

SAFETY AND DESIGN IMPROVEMENTS AT RURAL EXPRESSWAY MEDIAN CROSSOVERS

Kai Zhao
Dept. of Civil and Environmental Engineering
University of Missouri- Columbia

ABSTRACT

Current progress of study on safety and operational issues of a particular type of wide rural median crossovers in the state of Missouri was described. In so far as the progress of the study, two potential analysis tools were compared. Found to be able to provide needed information, the CORSIM simulation software was selected as the main analysis tool in further study instead of the other potential tool, Highway Capacity Software. General CORSIM diagram of studied median crossovers was presented. Three sites were selected for data collection upon particular criteria. Traffic data in those three sites were recorded for further study use. Observations of safety and operational problems occurred in those sites were presented. Potential improvement techniques were recommended.

INTRODUCTION

According to the standard plans on the web page of the Missouri Department of Transportation (MoDOT) (*1*), a typical type II median crossover has a wide median (at least 18m) which has a separate deceleration lane for the left-turn vehicles in each direction on the major road. Normally, the side roads are controlled by two-way STOP signs, and the median area is controlled by YIELD signs. A simple sketch of this kind of crossover is shown in FIGURE 1-1. A detailed sketch is available on the web page (*1*).

While a wide median crossover can serve the normal function of providing storage space for crossing traffic in addition to left-turn vehicles and U-turn vehicles, there are some problems that affect the safety and operation of the intersection as a whole associated with wide median crossovers. The specific problem MoDOT faces is that multiple vehicles can be stored in the median area when the volumes increase through a crossover area. Those stored vehicles can actually block each other and impede visibility to oncoming vehicles. Some long vehicles (e.g., a WB-20 truck 22.5 meters long) may enter a wide median crossover without enough area to store it when trying to make a maneuver through the crossover area, and protrude into the through lane. This produces a dangerous situation to the vehicles going through the major expressway in high speed.

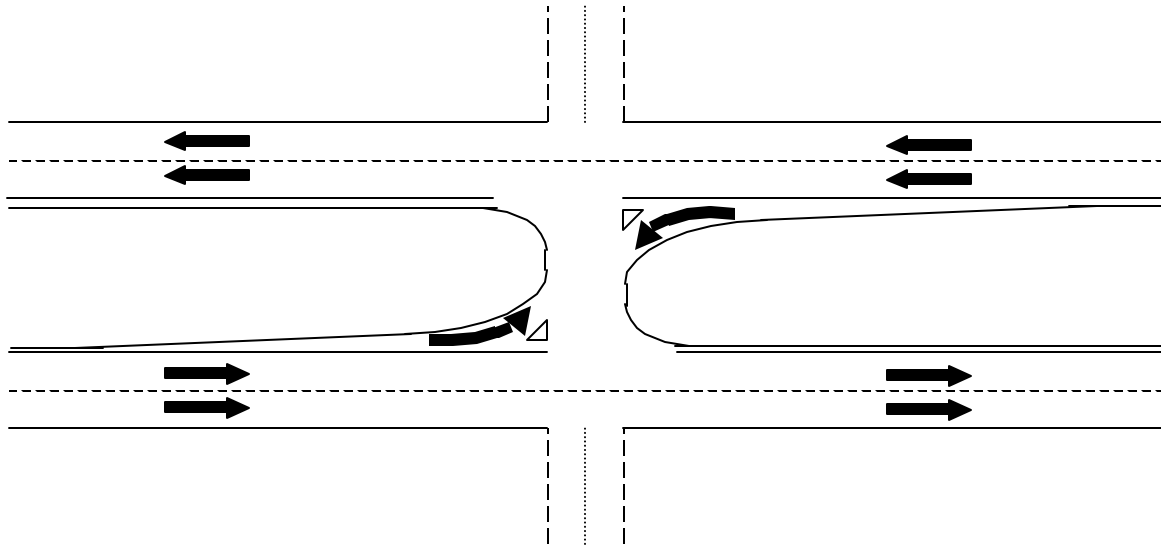


FIGURE 1-1: Typical type II median crossover

The object of the research is to try to provide a means for MoDOT engineers to determine whether particular high-speed rural expressway crossovers are performing satisfactorily and, if not, to assess alternatives for crossover design. The research begins in January 2000 and is expected to be completed by July 2001. This paper describes the progress so far.

