	Lane Changes Permitted
Single Lane Roundabout						
100	35	14	1	N/A	3	N/A
115	45	15	2	N/A	4	N/A
130	55	16	2	N/A	4	N/A
150	65	17	3	N/A	5	N/A
Double Lane Roundabout						
150	50	16	2	*	4	1
165	60	16	3	*	4	2
180	65	17	3	1	5	2
200	75	18	4	1	6	3
215	85	19	4	2	6	4
230	90	19	5	2	7	4

*Does not allow adequate sign reading and decision time

Table 1. Recommended maximum sign information load: number of destination names or route numbers.

Task 2

Task 2 was a laboratory study performed in the Sign Simulator Laboratory at Turner-Fairbank Highway Research Center. Four advance navigation sign formats were evaluated to determine which results in the best driver performance in identifying the desired exit and in selecting an appropriate lane for that exit. The four sign formats that were evaluated are shown in Figures 1, 2, 3 and 4.

Figure 1. Conventional roundabout route assembly (left) and guide sign (right).

Figure 2. Diagrammatic roundabout guide sign.

Figure 3. Alternate conventional guide sign similar to those used in Maryland.

Figure 4. Vertical Lane line guide sign similar to those used at some New York roundabouts.

Participants were presented a destination followed by a guide sign, or guide sign and route assembly, followed by a picture of a roundabout entrance with turn restriction markings. Participants were asked to make an entrance-lane choice and an exit leg choice based on the presented stimuli. Response measures were decision accuracy, decision latency, and decision confidence.

The turn restriction markings used in the study are shown in Figure 5.

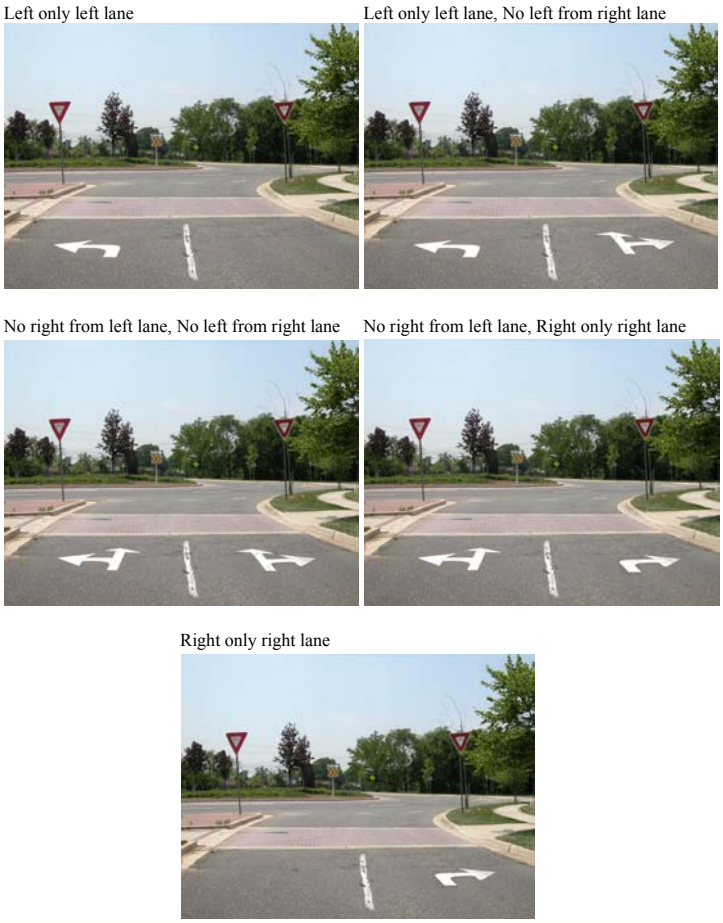


Figure 5. The 5 lane restriction marking combinations used in Task 2.

Task 2 Findings

Overall, participants selected the correct lane only 68.6 percent of the time. This level of performance, which was essentially chance performance, suggests that most participants did not understand the importance of the turn restriction arrows, and that most Vertical Lane group participants did not understand the importance of the left-right organization of information on that sign format. Despite near chance performance in lane choice, participants were fairly confident of their lane selection choices. Participants were somewhat less confident with the Vertical Lane and Alternate Conventional signs than they were with the Conventional and Diagrammatic signs.

Overall, responses to the Vertical Lane and Alternate Conventional type signs were slower than those to the Conventional and Diagrammatic signs.

Conclusions

- The method of predicting vehicle speed through roundabouts that is described in the FHWA publication, *Roundabouts: An Informational Guide* provides a good basis for predicting the amount of time drivers will have available for reading roundabout exit signs.
- Exit signs placed in advance of a roundabout exit provide better visibility sight distance and will allow for more information to be placed on the sign.
- No more than two pieces of information should be placed on exit signs that are located on the splitter island.
- For advance guide signs, when route shields and destination names are combined on the same sign or set of signs, conventional or diagrammatic signs are recommended.

