



The Effects of Countdown Signals on Intersection Capacity

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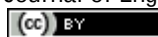
Total start-up lost time;

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ABSTRACT

This study presents the effects of countdown signals on the total start-up lost time of automobiles at signalized intersections based on the data collected at intersections in Bangkok, Thailand. This countdown signal is used to warn motorists in queue at the stop line during any red phase on when the green phase will be started. The data indicated that the countdown signals did not have any effects on the saturation headway of automobiles, but on the total start-up lost time. With the use of the countdown signals, the total start-up lost time was decreased from 4.3 seconds to 2.9 seconds, or was reduced by thirty-three percent. Therefore, the countdown signals may be used to increase the capacity of signalized intersections.

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1. Introduction

Increasing the capacity of a signalized intersection may be done mainly in two ways. One is to increase the saturation flow rate of automobiles (an inverse of the saturation headway). Another is to increase the effective green time of each green phase. However, it is relatively difficult to increase the saturation flow rate of automobiles at a signalized intersection since it crucially requires a geometric modification or a prohibition of trucks/buses entering an existing intersection. Thus, the alternative is to increase the effective green time of each green phase if

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the total start-up lost time of automobiles is to be reduced. In order to cut down the start-up lost time of automobiles, all motorists in queue at a signalized intersection need to be informed when the signal is going to turn green. Generally, motorists in queue at the start of the green phase will move faster if they are prepared for a green light. The sooner the queue moves, the smaller the value of the total start-up lost time becomes.

The countdown signals have been introduced and installed at signalized intersections in Bangkok, Thailand over a decade. The countdown signal is a big digital clock. The clock is synchronized with a signal-timing controller. It starts counting from the start down to zero at the end of the phase. Thus, the countdown signal may be used to inform motorists in queue at the stop line during any red phase on when the green phase will be started. Theoretically, a countdown signal will reduce the total start-up lost time of automobiles, and increase the effective green time of each green phase that results in an increased capacity of signalized intersections. The typical signalized intersection equipped with a countdown signal is illustrated in Figure 1.



Figure 1: Automobiles in queue at a signalized intersection equipped with a countdown signal.

The saturation headway and the total start-up lost time of automobiles have been studied by many researchers (Transportation Research Board, 2000; Messer and Fambro, 1977; Zhang and Chen, 2009; Bonneson, 1992; Mukwaya and Mwesige, 2012). The most commonly used saturation headway and the total start-up lost time are 1.9 seconds per vehicle (Transportation Research Board, 2000) and 2.0 seconds per phase (Messer and Fambro, 1977), respectively. So far, no studies on the effects of the countdown signals in regards to the saturation headway and the total start-up lost time of automobiles have been found.

2. Objectives

The objectives of this paper are to examine the effects of countdown signals on the saturation headway and the total start-up lost time of automobiles at signalized intersections. The methodology in this paper is comparing the saturation headway and the total start-up lost time of automobiles at signalized intersections when the countdown signal is in use and when it is not in use.

3. Data Collection

Thirty signalized intersections in Bangkok, Thailand were surveyed to collect data for this study. The characteristics of these intersections are through lanes with countdown signals, no trucks, no buses, no bicycles, no motorcycles, no grade, low volume of pedestrians, 3.3-m (11-ft) wide lane (normal lane-width for streets in Bangkok, Thailand). In addition, the countdown signals at these intersections were sometimes turned off.

The automobile traffic, when the countdown signal was in use and was not in use, was video-recorded using camcorders. To provide a better view of automobiles in queue, these camcorders were set up to capture traffic movements from 150-m upstream of each signalized intersection. The data collection process was done on sunny days. During the data collection, a minimum of nine automobiles was often in queue at the stop line during a red phase.

4. Data Reduction

All videotapes were reviewed and captured into an audio-video-image format (AVI) using a video capture card. This process breaks the automobile movements down to 10 frames per second. Only the AVI files with at least nine automobiles in queue at the stop line during the red phase were reviewed frame by frame using the Vehicle Videotaping Data Collector (Wei and Feng, 1999). The headway between automobiles departing the intersection at the beginning of a green phase was measured as the automobiles crossed the stop line at the intersection. The first headway is the elapsed time, in seconds, between the start of the green phase and the crossing of the front wheel of the first automobile in queue over the stop line. The second headway is the elapsed time between the crossing of front wheels of the first and the second automobiles over the stop line. Subsequent headways were measured similarly.

5. Data Analysis and Results

The data analysis and results in this paper are presented in two sections: (1) saturation headway of automobiles and (2) start-up lost time of automobiles.

5.1 Saturation Headway of Automobiles

Saturation headway of automobiles is the constant average headway between automobiles after the first few until the last automobiles in queue at the beginning of green clears the intersection. The data collected for this study showed that the headways between automobiles at all intersections remain constant after the sixth automobile in queue crossed the stop line for both when the countdown signal was in use and when it was not in use. As shown in Figure 2, the example of time headways of automobiles in queue, the constant headway “ h_s ” represents the saturation headway of automobiles. It is estimated as the constant average headway between automobiles after the sixth to the last automobiles in queue at the beginning of green clear the intersection.

