

TRAFFIC CONTROL DEVICES POOLED FUND STUDY SUMMARY RESEARCH REPORT

Signing for Intersection Geometrics that Require U-Turns

Susan T. Chrysler, Kay Fitzpatrick, Emira Rista, Amber Trueblood Texas A&M Transportation Institute

Stacie Phillips, Kimley-Horn

September 2019, DTFH6116D00039 TTI Task order 3

Introduction

Alternative intersection designs can improve traffic operations and safety but may be confusing to drivers due to turn prohibitions at intersections. Some of these designs include Median U-turns (MUT), Restricted Crossing U-turns (RCUT), J-turns, and ThrU-turns. Each of these intersection types require a driver to make a U-turn at a location away downstream the main intersection for the minor or major approach or both approaches. Agencies have used a variety of signing approaches, with combinations of regulatory and guide signs, to address wayfinding through these intersections.

Objective

This research project aimed to identify optimal signing sequences to guide drivers through alternative intersections that require U-turns.

Approach

The research team identified the state of the practice by reviewing State design guidelines, as well as studying photographs from alternative intersections identified by the Pooled Fund Study panel members. The team also reviewed the FHWA Manual on Uniform Traffic Control Devices (MUTCD). In addition, the team reviewed research literature concerning driver understanding of intersection and freeway signing. MUTCD sections on signs for circular intersections (roundabouts) and jughandle intersections provide guidance on guide and regulatory signs that could be applied to intersections that require U-turns. Roundabouts and jughandles share features with RCUTs and other alternative intersection designs in terms of violating driver expectations about allowed movements and direction of movement. Trailblazer signs were also considered as they provide path confirmation to reach a desired route. Based on these activities, the team selected eight research questions to be addressed in a human factors study that can be found in the Results and Recommendations Section. Multiple sign alternatives were evaluated for each of the eight research questions. In all, 32 unique individual signs or sequences of 4-5 signs were tested.

Human Factors Research Methods

The researchers created still images of signs and short computer animation video clips showing the approach to the intersection. The scenarios animated and illustrated were a two-lane major

approach, one-lane minor approach, and two-lane minor approach to an intersection that required U-turns. From these scenarios, the video clips were played at a speed equivalent to 40 mph and the still images were displayed for 5 seconds. Figure 1 shows an example of a still image.



FIGURE 1. EXAMPLE IMAGE FROM STILL IMAGE

Each participant completed the test individually at a computer work station in a room with others. The participant worked through the test using a response box with seven keys separate from the computer keyboard. An example question sequence for a still image is shown in Figure 2 illustrating the four steps to each test question. For video clips, the animation stopped automatically after each sign was passed then the test question and the confidence rating question were presented.

The study was conducted in St. Paul MN and College Station TX with 48 licensed drivers from each geographic area. An even number of male and female drivers were recruited. Approximately half of the drivers were over the age of 65 and half were younger than 65. Each participant saw 16 test questions and most completed the test within 25 minutes.

1	<p>In this scenario, you are driving north on County Road 5 approaching the intersection with a roadway called Oak Street. You want to go WEST on Oak Street. To continue to the photo, press button 7. The photo will be displayed for 5 seconds. After the photo is displayed, we will ask you a question about how you can reach your destination.</p>
2	<div style="text-align: center;">  <p>Shown for 5 seconds</p> </div>
3	<p>Answer: You want to go WEST on Oak Street. How would you proceed?</p> <ol style="list-style-type: none"> 1) I would turn left at this intersection. 2) I would turn right at this intersection. 3) I would go straight at this intersection and look for any opportunity to make a U-turn to come back from the other direction and turn right. 4) I would go straight at this intersection because I know there will be a designated place for me to make a U-turn to come back from the other direction and turn right.
4	<p>How confident are you of your answer?</p> <ol style="list-style-type: none"> 1) 100% confident. 2) 95% confident, slight chance I am wrong. 3) 75% confident, I am pretty sure I am right. 4) 50% confident, I could narrow it down to two of the options. 5) Not at all confident, I am basically guessing.

FIGURE 2. EXAMPLE QUESTION SEQUENCE FOR A STILL IMAGE

Results and Recommendations

Research Question 1: What sign designs on the **major** are best for a desired **left** turn at intersections that prohibit left turns?

In Research Question 1, participants saw a short video clip of the major leg approach to an intersection where it appeared that a driver could use the paved median to turn left but left turns were prohibited (e.g. MUT or ThrU intersection designs). The analysis showed:

- For the sign sequence leading up to the intersection, the current MUTCD signs performed significantly worse than any of the other signs.
- A sign that included the vertical hook U-turn arrow in place of the up arrow performed the best overall on the first advance sign position.
- Subsequent signs in the sequence that included a turn direction sign with a U-turn arrow and the U TURN plaque currently used for jughandle intersections performed the best.

The recommendation based on these results is shown in Figure 3.

Junction	Advance Route Turn	Destination	Directional Assembly	Confirming

FIGURE 3. RECOMMENDED TREATMENT FOR MAJOR APPROACHES TO INTERSECTIONS THAT REQUIRE A U-TURN DOWNSTREAM OF THE MAIN INTERSECTION.

Research Question 2: What sign designs on the minor are best for a desired left turn at intersections that prohibit left turns?

In Research Question 2, participants saw a short video clip of the minor leg approach to an intersection where it appeared that a driver could use the paved median to turn left but left turns were prohibited (e.g. MUT or ThrU intersection designs). The analysis showed the sign sequence made up of MUTCD route sign assemblies performed the best overall.

The recommendation for minor approaches is that route sign assembly information included in MUTCD Section 2D.29 can be applied without modification to intersections that prohibit left turns (see Figure 4).

