Research
Report Summary

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Effect of Large Vehicles on Left Turn Gap Acceptance at Signalized Intersections

Critical and follow-up headways are the foundation for estimating the saturation flow of permissive left turns at signalized intersections. Current critical and follow-up headways recommended in the 2016 Highway Capacity Manual (HCM) are based on limited data collected from five intersections in Texas in the 1970s. This study analyzed over 2,500 left-turning vehicles at 45 intersection approaches, provides insights into gap acceptance parameters, and evaluates the effect of different site-specific factors.

Research Objectives

Obtain critical and follow-up headways using data from different regions in the US.

Compare observed critical and follow up headways with exiting HCM estimates.

Assess the effect of operational and geometric specific characteristics on left turn gap acceptance.

Literature Review

Two gap acceptance parameters are the foundation for estimating saturation flow: critical and follow-up headways. Values of 4.50 and 2.50 seconds are available, respectively. These estimates do not account for geometric and operational measures, so the saturation flow estimates do not reflect intersection site-specific characteristics.

Data Collection

Video recordings of left turn maneuvers, opposing traffic, and traffic signal indication at urban signalized intersections with permissive or protected/ permissive left turns were used in this study. The research team obtained and collected about 500 hours of video data at 27 intersections between 2016 and 2019, from three different geographical regions in the United States— East (Florida, North Carolina, Virginia), Midwest (Wisconsin), and West/Southwest (Arizona). Based on the geometric characteristics, video field of view, one or multiple left turn approaches at each intersection were used, resulting in 45 approaches for analysis.

Key Findings

The aggregated mean critical headway was 4.87 seconds. The aggregated mean follow-up headway was 2.73 seconds. Headway estimates of this study were higher than the HCM values. The mean critical headway for large vehicles was 6.03 seconds which is different than the aggregated estimate of 4.87 seconds which only included passenger vehicles. With a decreasing value of the posted speed limit and width of opposing traffic lanes, the smaller the critical and follow-up headways result in higher saturation flow estimates.

Future Research Enabled

Driver distraction, green ball or flashing yellow arrow signal indication, pedestrians, and obstruction of line of sight were not addressed in this report, as there were not enough observations to conduct a detailed analysis. However, future research efforts should focus on addressing the influence of these other factors on gap acceptance behavior.

Video Data Reduction

Video processing consisted of collecting timestamps for left turning, opposing through, and right turning vehicles during the permissive phase. Left turn maneuvers that occurred during the protected or end of green phase were not considered. Figure 1 provides an example of the video processing set up. Approaches, stop bars, and traffic signal indication had to be clearly identified and visible in the field of view of the camera.

Two timestamps were recorded for each left turn maneuver—l_0 and l_1. The first timestamp l_0 was recorded when left turn vehicles arrived or crossed the left turn lane stop bar, time in which left turning vehicles were actively seeking and waiting for an acceptable headway. The second timestamp l_1 was recorded when left turn vehicles proceeded to cross over opposing traffic lanes. Timestamp t_i (i=0, 1, …, n) were recorded for opposing traffic when vehicles crossed the stop bar which served to calculated headways. Timestamps which were recorded in a spreadsheet developed to flag any potential errors, process headway information, index, and validate the data. The spreadsheet provided a detailed distribution of headways associated with each left turn vehicle, type of headway (lag or gap), calculated follow-up headways, and identified the largest rejected and accepted headway.