Previous studies in this area were reviewed. A few studies were found that address safety and operational issues on rural expressways with wide median crossovers. Among those, three documents need to be addressed. In NCHRP Report 375: Median Intersection Design (2), some safety and operational problems associated with wide median intersection were studied. Relative strategies of the geometrics and traffic control measures like special left-turn treatments and U-turn treatments were presented. Bonneson, James A. et al. (3) described current state of practice of potential measurements that some state highway departments used to improve traffic safety at intersections on rural expressways. In NCHRP Synthesis of Highway Practice 281: Operational Impacts of Median Width on Larger Vehicles (4), some safety and operational problems found in median crossover were classified into several groups and described in detail. Corresponding practices used by the states to improve each situation were summarized as alternative improvement techniques. The reader is referred to the above references for more details.

ANALYSIS METHODOLOGY

Analysis Tools

Two analysis tools were for potential use in the research. One is the *Highway Capacity Manual* (HCM) (5) by using the *Highway Capacity Software* (HCS) (6); the other is the simulation software *Traffic Software Integrated System* (7) through using the package of CORSIM.

The HCM, based on a deterministic model, provides a basic analysis methodology for two-way stop-controlled intersections, such as the type II median crossover. Unfortunately, the HCS cannot serve the objective of analyzing the performance of the crossover location. The HCM/HCS procedures do not provide information about the median storage spaces needed by vehicles. The potential for applying the HCM/HCS to a crossover as two separate intersections (where the major highway is modeled as two separate one way roadways) was examined, but abandoned because of the storage location of major road left-turns in the deceleration lane.

Computer simulation is a useful analytical tool for traffic engineering. The package of CORSIM of the Traffic Software Integrated System (7), like all other simulation softwares, makes it possible to predict the effect of expected strategies on the system's operational performance prior to field demonstration. It provides a whole set of measures of effectiveness (MOEs), including average vehicle speed, vehicle stops, delays, fuel consumption, and pollutant emissions which can be used to compare the effects of the applied strategy on the traffic stream, and hence provides the basis for selecting the most effective alternative. Furthermore, by defining the segment of the intersection as a studied area, CORSIM can analyze the MOEs of the segment as well as the median crossover as a whole, which cannot be accomplished by using the HCM/HCS. For this reason, CORSIM was chosen as the main analysis tool in this research.

Data Collection

Data input required by CORSIM generally includes geometrics of the intersection, lane usage, traffic volumes, traffic composition and turning movements, and control devices.

Traffic volumes are being collected by video camera. Traffic composition and turning movements and some other input of CORSIM, such as critical gap, will be derived from the data. Geometrics of the intersections and information of control devices are provided by MoDOT and by field verification.

The output of CORSIM will be compared with the recorded data. To quantify the impacts of the alternatives on each part of the system and identify trade-offs, output of alternatives will be compared with (8):

- Individual links (e.g., the median area)
- Intersections (e.g., the intersection as a whole)
- System components (e.g., major road through traffic vs. cross-minor road)

For the objective of this research, particular criteria were used to select field data collection sites:

- Traffic volume, especially the volume of traffic passed through the crossover, should be high.
- The experience of operational and/or safety problem in the study area is more frequent (e.g. number of accidents is higher for the same time period).
- Types of accidents related to median crossover are severe.
- A range of intersection geometrics or other characteristics of the crossover is preferred.
- The data collection site is convenient for video.

Three sites were selected based on these criteria. Two are typical type II median crossovers. The median crossover area of one intersection (US Highway 63 & Route H) is controlled by STOP sign, while the other's (US Highway 50 & Cityview Dr.) is controlled by YIELD sign. The third intersection (US Highway 54 & Business 54/Route W) is an intersection of typical type II median crossovers plus acceleration lanes for the left-turn vehicles turning onto the main road.