This study was conducted by FHWA RD&T and onsite support contractor Science Applications International Corporation. For more information about the study, or for a copy of the full research report:

- Visit http://www.pooledfund.org/documents/TPF-5_065/final_roundabouts_12-2004.pdf
- Contact Bryan Katz at (202) 493-3388 or by email at bryan.katz@fhwa.dot.gov

---

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 Joe Moyer at (202) 493-3370 or email joe.moyer@fhwa.dot.gov or contact Scott Wainwright (202) 366-0857 or email scott.wainwright@fhwa.dot.gov.
- Visit www.pooledfund.org and search for study# TPF-5(065).

Traffic Control Devices Pooled Fund Study Members

Caltrans, Greg Edwards	Nevada DOT, Scott Thorson*	Broward Co., FL, Lee Billingsley
Florida DOT, Mark Wilson	New Jersey DOT, Doug Bartlett & Patt Ott	City of Los Angeles, John Fisher
Georgia DOT, Keith Golden	New York DOT, David Woodin	FHWA, Scott Wainwright*
Illinois DOT, Larry Gregg	North Carolina DOT, Lori Cove	FHWA, Joe Moyer
Iowa DOT, Tim Crouch	Pennsylvania DOT, Glenn Rowe	FHWA, John Seabrook
Kansas DOT, Steven Buckley	South Carolina DOT, Don Turner	FHWA, Debra Chappell
Mississippi DOT, John Smith	Texas DOT, Greg Brinkmeyer	SAIC/FHWA, Bryan Katz
Missouri DOT, Julie Stotlemeyer	Wisconsin DOT, Tom Notbohm	SAIC/FHWA, Heather Howard
Nebraska DOR, Randy Peters	ATSSA, Roger Wentz	*Co-Chairs

FHWA Publication No: FHWA-HOP-06-089

Peripheral Transverse Lines Treatment

Pavement Markings for Speed Reduction

According to the U.S. Department of Transportation (USDOT), speeding is considered to be a contributing factor in about 30 percent of fatal crashes in the United States (Speed Management Team Work Plan, 2000). Since higher vehicle speeds result in more severe crashes, it is presumed that safety can be improved if vehicle speeds can be reduced in dangerous road sections. Based on positive results shown through previous research efforts, one speed reduction method uses unique pavement marking patterns that can change drivers' perceptions and give them the illusion that they are traveling faster than they really are. This relatively low-cost countermeasure is created by making the travel lanes appear narrow or adding optical patterns to the roadway surface.

An experiment was designed to examine whether perceptual countermeasures, such as unique pavement marking patterns, have the potential to reduce vehicle speeds upon entering curves. Peripheral transverse lines were examined in this study. Peripheral transverse lines are tick marks that appear on each side of the lane. These marks become successively closer together as the driver progresses down the road. Such a perceptual technique might be useful in lowering speeds in work zones, curves, roundabouts, and toll plazas. For this project, test sites were selected in New York, Mississippi, and Texas. Speed measures were taken to evaluate the effectiveness of the new markings during three phases: 1) before installation, 2) shortly after the installation, and 3) approximately 4 months after installation to examine long-term effects at each site. Speed measurements were taken both upstream and downstream of the experimental marking pattern.

For two of the sites, the markings resulted in a significant decrease in overall vehicle speeds for total vehicles as well as for specific classifications of vehicles. There were also reductions in speed for vehicles traveling with headways greater than 4 seconds; that is, vehicles that were not following other vehicles. For all vehicle types and all headways, speed reductions were found to be higher at the New York site (about 4 mph) than at the Mississippi site (about 2 mph), which were interstate and arterial roadways, respectively. In Texas, where the markings were placed on a local road, the overall speed reductions were not significant.

For dangerous curves on interstate and arterial roadways, where many drivers may not be familiar with the road, engineers should consider the possibility of including such perceptual countermeasures for excessive speed in their long-range planning, and should also consider volunteering local roadway segments for future research studies to optimize marking pattern designs.


I-690 in Syracuse, NY


MS 468 in Flowood, MS

This study was conducted by Science Applications International Corporation. For more information about the study, or for a copy of the full research report:

- Visit http://www.pooledfund.org/documents/TPF-5_065/speed_reduction.pdf
- Contact Bryan Katz at (202) 493-3388 or by email at bryan.katz@fhwa.dot.gov

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 Joe Moyer at (202) 493-3370 or email joe.moyer@fhwa.dot.gov or contact Scott Wainwright at (202) 366-0857 or email scott.wainwright@fhwa.dot.gov.
- Visit www.pooledfund.org and search for study# TPF-5(065).

