Studying Driver's Lane Changing Behavior Under Heavy Traffic Volumes

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Abstract

The goal of this paper was to develop a method to study the driver's lane changing behavior occurring on arterial streets under heavy traffic volumes. This work focus on studying roadway segments with short spacing between signalized intersections suffering from delay problems due to the lane changing behavior. The heavy delay problems result from the through vehicles changing lanes to turn right at the downstream intersection conflicting with side street vehicles entering from an upstream intersection and changing lanes to turn left or go through at the downstream intersection. The method utilized video cameras and road tubes to collect the data. It was found that this method was effective, accurate, and allowed for collecting accurate information regarding the driver's lane changing behavior.

Introduction

Two sites were selected for the analysis. These two sites suffer from a delay problem due to the lane changing behavior. The first site was on State Road 421 between the I-95 Off-Ramp and Airport Road in Port Orange, Florida and the second site was on State Road 50 between State Road 408 Off-Ramp and Bonneville Drive in Orlando, Florida. The two sites exist at the exit ramp of a diamond interchanges where the side street vehicles enter the arterial street through a free right turn lane. These two sites have the following criteria: relatively short spacing between two signalized intersections that are running in coordination; moderate to heavy road volumes; and no driveways or median openings between the two signalized intersections. The arterial segment had two through lanes. The downstream intersection had a left turn lane and a right turn lane. Figure 1 shows the studied movements occurring on the two arterial segments. These movements caused heavy delay along the two segments as shown in Figure 2.

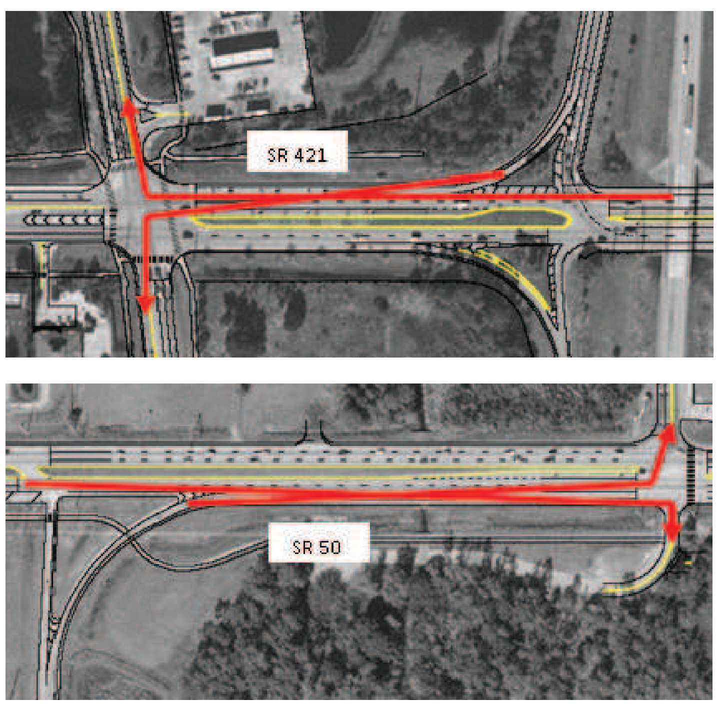

Figure 1. Aerial maps showing the studied movements at the two studied sites.

Figure 2. Breakdown conditions on the two arterials.

Data Collection

Video cameras were used to collect the data. The cameras were used for two purposes. First, the cameras were used to record the driver's behavior. Second, the cameras were used to obtain volume counts and turning percentages along the arterials. To be able to achieve these two goals, the cameras were positioned on a high position (the I-95 bridge and the SR 408 bridge) to cover the studied segments (see Figure 3). The lane changing area was defined as the area between the end of the gore area at the first intersection to the stop bar at the second intersection. The cameras were zoomed in to capture the movement of each vehicle within the lane changing section. In order to determine the location where the vehicle performed the lane changing, road tubes were placed at a 100 feet spacing starting at the gore area as shown in Figure 3. The tubes acted as distance meters. In addition to the video, aerial photographs and detailed sketches of the two sites were obtained. These sketches included the geometry of each site including the number of lanes, channelization, auxiliary lanes, and the distance between the two signalized intersections. At each site, eight hours of data were collected on a normal weekday using the video recording equipment. The time periods were selected so that two hours in the morning period (7:00 a.m. to 9:00 p.m.), two hours in the midday period (11:00 a.m. to 1:00 p.m.), and four hours in the evening period (2:00 p.m. to 6:00 p.m.) were observed.

The reduction of the field data involved observing the videotapes of each site. The videotapes were used to observe the lane changing movements and also to obtain accurate counts and turning percentages along the arterial. This method was used since it was hard to observe the lane changing and to count the vehicles in real time at high volumes. Accuracy in video data is due mainly to the fact that the viewer is able to view the videotape more than one time. Therefore, the viewer can concentrate on a single movement and then when finished rewind the tape and observe a different movement. Data reduction sheets were created for each site so

Figure 3. Video camera positioned on the bridge and road tubes placed every 100 feet along the arterial.

that the lane changing distance and the origin-destination patterns of individual vehicles could be recorded. The lane changing distance is defined as the distance from the gore area to the location where the vehicle crossed to the desired lane. Videos were then watched in slow motion to verify the lane changing distance, the origin-destination information, and the number of lane changes required to complete the movement. The origin-destination volumes, the lane changing distances, and number of lane changes were recorded in one-minute increments.