Traffic data are being collected for two hours including the peak hour. The author found that the time periods with the higher traffic volumes passing through the median crossover area corresponded to the peak flow time period for each intersection.

A feasible set up of the video camera to record the field data is shown in FIGURE 2-1 (2).

The videotape data will be used to:

- Count traffic volumes. Traffic volumes will be counted separately for each individual turn movement (through, or left-turn) in each approach and in each direction of median area.
- Classify the vehicle mix.
- Calculate critical gap.
- Identify operational problem.
- Identify and count erratic maneuvers.
- Identify problems encountered by specific vehicle type in negotiating the intersections.

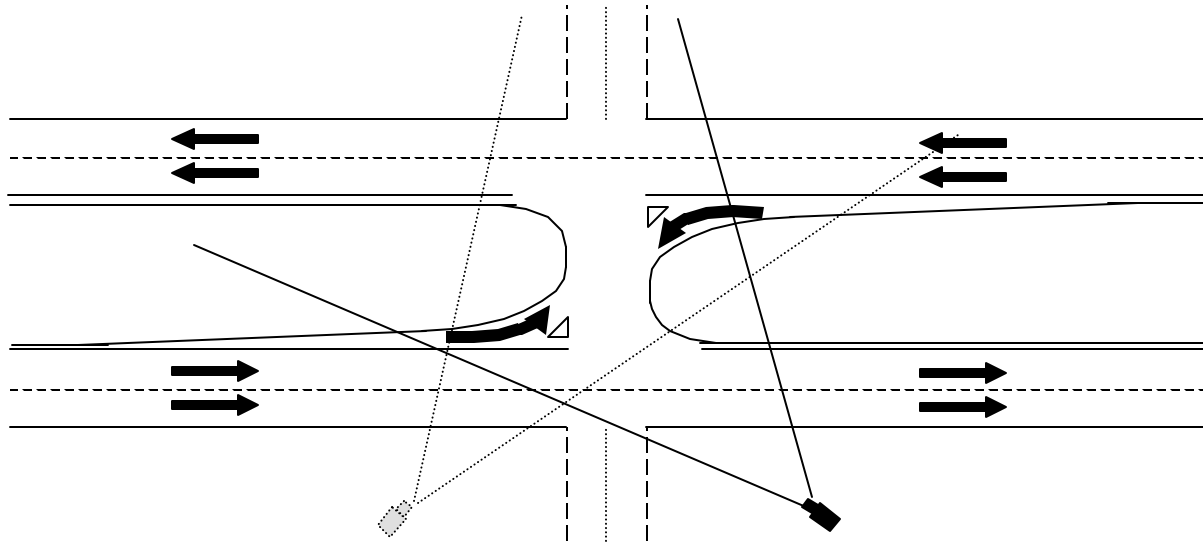


FIGURE 2-1: Typical setup for video camera

GENERAL SIMULATION PROCEDURE

Converting the intersection layout to a so-called link-node diagram is the first step to build the final model. In CORSIM, links are one directional segments of the studied facility, and nodes are usually the intersections of two or more links. According to the typical layout of the rural type II median crossover, the link-node diagram for it generally is like the diagram in FIGURE 2-2.

In the diagram, links between node 2 and 5 represent the median in the rural type II median crossover. The link from node 8001 to 8002 represents one direction of the major road, and link from node 8003 to 8004 represents the other direction. The various links between node 8005 and node 8006, except those between node 2 and 5, represent the two directions of the minor road that cross through the major road. Link from node 7 to 2 and link from node 8 to 5 are controlled by stop sign. Link from node 2 to 5 and link from node 5 to 2 are mostly controlled by yield sign.

There are two limitations in the current versions of CORSIM should be noted:

- In version 4.32, control delay is not calculated. The simulation can output total delay, queue delay, and stop delay.
- The software cannot show curved links, such as the right turn channelization. Some of the curved links can be coded by dividing the link into several short segment to get a smooth curve line, but usually short-distance links may cause a great deal of problems.