Traffic Control Devices Pooled Fund Study Members

Caltrans, Greg Edwards
Florida DOT, Mark Wilson
Georgia DOT, Keith Golden
Illinois DOT, Larry Gregg
Iowa DOT, Tim Crouch
Kansas DOT, Steven Buckley
Mississippi DOT, John Smith
Missouri DOT, Julie Stotlemeyer
Nebraska DOR, Randy Peters
Nevada DOT, Scott Thorson*
New Jersey DOT, Doug Bartlett & Patt Ott
New York DOT, David Woodin
North Carolina DOT, Lori Cove
Pennsylvania DOT, Glenn Rowe
South Carolina DOT, Don Turner
Texas DOT, Greg Brinkmeyer
Wisconsin DOT, Tom Notbohm
ATSSA, Roger Wentz
Broward Co., FL, Lee Billingsley
City of Los Angeles, John Fisher
FHWA, Scott Wainwright*
FHWA, Joe Moyer
FHWA, John Seabrook
FHWA, Debra Chappell
SAIC/FHWA, Bryan Katz
SAIC/FHWA, Heather Howard

*Co-Chairs

FHWA Publication No: FHWA-HOP-06-087

Traffic Control Devices at Transponder-Controlled Toll Booth Lanes

Background

The number of toll roads is increasing in the United States, with a consequent increase in the use of electronic toll collection (ETC). As of 2003, 18 States had deployed ETC to support 3,505 toll lanes Although ETC can result in significant increases in traffic flow, the increase in ETC has, in some cases, led to driver confusion as to which lane to use. Typical lane assignments are: 1) exact change, 2) full service, and 3) transponder-equipped vehicles only. Inadequate or inconsistent signing can confuse drivers and result in maneuver errors.

Objective

The objective of the project was to develop recommendations that could support standards for identifying those toll lanes that are designed for transponder-equipped or electronic toll collection (ETC) vehicles. The study addressed the following sign characteristics:

- ♦Background color
- ♦Font color
- ♦Underlay color
- ♦Logo style.

Example Laboratory Experiment Sign

Laboratory Signs Designed to Test Four Basic Elements

The study focused on the four basic elements of toll road signs for ETC lanes: background color, font color, underlay color, and logo style.

These elements were used in various combinations to determine which arrangements were most effective in providing high visibility and ease of recognition for drivers to alert them to the correct lane for ETC transponder users. Figure 1 is one of 120 sample toll road sign combinations that was presented to the 60 research participants in the Turner-Fairbank Highway Research Center's Sign Design and Research Facility.

Approach

Data collection was performed in the FHWA RD&T's Highway Sign Design and Research Facility, which is located at the Turner-Fairbank Highway Research Center. The laboratory uses a computer controlled slide projector with a zoom lens to present signs from an apparent distance of 2 miles and then enlarges the signs so they appear as they would if approached at a speed of 35 miles per hour.

Participants pressed a button when they first detected the sign, again when they could read the guidance information on the sign, and finally when they could read the logo on the sign. Each time they pressed the button, the zoom action was stopped so that the participant's response could be recorded.

The combinations of font color, background color, underlay color, and logos were each presented with various MUTCD standard colors. These combinations included black text on a black background so that participant guessing could be both discouraged and assessed.

Background colors used for the guide signs	Black, white, yellow, green, light blue, purple
Font colors used for the guide signs	Black, white, yellow, green
Colors used for the layer under the logos (underlay)	Black, green, yellow, light blue, purple
Logos used	FasTrak, E-ZPass, IPass, EZ-TAG
Guidance messages used on the signs	2 Left Lanes, 2 Right Lanes, Left Lane, Right Lane

FINDINGS

- Overall, green as a background color obtained the longest guidance information legibility distance.
- Fonts that provided the highest contrast to the background color (such as white) were most effective for legibility.
- The EZ TAG pictograph (which was purple, as were all pictographs in this study) showed dramatically longer legibility distances than did the other pictographs; this result was consistent across all underlay colors.
- The underlay colors with greatest contrast to the pictographs were most effective and included all the lighter colors tested (white, yellow, and light blue).

RECOMMENDATIONS

- A green background with white text is the established guidance sign color for interstates. Its effectiveness in this study suggests that this combination should also be used for guidance at ETC stations.
- Purple appears to be a good choice for ETC logos, but only if the underlay is a highly contrasting color such as white, yellow, or light blue.
- This study indicates that "more stylized" logos can be difficult to read, especially at longer distances and for drivers who may be new to a toll facility. It is recommended that logos consist of low spatial frequency symbols or text.
- Older drivers need more time to detect and process guidance information. Font size, logo design, and underlay contrast should be selected to accommodate the needs of older drivers.

