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Density Models and Safety Analysis for Rural Unsignalised Restricted Crossing U-turn Intersections

Rafael Olarte[a]*, Joe G. Bared[b], Larry F. Sutherland[c], Anand Asokan[d]

[a]*University of Maryland, College Park, Department of Civil and Environmental Engineering, 1173 Glenn Martin Hall, Bldg # 088, College Park, MD, 20742, U.S.A.*
[b] *Federal Highway Administration, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, VA 22101, U.S.A.*
[c] *Parsons Brinckerhoff, 2545 Farmers Drive, Suite 350, Columbus, Ohio 43235, U.S.A.*
[d] *Virginia Polytechnic Inst. and State Univ., Northern Virginia Campus, Dept. of Civil and Env. Engineering, 7054 Haycock Rd, Falls Church, VA 22043, U.S.A.*

Abstract

The first objective of this study was to provide designers with a model that would help them assess the suitability of implementing an unsignalized restricted crossing U-turn (RCUT) based on the traffic volume arriving to a given rural intersection. Specifically, this study identified the zones that were most susceptible to bottlenecks and provided regression models that calculate the traffic density as a function of the traffic volume. In addition, the second objective of this study was to look at how the number of traffic conflicts varied with the traffic volume. Two geometric design cases were studied: four-lane and six-lane arterials using 1000 foot long (305 m long) weaving sections. VISSIM traffic simulations were used to identify the critical zones, and calculate the traffic density for different traffic flows. Volumes and densities allowed the development of regression models. Two critical zones were identified: where vehicles coming from the minor road merge to enter the U-turn and where vehicles exiting the U-turn merge to the multilane arterial. Also, based on the classification given by this study to the traffic volumes, a sensitivity analysis determined which of them had the greatest impact on the level of service. For the number of traffic conflicts from simulation, the Surrogate Safety Analysis Model was applied to measure them. This study found that at certain traffic volumes, traffic conflicts rise sharply.

Keywords: J-turn ; RCUT; restricted crossing u-turn ; superstreet

1. Introduction

The restricted crossing U-turn (RCUT), also known as super street or J-turn, is a design typically used when a minor road intersects a major arterial road. This study focuses on applications of the RCUT to stop controlled rural multilane arterial intersections. The RCUT restricts direct through and direct left-turns from the minor road by requiring them to (1) turn right, (2) travel to a median intersection, and (3) make a U-turn through the median. Figure 1 depicts these three steps. After making the median U-turn, the equivalent of making a left-turn is made by continuing through the main intersection, and the equivalent of a through movement is made by a redirected right turn at the main intersection.

The main intersection can be designed to allow direct left-turns from the major road (as the case shown in figure 1), or they can be restricted when opposing through traffic combined with left-turns are heavy. This study focuses on RCUTs which are rural, unsignalized, and with this latter restriction.

* Corresponding author. Tel.: +1-240-595-1544; fax: +1-301-405-2585.
E-mail address: olarte@umd.edu.

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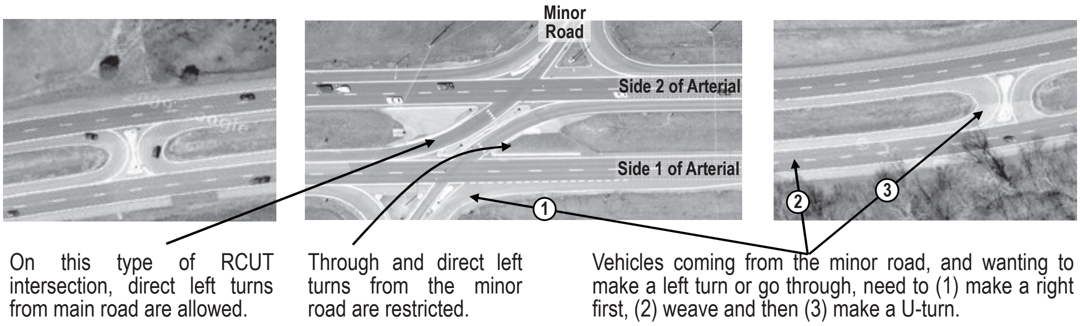

