SAFETY AND OPERATIONAL EVALUATION OF RIGHT TURNS FOLLOWED BY U-TURNS AS AN ALTERNATIVE TO DIRECT LEFT TURNS

(4 Volumes)

PROBLEM STATEMENT

Florida increasingly uses restrictive medians and directional median openings on multi-lane highways to manage left turn egress maneuvers from driveways or side streets. By installing nontraversable medians and replacing full-median openings with directional median openings at various locations, Florida is limiting unsignalized median openings to left turns from the major arterial; hence, **Direct Left-Turn** (**DLT**) egress maneuvers from driveways or side streets would be replaced by making a **Right Turn Followed By A U-Turn** (**RTUT**) at downstream median openings or signalized intersections.

OBJECTIVES

The primary objectives of this study were (1) to explore methodologies for evaluating the safety and operational effects of a widely used access management technique: right turns followed by U-turns as an alternative to direct left-turns, and (2) to provide information on the potential safety and operational impacts of these alternatives under various conditions. This research focused on the safety and operational effects of U-turns at signalized intersections on roadways with six or more lanes, and on the safety and operational effects of U-turns on four-lane roadways.

FINDINGS AND CONCLUSIONS

Field studies were conducted at twenty four selected street segments in the Tampa Bay area. Over 900 hours of traffic data were collected using video cameras. Video cameras were set up on scaffoldings to achieve adequate viewing height, and all of the traffic movements at the selected sites were recorded. While reviewing videotapes, each vehicle coming from a driveway making a DLT or RTUT was tracked. Delay and travel time for each vehicle making DLTs or RTUTs were recorded. Researchers also gathered information on traffic volumes, signal parameters, and roadway geometrics.

In this study, researchers used conflict data analysis to conduct safety analyses of the alternatives, and an empirical model (developed using field data) to conduct operational analyses..

Volume I: Safety Evaluation of Right Turns Followed by U-Turns (6 or more lane arterials) at Signalized Intersection as an Alternative to Direct Left Turns—Conflict Data Analysis

Nine types of conflicts were selected for this study: five related to RTUT movements and four related to DLT movements. Descriptive analysis and conflict rate analysis was conducted. Two types of conflict rates, conflicts per hour and conflicts per thousand involved vehicles, were used for safety comparison of the two left-turning alternatives. DLT movements generated, on average, 6.7 conflicts per hour, while vehicles making RTUT at signalized intersection generated 2.4 conflicts per hour. The average number of conflicts per thousand vehicles involved for DLT and RTUT movements was 40.6 and 26.2, respectively. Severity of conflicts was analyzed by a Risk of Collision (ROC) score. In general, when

both DLT and RTUT are compared, based on the results of this study, RTUT movements reduce the number of conflicts, and the overall severity of RTUT-related conflicts are significantly lower than is the severity of DLT-related conflicts.

Volume II: Operational Evaluation of Right Turns Followed by U-Turns (6 or more lane arterials) at Signalized Intersections as an Alternative to Direct Left Turns

Delay and travel time models were developed based on collected field data. The delay and travel time of DLT and RTUT at signalized intersection on 6 or more lane arterials (3 or more lanes in each direction) were determined as a function of conflicting volumes, signalization conditions, and roadway geometrics. Curves were developed based on regression results depicting operational differences between vehicles making a DLT and those making a RTUT. The curves demonstrated the break points at which drivers making a right turn followed by a U-turn at a downstream signalized intersection experienced less delay and travel time than those attempting to make a direct left turn through a median opening onto a major road.

A binary logistic regression model was developed to estimate the percentage of drivers that would like to make a RTUT rather than a DLT under particular traffic and roadway geometric conditions. The findings indicate that the left-turn volume off major road onto minor road had significant impacts towards increasing the amount of RTUT. Additionally, the regression model developed in this study also indicated that fewer drivers would select RTUT when the offset distance from the driveway to the downstream signalized intersection is relatively long.