This study was conducted by the Center for Applied Research. For more information about the study, or for a copy of the full research report:

- Visit http://www.pooledfund.org/documents/TPF-5_065/tollbooth.pdf
- Contact Bryan Katz at (202) 493-3388 or by email bryan.katz@fhwa.dot.gov

---

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 Joe Moyer at (202) 493-3370 or email joe.moyer@fhwa.dot.gov or contact Scott Wainwright at (202) 366-0857 or email scott.wainwright@fhwa.dot.gov.
- Visit www.pooledfund.org and search for study# TPF-5(065).

Traffic Control Devices Pooled Fund Study Members

Caltrans, Greg Edwards	Nevada DOT, Scott Thorson*	Broward Co., FL, Lee Billingsley
Florida DOT, Mark Wilson	New Jersey DOT, Doug Bartlett & Patt Ott	City of Los Angeles, John Fisher
Georgia DOT, Keith Golden	New York DOT, David Woodin	FHWA, Scott Wainwright*
Illinois DOT, Larry Gregg	North Carolina DOT, Lori Cove	FHWA, Joe Moyer
Iowa DOT, Tim Crouch	Pennsylvania DOT, Glenn Rowe	FHWA, John Seabrook
Kansas DOT, Steven Buckley	South Carolina DOT, Don Turner	FHWA, Debra Chappell
Mississippi DOT, John Smith	Texas DOT, Greg Brinkmeyer	SAIC/FHWA, Bryan Katz
Missouri DOT, Julie Stotlemeyer	Wisconsin DOT, Tom Notbohm	SAIC/FHWA, Heather Howard
Nebraska DOR, Randy Peters	ATSSA, Roger Wentz	*Co-Chairs

FHWA Publication No: FHWA-HOP-06-088

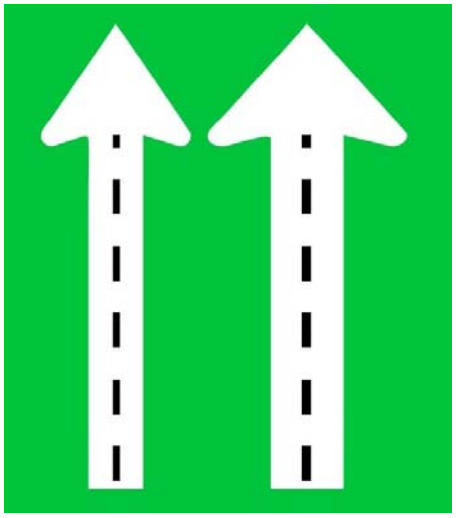
Traffic Control Devices Pooled Fund Study

Diagrammatic Freeway Guide Sign Design

Current Standard

Enhanced Sign ("Exit Only")

Arrow Per Lane



Standard versus Modified Diagrammatic Elements

PROBLEM STATEMENT

Providing highway navigational information that is clearly understood, timely, and easy to read is critical to ensuring that road users are able to safely navigate to their destinations. Clear navigational information is even more critical for older road users whose capabilities may be diminished relative to those of younger drivers. Highway driving for older drivers can be challenging because of their generally longer reaction times and reduced visual capabilities (Staplin, et al., 2001). These challenges, coupled with the extra demands imposed by the tactical decisions of navigating – including lane-changing, merging, and exiting on high speed highways – suggested by Staplin et al. indicate that highway guide signs to improve older driver performance on roadways can be achieved by increasing decision sight distance.

Improved highway guide signing is critical on highways with lane splits, lane drops at exits, shared exit lanes, and multiple highway exits. Recommendations in the Highway Design Handbook for Older Drivers and Pedestrians (Staplin, et al.,2001) suggested specific changes to the MUTCD design standard for diagrammatic signs (Federal Highway Administration, 2003). These recommendations suggest that freeway guide signs should utilize upward-pointing arrows (1 per lane) to show both the number and direction of lanes for particular highway geometric conditions (e.g., exits, lane splits, lane drops). The design recommendations differ from the current design of a single arrow shaft with bifurcating arrow heads and dashed lane lines within the shaft (Federal Highway Administration, 2003). The Staplin, et al, recommendations, which are hereafter referred to as Arrow Per Lane (APL) were based primarily on a series of opinion surveys of highway safety experts and designers – not on empirical research. Performing an empirical evaluation of design recommendations was one purpose of the present study.