Figure 1 Main features of an unsignalized RCUT intersection in a rural area in Maryland (Google Maps, 2009)

1.1. Objective and Importance of the Research

Implementing an unsignalized RCUT instead of having an at-grade signalized intersection reduces operational costs. And it has been shown through several studies that unsignalized RCUTs diminish the number of accidents (Hummer, & Jagannathan, 2008; Hochstein, Maze, Welch, Preston & Storm, 2009; Hugues, Jagannathan, Sengupta, & Hummer, 2010). Given these benefits, it would be of interest for designers to have a tool that would allow them to assess the viability of implementing an unsignalized RCUT. Such a tool would require having a model that calculates the level of service as a function of, not only the traffic volume, but the geometry of the design. Also, it would require validating the model with several existing RCUTs. This study is just a first step in obtaining such a model. This study does answer the question of how the level of service is affected by the levels of traffic volume arriving to the intersection but it is limited to two specific simulated unsignalized RCUTs. To some extent, this study also takes into account the geometry of the design by providing a model for a four-lane arterial and another model for a six-lane arterial. As the reader will observe, answering the above question through the development of a statistical model, required answering two simpler questions. First, which zones within the RCUT are more prone to present bottlenecks? Second, how should the level of traffic volume be segregated in order to analyze its impact over the level of service? For example, this study found out that attention should be put on where the volume originates and where it ends. The resulting statistical models were used to determine how sensible the level of service is to each of the segregated levels of traffic volumes.

Finally, this study also analyzed some safety features of RCUTs. Specifically, this study provided some graphical insight and argumentation on how the number of "traffic conflicts" from simulation varies with the traffic volumes served by the RCUT. The concept of traffic conflict used in this study is the same as the one used by Amundsen and Hyden (as cited in Gettman, G., Pu, L., Sayed, T., & S. Shelby, p. 4): "an observable situation in which two or more road users approach each other in time and space to such an extent that there is risk of collision if their movements remain unchanged". Traffic conflicts and traffic crashes are two different representations. But it is the assumption that an increase of the former increases the probability of occurrence of the latter. Traffic conflicts were recorded for this study using the same simulation data generated for the density models. Although a statistical model could also be developed as with the traffic density, this study found out that a better understanding of the traffic conflicts needs to be addressed before suggesting a credible statistical model.

1.2. Organization of the Paper

This paper is organized as follows. First, a section called "PREVIOUS WORK" shows that although similar studies have been conducted, they have not really addressed the concept of the rural unsignalized RCUT. Second, a section called "METHODOLOGY" presents how an RCUT was simulated using the VISSIM software (PTV AG, 2008) and the assumptions that were made. Also, this section presents how the application of a software package was implemented for counting the number of traffic conflicts. Third, a section called "RESULTS" presents the statistical models that explain, as it is the main objective of this study, how traffic volume affects the level of service. Not only this section provides the estimation of statistical coefficients but it provides the critical areas that are more susceptible to bottlenecks and that in consequence should be part of the model. This section also presents, in a more specific case, how the number of traffic conflicts varies with the traffic volume. Fourth, a section called "DISCUSSION" analyses the implications of the density models and analyses the sensitivity of the level of service to traffic volumes depending on where they originate and end. This section also gives a qualitative explanation to the results obtained in terms of surrogate safety. Finally, conclusions and recommendations for further research are presented.

2. Previous work

The RCUT derives from the original concept introduced by Kramer (1987). His goal was to develop an innovative intersection that would reduce congestion on suburban arterials. The intersection would also have provisions for accommodating pedestrians and transit. Currently, there seems to be no full implementation of Kramer's design. This study utilizes his ideas of (*a*) replacing