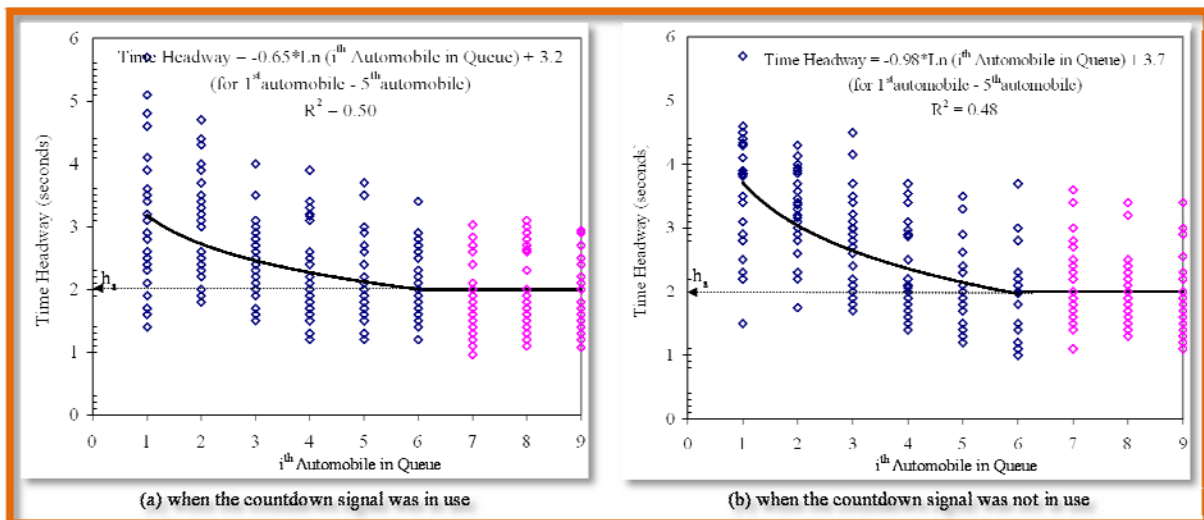


Figure 2: Headways of automobiles in queue at intersections.

Based on the data from all intersections, the saturation headways of automobiles in both situations slightly differ. Therefore, the statistical analysis was performed to test whether the saturation headways of automobiles were affected by the countdown signal. The comparison of means shows that the saturation headways of automobiles for the two cases are not significantly different at a significant level of 0.05, as presented in Table 1. This suggests that the saturation headway is not affected by the countdown signal. Therefore, the saturation

headway could be combined, and the average saturation headway for the lane width of 3.3-m in Bangkok, Thailand was measured to be 1.9 seconds which is slightly lower than the value used for the same width in the HCM 2000 (1.97 seconds) (Transportation Research Board, 2000).

Table 1: Saturation headway of automobiles.

	countdown signal was in use	countdown signal was not in use
Mean (seconds)	1.9	1.9
Variance (seconds ²)	0.005	0.006
Observations	30	30
Hypothesized Mean Difference		0.0
Degree of Freedom		29
t Stat		-1.61
P(T<=t) two-tail		0.12
t Critical two-tail		2.05
t-Test: Paired Two Sample for Means		

5.2 Total Start-up Lost Time of Automobiles

At the beginning of each green phase, automobiles in queue depart the intersection with the first few automobiles experiencing a start-up reaction time and acceleration time before achieving a constant speed. As mentioned in the previous section, the headways between automobiles at all intersections remain constant after the sixth automobile in queue crosses the stop line. After the first five automobiles, the effects of start-up reaction and acceleration are minimal. The example in Figure 2 depicts the headways of the first five automobiles are higher than the saturation headway, and are expressed as $h_s + t_i$ where t_i is the incremental headway for the i^{th} automobile due to the start-up reaction and acceleration. The incremental headway decreases as i increases. The sum of the incremental headways is called the total start-up lost time.

With a glance at the data, the total start-up lost time of automobiles is slightly lower when the countdown signal was in use. Hence, the statistical analysis was performed to test whether the total start-up lost time of automobiles was affected by the countdown signal. The comparison of means shows that the total start-up lost time of automobiles was lower when

the countdown signal was in use at a significant level of 0.05, as presented in Table 2. This suggests that the motorists depart the intersection faster when the countdown signal is used. With the use of the countdown signal, the total start-up lost time was reduced from 4.3 seconds to 2.9 seconds, or reduced by thirty-three percent. Nonetheless, these values are higher than the value used in the HCM 2000 (2.0 seconds per phase) (Transportation Research Board, 2000). As a result, the value used in the HCM 2000 cannot represent the total start-up lost time of automobiles in Bangkok, Thailand.

Table 2: Total start-up lost time of automobiles.

	countdown signal was in use	countdown signal was not in use
Mean (seconds)	2.9	4.3
Variance (seconds ²)	0.101	0.144
Observations	30	30
Hypothesized Mean Difference		0.0
Degree of Freedom		29
t Stat		-20.23
P(T<=t) two-tail		<0.01
t Critical two-tail		2.05

t-Test: Paired Two Sample for Means

6. Conclusion

The findings of this paper could be summarized as follow:

- 1) The countdown signals do not have any effects on saturation headway of automobiles. The time headways between automobiles at signalized intersections in Bangkok, Thailand were constant after the sixth automobile in queue crosses the stop line. Additionally, the saturation headway of automobiles for the lane width of 3.3-m (11-ft) was measured to be 1.9 seconds.
- 2) The countdown signals may be used to reduce the total start-up lost time of automobiles at signalized intersections. The total start-up lost time was reduced from 4.3 seconds to 2.9 seconds, or yielded a 33 percent reduction when the countdown signal was in use.

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