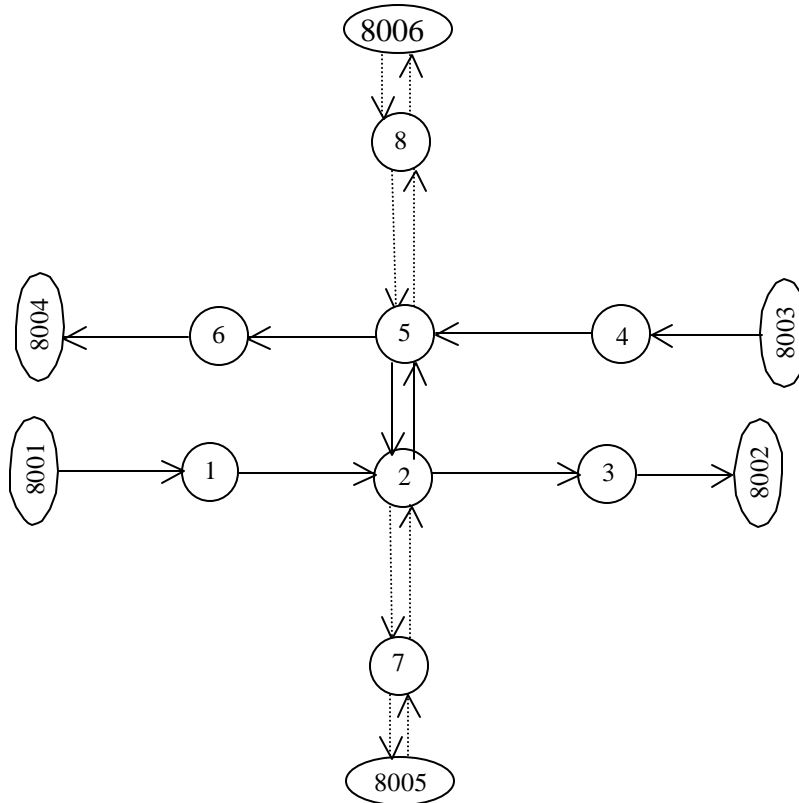


FIGURE 2-2: General representation of O-D diagram of typical type II median crossover

ANTICIPATED RESULTS

From the observation of the field data collected so far, there are some problems associated with the median crossover at the three selected sites. Some safety and operational problems are listed below:

1. Though all of the three intersections serve the function for vehicles traversing well, they did have some extreme situations. The median area of Hwy. 63 & Route H had as many as 6 vehicles stored in one direction, which made the queue backup into the deceleration lane. The median area of Hwy. 50 & Cityview Dr. had 5 vehicles stored in one direction. Most vehicles in the queue backtracked to the deceleration lane because the median area of this intersection can only store at most two passenger cars. For the Hwy. 54 & Bus. 54/ Route W, 7 vehicles were stored once in the minor road. Because the median area of this intersection is relative narrower, it can store only one vehicle for each direction. These are some potential sources for the safety concern.

2. Vehicles stored in the median area can block the vehicles wanting to traverse the median area from the other direction. One such situation occurred in the intersection of Hwy. 63 & Route H when there are 3 vehicles stored in the median area. The passway for the left vehicles on the other direction was blocked by the queue of the three vehicles. Only when a vehicle in the queue discharged was the blocked vehicle able to enter into the median area from the deceleration lane.
3. When the queue backed up to the deceleration lane, there seemed to be confusion for the vehicles wanting to traverse the median area from the minor road. Also, there were conflicts between stored vehicles and vehicles entering the median from other directions.
4. For some drivers who had to traverse the median area from the minor road to the major road, a longer waiting time for the first stage of gap acceptance may make the driver want to reduce his/her normal gap acceptance time for the second stage. There is one observation in the intersection of Hwy. 50 & Cityview Dr. where a car from the minor road passed through the nearside of the major road after a long time waiting. The driver seemed to want to leave the median area soon. After a few seconds of waiting in the median area, the driver tried to pull onto the major road, but had to back up into the median area again because of the gaps between the vehicles on the major road were not permissive.
5. There was confusion of priority between drivers in conflict with each other. Though most of the drivers assumed that the vehicles on the major road had the priority, some did not comply with that assumption.
6. There was confusion of the right of way in the median area. When the intersection was not at a right angle and was not marked, drivers used the median area in various ways. Some drivers turning left from the major road occupied the right side of the median area, while some others used the left side of the median to cross the major road traffic.
7. Drivers tend to ignore the storage function of the median area if the median area is narrower. This situation was found in the intersection of Hwy. 54 & Bus. 54/Route W. The median area can store only a car stopping at any significant angle. Though a few drivers used this narrow median as a refuge, most of the drivers tend to complete the two-stage gap acceptance at once without stopping in the median area. The median area seemed to be too narrower for drivers to make them feel comfortable to use it as