OVERVIEW

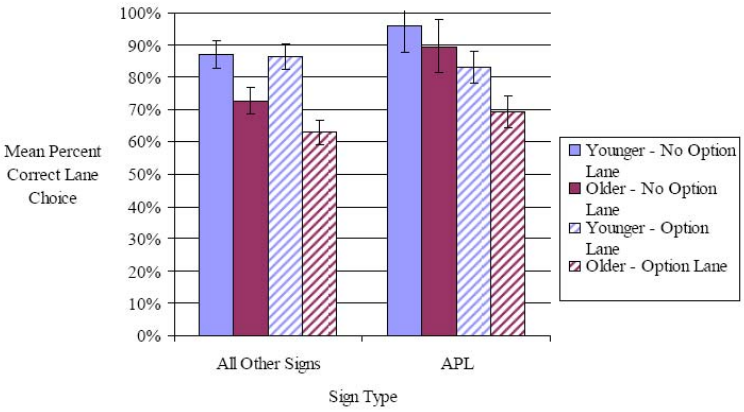
As part of the project, the FHWA Human Centered Systems Team evaluated freeway guide signs' efficiency in directing drivers to the appropriate lane(s) that could be used to reach their destination. Forty-eight drivers (with equal proportions of male and female drivers and older and younger drivers) viewed forty-nine signs and indicated when they were "100% confident" that they could identify all lane(s) that could be used to reach their destination. The signs included in the study consisted of five different types, which are referred to as: (1) Standard, (2) Modified, (3) Enhanced, (4) Enhanced Modified, and (5) Arrow Per Lane.

In addition to varying the sign types on a trial by trial basis, the parameters were the direction of exits (left and right), the number of exiting lanes, and the presence of option lanes. Participants viewed the signs at the Highway Sign Design and Research Facility at the FHWA Turner-Fairbank Highway Research Center. As the signs were presented to participants, they indicated by a button press when they were sure of which lane(s) could be used to get to their destination. The distance to each sign when the choice was made (decision sight distance) and the correctness of each decision were recorded.

RESULTS AND CONCLUSIONS

In terms of correct lane choices, the Arrow Per Lane (APL) signs yielded significantly better performance than the other types. This result was especially evident for scenarios with multiple lane exits and the presence of option lanes. In all conditions, the performance of younger participants was significantly better than that of the older participants. The younger group was correct 86% of time with their lane choices overall, compared to older participants who were correct only 69% of the time. Younger participants also showed significantly longer simulated decision sight distances than older participants, averaging approximately 10% longer distances for all sign types.

These findings indicate that the APL sign type is appropriate for all drivers and is especially beneficial for older drivers. Both age groups made more correct lane choices with the APL signs than with the conventional signs. Older drivers especially benefited in this regard. Based on statistical significant data, the research team concluded that the APL sign provided superior navigation guidance with regard to both decision sight distance and correct lane choice.



Mean Percent Correct Lane Choice by Sign Type, Presence of an Option Lane and Age Group

In the present experiment the signs were presented without the surrounding roadway context. Because the APL sign has arrows that are intended to provide additional meaning by being centered over the lanes to which they apply, additional research in which the highway context is provided may show that the present study underestimates the benefit of these signs relative to the other types. In addition, the present study did not employ Exit Only placards on the Arrow Per Lane signs. The additional benefit to comprehension that these placards may provide should be evaluated.

This study was conducted by Science Applications International Corporation for FHWA. For more information about the study, or for a copy of the full research report:

- Visit http://www.pooledfund.org/documents/TPF-5_065/Diagrammatic_Freeway_Guide_Sign_Design_rev4_final.pdf
- Contact Bryan Katz at (202) 493-3388 or by email bryan.katz@fhwa.dot.gov

---

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 email amanda.emo@fhwa.dot.gov or contact Scott Wainwright at (202) 366-0857 or email scott.wainwright@fhwa.dot.gov.
•Visit www.pooledfund.org and search for study# TPF-5(065).

Traffic Control Devices Pooled Fund Study Members

Caltrans, Wayne Henley
Florida DOT, Mark Wilson
Georgia DOT, Kathy Bailey
Illinois DOT, Larry Gregg
Iowa DOT, Tim Crouch
Kansas DOT, Steven Buckley
Mississippi DOT, John Smith
Missouri DOT, Julie Stotlemeyer
Nebraska DOR, Dan Waddle/Randy Peters
Nevada DOT, Dave Partee/Scott Thorson*
New Hampshire DOT, William Lambert
New Jersey DOT, Doug Bartlett/Pat Ott
New York DOT, Barbara Abrahamer/David Woodin
North Carolina DOT, Ron King
Pennsylvania DOT, Glenn Rowe
South Carolina DOT, Don Turner
Texas DOT, Doug Skowronek
Wisconsin DOT, Tom Notbohm
ATSSA, Roger Wentz
Broward Co., FL, Lee Billingsley*
City of Los Angeles, John Fisher
FHWA, Scott Wainwright
FHWA, Amanda Emo
FHWA, John Seabrook
FHWA, Ed Rice
SAIC for FHWA, Bryan Katz