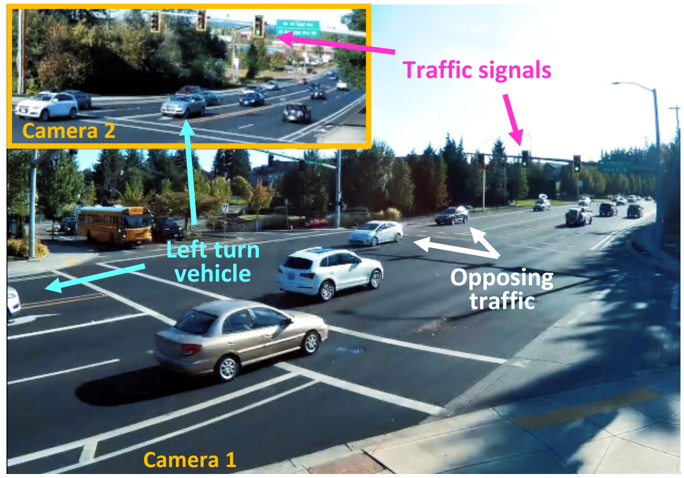

Figure 1. Screenshot of Video Processing

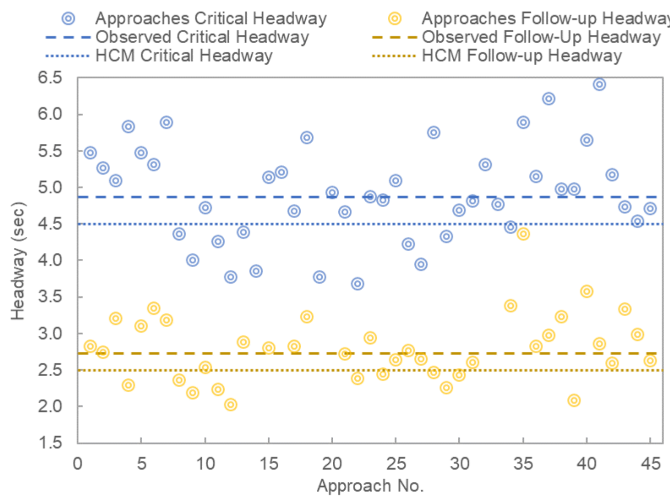

Figure 2. Critical and Follow-Up Headway

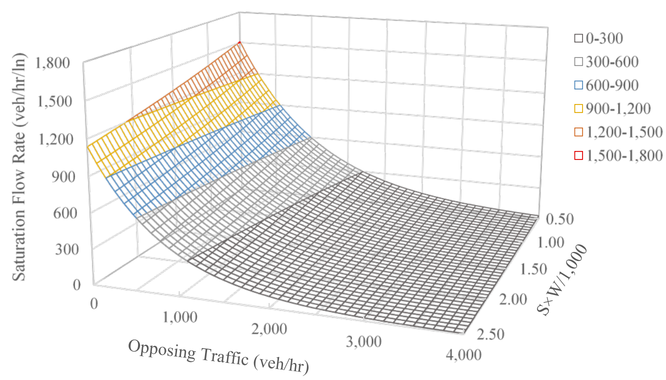

Figure 3. Saturation Flow Rate as a Function of Opposing Traffic and S×W/1,000

Mean Critical and Follow-Up Headway

Observations ranged between 25 and 83 left turns with a total of 2,108 observations. Mean critical headway estimates ranged between 3.68 and 6.41 seconds. The aggregated mean critical headway was 4.87 seconds. Limited number of left turn observations were available for large vehicles. There were only 18 left turn observations involving large vehicles (2 school buses, 12 single unit trucks, and 4 semi-trucks). The mean critical headway for large vehicles was 6.03. Despite the limited number of observations, the mean critical headway for large vehicles is different than the aggregated estimate of 4.87 seconds which only included passenger vehicles. Thus, in line with previous research, large vehicles require longer gaps to complete left turn maneuvers with permissive indication. Mean follow-up headway estimates ranged between 2.03 and 4.36 seconds. The aggregated mean follow-up headway was 2.73 seconds.

Meta-Regression Analysis

Models presented in this research are a function of the posted speed limit and width of opposing traffic (S×W/1,000). Thus, the saturation flow can be directly evaluated as a function of these predictor variables and opposing traffic flow as illustrated in Figure 3. The results show that with a decreasing value of S×W/1,000, the greater the saturation flow.