a storage area. Complicating the situation, most of the vehicles here were recreation vehicles with longer length than a passenger car.

In general, according to D. Harwood and W. Glauz (4), those problems that may occur in the type II median crossovers can be classified as:

1. Undesirable driving behavior, which includes:
 - Encroachment on through lanes by vehicles in the median opening.
 - Side-by-side queuing in the median opening.
 - Angle stopping in the median opening.
2. Collisions between left-turning vehicles and vehicles stopped in the median opening area.
3. Collisions between vehicles turning left from the divided highway and other same-direction vehicles.
4. Collisions between vehicles turning left from the median area and opposing through vehicles.
5. Collisions between vehicles making U-turns and opposing through vehicles.

POTENTIAL RECOMMENDATION TECHNIQUES

There are some safety and operational problems related to the Type II median crossovers. To improve the situation, the geometrics of the intersection, characteristics of traffic flow in each direction of the intersection, and traffic control devices are all involved in the consideration of mitigation techniques. Based on the field observation and related literature like (2, 4), some mitigation techniques are recommended below. Further study will be conducted by using the CORSIM simulation software to analyze the current performance of the selected intersections, and to compare it with some alternative mitigation techniques later on.

- Make the geometrics of the intersection uniform
- Widen some narrow medians: The width of median should be able to store at least one of the largest vehicles using the intersection most often safely. The width of the median should not cause the line stored in the intersection which combined by any kind of vehicles like passenger cars or school buses encroach the through lanes.
- Provide median acceleration lanes: It was indicated by NCHRP Report 375 (2) that, on the basis of the guidelines used by state highway agencies, acceleration lanes for left-turning vehicles from a crossroad onto the divided highway should be considered at locations where adequate median width is available, and:
 - (a) limited gaps are available in the major-road traffic stream;

- (b) low-speed turning traffic merges with high-speed through traffic;
 - (c) there is a significant history of rear-end or sideswipe accidents;
 - (d) intersection sight distance is inadequate;
 - (e) high volumes of trucks entering the divided highway.
- Extend edgelines to better define median opening area.
 - Mark double yellow centerline on roadway in the media opening to discourage angle stopping.
 - Remove STOP signs in median. The actual practice of most highway agencies was to use no control in the median opening area for median widths up to 9m(30ft), to use YIELD control for median widths from 9 to 25m(30 to 82ft), and to use STOP control for median widths of 25m(82ft) or more (2).
 - Install traffic signals. Traffic signals are less desirable in rural area because of high approach speeds. Installation of traffic signals at median openings should be considered only at locations where the *Manual on Uniform Traffic Control Devices (10)* signal warrants are met (4).
 - Install better delineation.
 - Install advance intersection signing.
 - Install bigger signs.
 - Prohibit left -turn maneuvers.
 - Increase the deceleration and storage length of existing left-turn lanes. Extending the length of a left-turn lane may only be feasible where the highway median is sufficiently wide to accommodate the extended median (4). AASHTO policy provides guidance on the appropriate deceleration and storage lengths for left-turn lanes (9).
 - Provide median crossover or indirect routes for U-turns.
 - Prohibit left -turn maneuvers or U-turn maneuvers.
 - Close median opening.
 - Reconfigure median to prohibit crossing maneuvers while still permitting left-turns. Consideration must be given to the alternate routes that will be used by the diverted traffic and the traffic operational and safety impacts on other locations for the above three techniques.

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