* Retired

FHWA Publication No: FHWA-HOP-09-023

Traffic Control Devices Pooled Fund Study

Lane Restriction Signing and Marking For Double-Lane Roundabouts

OVERVIEW

A previous Federal Highway Administration (FHWA) study indicated that many drivers do not properly interpret lane restriction pavement markings at roundabouts. In that study traditional lane restriction markings had almost no influence on drivers' choice of lane on the approach to a double-lane roundabout. The present study investigated the effectiveness of different entry lane restriction signing and pavement marking schemes for double-lane roundabouts. Five signing and marking schemes were investigated:

Figure 1: Example of Traditional Arrows

1. Traditional Arrow signs and markings
2. Fishhook Arrows signs and markings
3. Traditional Arrow signs and markings with clarifying wording
4. Fishhook Arrow signs and markings with clarifying wording
5. Destination Lane Restriction sign with no lane restriction pavement markings.

The study was conducted in the FHWA Highway Driving Simulator. Ninety research participants were assigned to one of the five signing and marking schemes, with 18 research participants in each group. Each participant drove through 18 simulated roundabouts that were signed and marked in accordance with their assigned scheme.

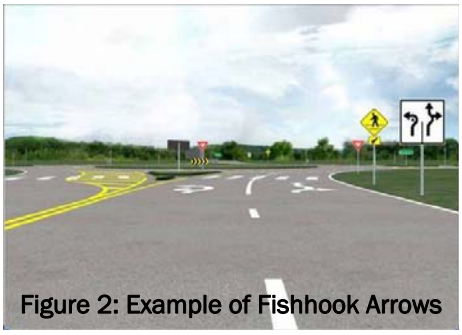


Figure 2: Example of Fishhook Arrows

Participants were instructed to follow directional signs to reach their destination. The location of the destination was randomized so that throughout the 18 trials the destination could be straight, to the left, or to the right of the roundabout entry. Sign restrictions varied so that during some trials only one lane could be used to reach a destination and during others both could be used to reach that destination. For each trial the entry lane used was recorded. After driving the 18 roundabouts, each participant passively viewed the same 18 roundabouts in a different order and reported his/her understanding of the meaning of the entry lane restrictions. Finally, each participant rated the "workability" (how well each signing and marking scheme would work on actual roadways) of each of the 5 schemes.

RESEARCH QUESTIONS

In the first part of the experiment participants drove through simulated roundabouts. The driver behavior observed was intended to address:

- How well drivers comply with indicated entry lanes
- If any signing and marking schemes perform unsatisfactorily
- If any schemes were superior to any of the others

The second part of the experiment evaluated how well drivers comprehend which lanes are allowed. The recorded verbal responses were intended to address:

- How well drivers understood allowed options
- How well the concept of "either lane" was comprehended
- The efficacy of the various schemes to control traffic flow

The third part of the experiment obtained participant ratings of the "workability" of the alternative signing and marking schemes. The ratings were intended to address:

- Workability ratings drivers assigned the different schemes
- If any of the schemes was rated as unworkable (would not work at all)
- If any of the schemes rated as more workable than the others

In addition there were a number of general research questions which were answered from various portions of the three experiments, either singly or in combination. These were:

- Any signing and marking schemes leading to wrong-way rotation
- The efficacy of diagrammatic navigation signs
- Drivers bias toward the right or left entry lane
- Any meaningful age or gender effects

RESULTS

Compliance

The compliance experiment conducted in the driving simulator showed that:

- Drivers complied with indicated entry lanes about 89 percent of the time.
- None of the signing and marking schemes performed unsatisfactorily by an overall 85 percent correct criterion.
- None of the schemes were superior to any of the others in terms of correct lane choices.

Comprehension

The comprehension test showed that:

- Drivers understood left and right lane options about 90 percent of the time.
- The concept of "either lane" was poorly comprehended, and was correctly identified only 44 percent of the time.
- The lack of comprehension of allowed lane choices may reduce the effectiveness of lane restrictions to control traffic flow.

Workability Ratings

The workability ratings showed that:

- Drivers rated all schemes slightly above the mid-point of the scale, which was labeled "Might Work".
- None of the schemes were rated as unworkable (would not work at all).
- None of the schemes were rated as more workable than any of the others.

General Observations

In addition a number of general research observations emerged from the present study:

- None of the schemes led to wrong way rotation.
- Diagrammatic navigation signs were extremely effective (99 percent) in indicating the correct exit for the intended destination.
- Drivers exhibited a bias toward the right entry lane (66/34).
- There were no meaningful age or gender effects.