Analysis of Data

It was also found that there are five types of lane changing movements occurred. Type 1 and Type 2 were originated from the mainline and attempted to reach the right turn lane at the second signalized intersection. Type 1 vehicles had to perform one lane change in order to complete the desired lane changing maneuver. Type 2 vehicles had to perform two lane changes in order to complete the desired maneuver (change one lane to the second through lane then a second lane change to the right turn lane). Types 3, 4, and 5 were lane changing movements originated from the side street free right turn lane to go through or turn left at the second signalized intersection. Type 3 vehicles had to perform one lane change in order to complete the desired lane changing maneuver (move to the through lane). Type 4 vehicles had to perform two lane changes in order to complete the desired lane changing maneuver (change one lane to the first through lane then a second lane change to move to the second through lane). Type 5 vehicles had to perform three lane changes in order to complete the desired lane changing maneuver; the first land change to move to the first through lane, the second lane change to move to the second through lane, and the third lane change to the left turn lane.

It was found that 64% of the lane changing movements were originated from the side street and 34% was originated from the main street. The majority of lane changing volume occurred between Type 1 (35%) and Type 3 (40%), which accounted for 75 % of the total lane changing volume. Type 2 was the lowest lane changing volume (1%), which indicated that most vehicles that wanted to perform the lane changing movement from the main street preferred to change lanes to be in the outside through lane before entering the lane changing area to minimize the number of lane changes to only one lane change. The percentage of Type 4 was 13%, which indicated that some of the vehicles preferred to change two lanes to be in the inside through lane on the main street. This is probably due to the impression that the inside through lane will be faster than the outside through lane due to less distraction after the intersection. Type 5 (11%) is mainly based on the number of vehicles that had to perform a left turn at the second intersection.

The average lane changing distance for the 4,443 vehicles tracked for each type of lane changing were calculated. The average lane changing distance (D1) is the average of the lane changing distances required to perform the first lane change measured from the end of the gore area (applicable to all types). The average lane changing distance (D2) is the average of the lane changing distances required to perform the second lane change measured from the end of D1 (applicable only to types 2, 4 and 5). The average lane changing distance (D3) is the average lane changing distances required to perform the third lane change measured from the end of D2 (applicable only to type 5).

It was found that Type 5 has the minimum value of D1. These vehicles had to perform three lane changes and they had to start the lane changing movement as soon as they enter from the side street to the main street. D1 for Type 1 was also low because some of the vehicles in this type started the lane changing movement before the end of the gore area (driving on the gore area striping). The maximum value of D1 was for Type 3 where vehicles had to perform only one lane change. D1 for Type 2 and Type 4 were very close (157 feet and 143 feet respectively). These two types had to perform the same number of lane changes (two) in order to complete the desired lane changing maneuver.

A comparison of D1, D2, and D3 was done for the two studied sites. The main difference between the two sites was the distance between the end of the gore area to the stop line at the second intersection (LG). LG for the first site was 532 feet and for the second site was 730 feet. It was found that D1, D2, and D3 decreased dramatically when LG decreased which indicates the great effect of the distance between the two intersections on the average lane changing distance for the different lane changing types.

Conclusions

This paper has examined the different lane changing movements occurring between two close-spaced intersections for two sites in Florida. The two sites have a heavy right turn volume entering from the side street and close-spaced intersections. The paper has also studied the breakdown conditions occurring on the two arterial segments and caused by the lane changing movements. It was found that the breakdown conditions occur in two cases. The first case occurred when the main street through volume was heavy with moving queues observed extending onto the first intersection. In this case, vehicles entering from the side street could not find adequate gaps on the main street and had to reach a complete stop waiting for a gap on the main street. In the second case, the left turning volume at the second intersection was heavy and blocking the whole left turn lane. Although the main street volumes were moderate and adequate gaps were available, vehicles entering from the side street and willing to perform a left turn at the second intersection had to stop blocking the free right turn lane and waiting for the left turning vehicles to clear.

The analysis also revealed that the lane changing distances were also affected by the distance between the two intersections. As the spacing between the two intersections increased, the lane changing distances for all movements increased. By increasing the distance between the two intersections, drivers will have more space and time to adjust and to perform the lane changing movement. In addition, the lane changing distances within the same site were affected by the number of lanes changed. If a driver wants to change three lanes, he/she will perform the first lane change at a much shorter distance than a vehicle that wants to change only one lane. Based on the analysis introduced in this paper, it was concluded that lane changing movements on arterial streets can cause major delay problems streets unless adequate spacing between intersections is provided. It was found that the data collection method utilized was effective, accurate, and allowed for collecting accurate information regarding the driver's lane changing behavior.