

# TECHBRIEF



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## Field Evaluation of a Restricted Crossing U-Turn Intersection

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This document is a technical summary of the Federal Highway Administration (FHWA) report, *Field Evaluation of a Restricted Crossing U-Turn Intersection* (FHWA-HRT-11-067).

### Objective

This TechBrief describes comparisons of field observations of the operations of an unsignalized restricted crossing U-turn (RCUT) intersection in Maryland with a roughly comparable conventional stop-controlled intersection on the same corridor. It also summarizes the results of several crash analysis approaches for intersections converted from conventional designs to RCUT designs along two four-lane divided highway corridors in Maryland.

### Introduction

An RCUT intersection is a promising treatment used to mitigate right-angle crashes where two-lane minor roads intersect with rural four-lane divided highways.

The RCUT design allows left turns from the highway onto intersecting minor roads, but it restricts turns from the minor road. Drivers desiring to make left or through movements from the minor road must first turn right and then make a U-turn to continue their desired movement. Figure 1 shows the RCUT intersection observed in this study.

### Research

One objective of the RCUT study was to observe an operational RCUT intersection on a rural four-lane divided highway to evaluate its safety and operations from a human factors perspective. The observations were intended to support design guidance for future RCUT designs. To provide perspective on

Figure 1. RCUT intersection observed in this study.



Source: Google<sup>®</sup>, U.S. Geological Survey, Data SIO, NOAA, U.S. Navy, NGA, GEBCO.

the RCUT intersection, observations were also made at a nearby conventional intersection on the same corridor.

The observations focused on the following:

- Conflicts between vehicles.
- Merging behavior.
- Lag acceptance.
- Weaving.
- Travel time differences between conventional and RCUT intersections.

A second objective was to perform a crash analysis to examine the effects of conversions from conventional intersections to RCUTs on two rural high-speed divided highway corridors in Maryland. This analysis focused on nine RCUT intersections that were deployed in Maryland between 1988 and 2003. Six of these

intersections were deployed on US-15 in Western Maryland, and three were deployed on US-301 on the Delmarva Peninsula in Eastern Maryland.

Observational data were collected by scoring video collected at two Maryland intersections: an RCUT intersection and a nearby conventional intersection on the same highway—US-15 in Frederick County. At the RCUT, recordings were made on two weekdays. Six digital cameras, three on each of two masts, were used to record operations.

The RCUT intersections selected for the crash analysis are listed in table 1. The table also shows the log mile location of the intersection, the date the RCUT conversion was completed, and the nature of the U-turn crossings that were provided for left and through movements from the minor road. U-turn locations are labeled as dedicated directional U-turns (DDUTs) if

they were channelized to permit U-turns originating from the direction of the main intersection. If the U-turns were made at a conventional intersection at the deployment date, then the U-turn location is labeled "Inter." If drivers making through or left movements needed to use another RCUT intersection to make the U-turn, then the RCUT label is used.

Before-and-after comparisons of traffic crashes were made for each RCUT intersection, the sections of road between the RCUT intersection, and the U-turn locations. The approach is intended to capture the total impact of the RCUT treatment on crash probability.

## Results and Conclusions

Based on the number of turning movements from the minor road, there were proportionally fewer traffic conflicts at the RCUT intersection. In particular, the RCUT intersection eliminated conflicts between vehicles turning left off of the highway and vehicles from the minor road turning left onto the highway. Additionally, the RCUT design appeared to have little or no effect on induced weaving movements on the highway.

The RCUT design that forced left and through traffic from the minor road to turn right and travel 1,800 ft to a directional U-turn crossing

added about 1 min to total travel time. The travel time penalty would likely decrease if the main road volume reduced the number of available gaps for direct left and through movements.

Although acceleration lanes are not an intrinsic part of the RCUT design, they were part of the design at the RCUT observed in this study. Drivers who made left or through movements from the minor road appeared to make effective use of them.

Three approaches were used to estimate the effects of an RCUT conversion on crashes, and they all led to the same conclusion: the RCUT design reduces crashes. A simple 3-year before-and-after analysis suggested a 30 percent decrease in the average number of crashes per year. An analysis that adjusted the observed crash rate at RCUT locations for the observed crash rate at nearby conventional intersections on the same corridors suggested a 28 percent decrease in the average annual number of crashes. An Empirical Bayes analysis that adjusts for the expected number of crashes at similar intersections and average annual traffic suggested a 44 percent decrease in crashes.

Not only did the expected number of crashes decrease between 28 and 44 percent, but the crash data also suggest that the overall severity

Table 1. Maryland RCUT intersections.

| Intersection                | Log Mile <sup>a</sup> | Deployment Date | Number of Approaches | Southern U-Turn Location (Log Mile) | Northern U-Turn Location (Log Mile) |
|-----------------------------|-----------------------|-----------------|----------------------|-------------------------------------|-------------------------------------|
| US-15 at Hayward Road       | 16.180                | 9/1988          | 4 <sup>b</sup>       | DDUT at 15.829                      | Inter at 16.530                     |
| US-15 at Willow Road        | 17.070                | 11/1992         | 4                    | Inter at 16.530                     | Inter at 18.020                     |
| US-15 at Biggs Road         | 18.020                | 11/1992         | 4                    | RCUT at 17.070                      | RCUT at 18.330                      |
| US-15 at Sundays Lane       | 18.330                | 11/1992         | 4                    | RCUT at 18.020                      | RCUT at 18.870                      |
| US-15 at College Avenue     | 34.210                | 8/1994          | 4                    | DDUT at 33.823                      | DDUT at 34.619                      |
| US-15 at US 15 Business     | 35.020                | 9/1988          | 4                    | DDUT at 34.619                      | DDUT at 35.477                      |
| US-301 at Main Street       | 12.380                | 1/2003          | 4                    | U-turn                              | Inter at 12.880                     |
| US-301 at Del Rhodes Avenue | 12.880                | 1/2003          | 4                    | Inter at 12.380                     | DDUT at 13.146                      |
| US-301 at Galena Road       | 43.670                | 1/2002          | 4                    | DDUT at 43.360                      | DDUT at 43.905                      |

<sup>a</sup>The log miles are from Maryland State Highway Authority crash records except where offsets were added at county boundaries to adjust for changes in the way log miles were recorded by various agencies.

<sup>b</sup>This intersection has since been converted from a four-way to a three-way intersection.

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of crashes that occurred was lower with the RCUT design than a conventional stop-controlled intersection. A 9 percent reduction was observed in the proportion of crashes that result in injuries or fatalities.

RCUT acceleration lanes for right turns and U-turns are strongly recommended to reduce traffic conflicts and minimize the delay incurred while drivers wait for acceptable gaps in the mainline traffic.

## Recommendations

The observational data and the crash analyses indicate that the RCUT design has a substantial safety benefit. The travel time penalty is small and would likely decrease with higher volumes of traffic on the major road.

**Researchers**—This study was performed by the FHWA Research, Development, and Technology Human Factors Team. The principle investigator was Vaughan W. Inman of SAIC. Robert P. Haas of SAIC co-authored the technical report.

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**Key Words**—Restricted crossing U-turn, Superstreet, J-turn, Alternative intersection design, Highway safety, Driver behavior, Divided highway, Intersection safety.

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