This study was conducted by Science Applications International Corporation for FHWA. For more information about the study, or for a copy of the full research report:

- Visit http://www.pooledfund.org/documents/TPF-5_065/FinalRoundaboutReport.pdf
- Contact Bryan Katz at (202) 493-3388 or by email bryan.katz@fhwa.dot.gov

---

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 email amanda.emo@fhwa.dot.gov or contact Scott Wainwright at (202) 366-0857 or email scott.wainwright@fhwa.dot.gov.
•Visit www.pooledfund.org and search for study# TPF-5(065).

Traffic Control Devices Pooled Fund Study Members

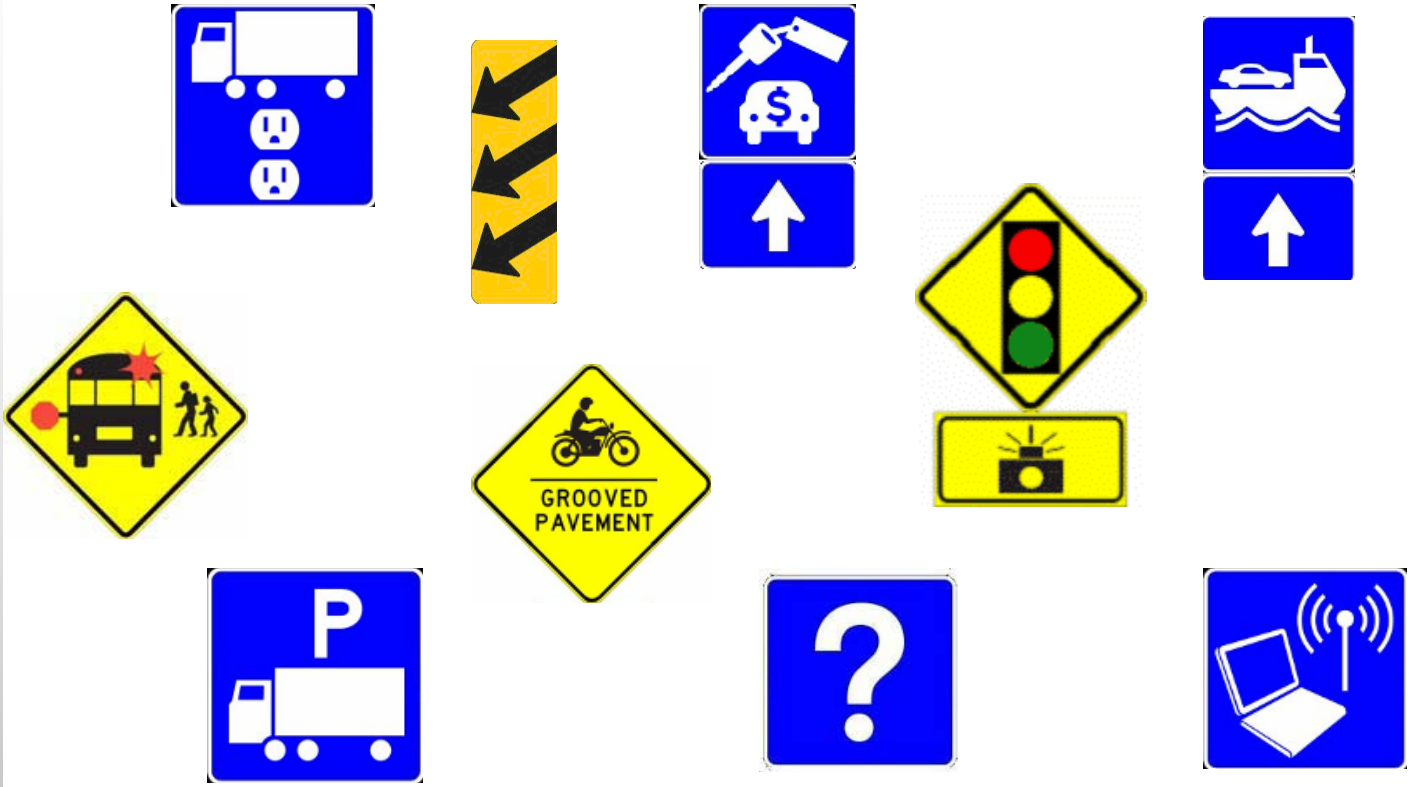
Caltrans, Wayne Henley
Florida DOT, Mark Wilson
Georgia DOT, Kathy Bailey
Illinois DOT, Larry Gregg
Iowa DOT, Tim Crouch
Kansas DOT, Steven Buckley
Mississippi DOT, John Smith
Missouri DOT, Julie Stotlemeyer
Nebraska DOR, Dan Waddle/Randy Peters
Nevada DOT, Dave Partee/Scott Thorson*
New Hampshire DOT, William Lambert
New Jersey DOT, Doug Bartlett/Pat Ott
New York DOT, Barbara Abrahamer/David Woodin
North Carolina DOT, Ron King
Pennsylvania DOT, Glenn Rowe
South Carolina DOT, Don Turner
Texas DOT, Doug Skowronek
Wisconsin DOT, Tom Notbohm
ATSSA, Roger Wentz
Broward Co., FL, Lee Billingsley*
City of Los Angeles, John Fisher
FHWA, Scott Wainwright
FHWA, Amanda Emo
FHWA, John Seabrook
FHWA, Ed Rice
SAIC for FHWA, Bryan Katz