Volume III: Safety Evaluation of Right Turns Followed by U-Turns (4-lane arterials) as an Alternative to Direct Left Turns—Conflict Data Analysis

Nine types of conflicts were utilized for this study: five related to RTUT movements and four related to DLT movements. Data collection sites were divided into two sets by geometric criteria. At the first set of sites, drivers had to complete the U-turn movement of a RTUT at a signalized intersection. At the second set of sites, the U-turns were accommodated at median openings.

At traffic signal sites, DLT movements generated two times more conflicts per hour than RTUT movements. When the effects of traffic volumes have been taken into consideration, RTUT movements had a 5 percent higher conflict rate than DLT movements. Severity comparison of DLT and RTUT movements indicated that RTUT-related conflicts were less severe than DLT-related conflicts.

At median opening sites, DLT movements generated 10 percent more conflicts per hour than RTUT movements. Furthermore, the other conflict rate, which considers the effect of traffic volumes, was 62 percent higher for DLT movements than for RTUT movements. Severity analysis results indicated that DLT movements had higher average severity scores than RTUT movements.

Volume IV: Operational Evaluation of Right Turns Followed by U-Turns (4-lane arterials) as an Alternative to Direct Left Turns

Delay and travel time models were developed based on collected field data. The delay and travel time of vehicles making DLT, RTUT at median opening, or RTUT at signalized intersection were determined as a function of conflicting volumes, signalization conditions, and roadway geometrics. Curves were developed based on regression results depicting operational differences between vehicles making a DLT and those making a RTUT at median opening or signalized intersection.

In order to determine the minimum turning radius required by U-turning vehicles, researchers developed an empirical model to estimate the relationship between the turning radius and the average turning time required by each U-turning vehicle; it can be used to estimate the average turning time required by U-turning vehicles under restricted geometric conditions. In addition, by analyzing the field data, the research team found that the average turning time of U-turning vehicles reaches a relatively stable state after the turning radius accommodated by the intersection reaches around 48 feet, and this could be considered the minimum turning radius required by most of the U-turning vehicles (except heavy vehicles) to finish the U-turn maneuver without taking extra turning time. Researchers used study findings to develop a procedure to estimate the minimum median width required to facilitate U-turn maneuvers or other functions on 4-lane arterials.

Finally, the results of this study allow for the conclusion that the access management technique (RTUTs as an alternative to DLTs from driveways or sideways streets) can be used safely and efficiently. Vehicles making a RTUT could have better safety and operational performance than those making DLTs under certain traffic and roadway geometric conditions.

BENEFITS

This project has provided information that will be useful to traffic engineers, planners, and designers. The Florida Department of Transportation prohibits DLTs onto major arterials. However, regarding median closures at existing DLT locations, FDOT sometimes faces objections from the owners of commercial developments that prefer direct access. In addition, some drivers have expressed their concerns about the safety of U-turns in the RTUT process. The findings of this research provide FDOT with the quantified data to address such issues.

The findings of this study are helpful in providing local and state transportation agencies with recommendations for the design and selection of median treatments on urban or suburban arterials. The potential median treatments include the installation of restrictive medians, closing median openings, and replacing a full median opening with a directional one.

Delay and travel time models provide a tool to help address public concerns related to the operational impacts of U-turns and would be particularly helpful in identifying the circumstances under which the right turns followed by U-turns take less time than direct left turns from driveways or side streets.

The study also looked extensively at the operations of distributing U-turn traffic at signalized intersections and unsignalized intersections. The research found that providing U-turn locations at a special unsignalized location before the traffic signal has many positive operational impacts. However, finding an appropriate location for this U-turn median opening before a traffic signal in built-out areas can be difficult due to the tight geometric conditions found there. The study provided guidance on distances drivers seem to be willing to travel in order to make U-turns. Also, guidance was given on adjustments that would need to be made to signal timing based on the number of expected U-turns at the signal.

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