Junction	Advance Route Turn	Intersection Lane Control	Directional Assembly

FIGURE 4. RECOMMENDED TREATMENT FOR MINOR APPROACHES TO INTERSECTIONS THAT REQUIRE A U-TURN.

Research Question 3: Which style of guide or other wayfinding sign is best for approaches on the major leg with a desired left turn movement?

Research Question 3 presented a still photo of a sign on a major approach. The median at the intersection was visibly closed. The analysis indicated the sign that contained the regulatory plaque with U TURN performed the best. This plaque is adapted from the regulatory signs for jughandle intersections show in MUTCD Figure 2B-9 Sheet 1. This result based on using still photos agrees with the results from Research Question 1 that examined the full sequence of signs on a major approach using video.

The recommendation for major approaches is to use the U-turn with directional arrow plaque as shown in Figure 5 (MUTCD Figure 2B-9 Sheet 1). The text legend U TURN here presents the same information as a U-turn arrow seen in other recommended signs.



FIGURE 5. RECOMMENDED SIGN FOR DIRECTIONAL ASSEMBLY IMMEDIATELY PRIOR TO MAIN INTERSECTION ON MAJOR APPROACH.

Research Question 4: Which style of guide or other wayfinding sign is best for approaches on the **minor leg with a desired **left** turn movement?**

In Research Question 4, a still photo of a sign as seen from the minor road approach to an intersection where left turns are prohibited were presented. The actual intersection was not visible on these photos as the signs being tested appeared in advance of the intersection. These signs showed an advance route turn assembly with arrows of different designs. The analysis showed the MUTCD advance route turn assembly with a horizontal right-pointing arrow performed well (see Figure 6(a)) as did a version of this sign with a horizontal U-turn arrow (see Figure 6(b)).

The recommendation for minor approaches is to use the MUTCD the Advance Route Turn Assembly with horizontal arrows as presented in Section 2D.31. The results of the study also suggest that optional use of a horizontal U-turn arrow could be used on these signs.

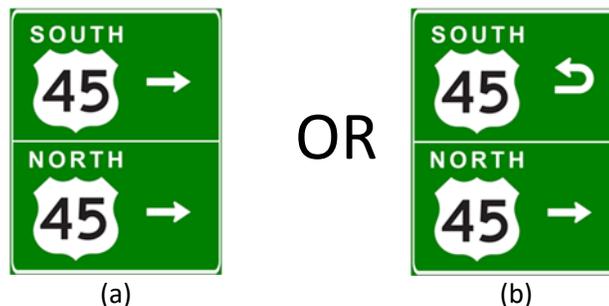


FIGURE 6. RECOMMENDED AND OPTIONAL SIGN FOR ADVANCE TURN ASSEMBLY FOR MINOR LEG APPROACH.

Research Question 5: Which style of guide or other wayfinding sign is best for approaches on the **minor leg with a desired **through** movement?**

Research Question 5 presented a still photo of signs on a minor road with the intersection visible in the distance. The MUTCD directional assembly utilizing the U TURN regulatory plaque adapted from jughandle intersections performed the best out of the signs tested (see Figure 7).

The recommendation for minor approaches for through movements is to use the MUTCD the Directional Assembly with horizontal arrows as presented in MUTCD Figure 2B-9 Sheet 1.



FIGURE 7. DIRECTIONAL ASSEMBLY RECOMMENDED FOR MINOR APPROACHES.

Research Question 6: Is a confirmation sign downstream of the main intersection needed?

The state of the practice review revealed some agencies used confirmation signs in areas with a long separation between the main intersection and the U-turn location. Question 6 used a video animation that asked participants to press the button as soon as they identified where to turn. The results showed the participants indicated their lane choice sooner with any of three sign designs shown in Figure 8. Therefore, the recommendation for confirmatory or turn direction signs downstream of the main intersection is any of these three signs. There was no difference among these signs, but each did better than no sign at all or the MUTCD route assembly with up arrows under both route markers.



FIGURE 8. RECOMMENDED CONFIRMATORY OR ADVANCE TURN SIGNS MAJOR ROAD IN ADVANCE OF THE U-TURN LANE.

Research Question 7: What advance lane assignment is need for multi-lane minor approaches that require downstream U-turns for prohibited movements?

Research Question 7 looked at multi-lane minor approaches by using an animation of a two-lane minor leg approach to an intersection. For vehicles that will be utilizing the downstream U-turn bay following the right turn at the main intersection, it is desirable to position these signs in the left lane on the minor approach. All sign sets that were tested performed well. No difference was found in this study between ground-mounted and overhead-mounted signs. Figure 9 shows examples of two of the four sign sequence tested as illustrations of the recommendation.



FIGURE 9. EXAMPLES OF TWO OF THE FOUR SIGN SEQUENCES TESTED FOR MULTI-LANE MINOR APPROACHES.

Research Question 8: Should directional arrows be modified to illustrate the U-turn maneuver for the major approach?

Research Question 8 compared two styles of advance route turn signs. The pattern of results suggested that participants chose the option that included the phrase “I would go straight at this intersection” more often when an up arrow was used than when the sign showed a U-turn arrow. The state of the practice review showed several states using some variant of an advance turn sign or regulatory turn lane assignment sign with a U-turn hook arrow shape. This type of sign also performed well when tested in this position using a video clip in Research Question 1.

The recommendation is that, if used, a confirmatory advance route turn sign after the main intersection use a U-turn hook arrow.



FIGURE 10. RECOMMENDED ADVANCE ROUTE TURN ON MAJOR APPROACH.