* Retired

FHWA Publication No: FHWA-HOP-09-024

Traffic Control Devices Pooled Fund Study

Design and Evaluation of Selected Symbol Signs



OVERVIEW

As part of this project, the Federal HighwayAdministration Human Centered Systems Team evaluated proposed symbols for new traffic signs. The ten (10) symbols evaluated were:

- Wireless Internet
- Rental Car
- Ferry
- Information
- Automated/Photo Enforcement
- School Bus Stop Ahead
- Motorcycle Warning
- Truck Parking
- Truck Electrification (electric plug-in service for trucks)
- Object Marker

The goals of this study were to develop alternative symbol sign designs and then test them to determine driver comprehension and legibility distance of the experimental symbols. Prior to developing alternative sign designs, the research team conducted four (4) focus groups with the general driving population as well as ten (10) focused interviews with truck drivers. Multiple alternatives for each sign were developed based on input from drivers about the critical factors of each symbol. Critical factors of a symbol include features such as a side view versus a front view, traditional versus modern, etc.

The research team then tested sign comprehension on 174 participants to determine driver comprehension for each sign alternative. The tests were administered to the general driving public, but drivers with Commercial Driver's Licenses (CDLs) were specifically targeted for the truck parking and truck electrification signs. The questions were designed to gauge if participants understood a sign's meaning or whether the sign was confusing. The alternatives were then evaluated in the Highway Sign Research Laboratory to determine at what distance they become legible. Based on driver input and the results of the comprehension and legibility testing, the research team provided recommendations on symbols that should be included in the next edition of the Manual on Uniform Traffic Control Devices (MUTCD). For some signs, the team was able to clearly recommend a new symbol. The team determined that for other signs, like rental car and truck electrification, there was too much driver confusion and as a result symbols were not recommended. The team's final recommendations also suggested continued use of the object marker sign currently in the MUTCD.

Sign/Symbol	Recommended Alternative(s)
Wireless Internet	 
Rental Car Location	No symbol recommended
Ferry	
Information	
Automated Enforcement	 
School Bus Stop Ahead	
Motorcycle Warning	 
Truck Parking	
Truck Electrification	No symbol recommended
Object Marker	No symbol recommended Continue to use current object marker

This study was conducted by Science Applications International Corporation for FHWA. For more information about the study, or for a copy of the full research report:

- Visit http://www.pooledfund.org/documents/TPF-5_065/symbol_sign_report_final.pdf
- Contact Bryan Katz at (202) 493-3388 or by email bryan.katz@fhwa.dot.gov

---

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 email amanda.emo@fhwa.dot.gov or contact Scott Wainwright at (202) 366-0857 or email scott.wainwright@fhwa.dot.gov.
• Visit www.pooledfund.org and search for study# TPF-5(065).

Traffic Control Devices Pooled Fund Study Members

Caltrans, Wayne Henley
Florida DOT, Mark Wilson
Georgia DOT, Kathy Bailey
Illinois DOT, Larry Gregg
Iowa DOT, Tim Crouch
Kansas DOT, Steven Buckley
Mississippi DOT, John Smith
Missouri DOT, Julie Stotlemeyer
Nebraska DOR, Dan Waddle/Randy Peters
Nevada DOT, Dave Partee/Scott Thorson*
New Hampshire DOT, William Lambert
New Jersey DOT, Doug Bartlett/Pat Ott
New York DOT, Barbara Abrahamer/David Woodin
North Carolina DOT, Ron King
Pennsylvania DOT, Glenn Rowe
South Carolina DOT, Don Turner
Texas DOT, Doug Skowronek
Wisconsin DOT, Tom Notbohm
ATSSA, Roger Wentz
Broward Co., FL, Lee Billingsley*
City of Los Angeles, John Fisher
FHWA, Scott Wainwright
FHWA, Amanda Emo
FHWA, John Seabrook
FHWA, Ed Rice
SAIC for FHWA, Bryan Katz

* Retired

FHWA Publication No: FHWA-HOP-09-025