Transportation Research Part C 17 (2009) 662–671

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Effects of countdown timers on queue discharge characteristics of through movement at a signalized intersection

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ARTICLE INFO

Article history:
Received 11 August 2008
Received in revised form 11 May 2009
Accepted 13 May 2009

Keywords:
Countdown timers
Start-up lost time
Saturation headway
Flow rate
t-Test

ABSTRACT

This study investigates how countdown timers installed at a signalized intersection affect the queue discharge characteristics of through movement during the green phase. Since the countdown timers display the time remaining (in seconds) until the onset of the green phase, drivers waiting in the queue at the intersection are aware of the upcoming phase change, and are likely to respond quicker. Thus, the countdown timers could reduce the start-up lost time, decrease the saturation headway, and increase the saturation flow rate. This study observed vehicle flow at an intersection in Bangkok for 24 h when the countdown timers were operating, and for another 24 h when the countdown timers were switched off. The signal plans and timings remained unchanged in both cases. Standard statistical *t*-tests were used to compare the difference in traffic characteristics between the "with timer" and "without timer" cases. It was found that the countdown timers had a significant impact on the start-up lost time, reducing it by 1.00–1.92 s per cycle, or a 17–32% time saving. However, the effects on saturation headway were found to be trivial, which implies that the countdown timers do not have much impact on the saturation flow rate of signalized intersections, especially during the off-peak day period and the late night period. The savings in the start-up lost time from the countdown timers was estimated to be equivalent to an 8–24 vehicles/h increase for each through movement lane at the intersection being studied.

1. Introduction

The signal countdown timer is an Advanced Traffic Information System that is increasingly popular in traffic congested Asian cities. The timer is a digital clock installed next to the signal head, continuously displaying the number of seconds remaining for each phase of the cycle, including the changes from green to amber, amber to red, and red to green. This timer offers drivers an exact indication of the onset of the next phase so that the drivers are able to make a better decision on how they should respond to the upcoming change, or how they should utilize the time waiting for the onset of the green phase. The countdown timer is often claimed to offer many benefits, including improvement of vehicle flow at the intersection, reduced occurrence of accidents, and the reduction of stress in drivers waiting in the queue (Kasetsart University, 2004).

One potential benefit of the countdown timer is an improvement in the queue discharge since the timer alerts drivers in the queue of the exact phase onset before the queue receives a green phase. However, there have been only a small number of studies investigating this behavior, and the results are still mixed. This study aims to analyze the impact of the signal

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doi:10.1016/j.trc.2009.05.005

countdown on the queue discharge characteristics during the green interval. In particular, this study attempts to investigate whether or not the installation of countdown timers reduces the start-up lost time, decreases the saturation headway, or increases the saturation flow rate on the through movement at the signalized intersection studied.

2. Literature review

The majority of the previous studies that are related to the traffic light change anticipation system (TLCAS) focused primarily on road safety and accident prevention aspects during the amber phase and the beginning of the red phase. The anticipation system for the onset of the amber/red phase has been implemented for several decades in a variety of ways, including a flashing signal phase and the green signal countdown device. The flashing signal system alerts drivers by using the flashing green phase, or the flashing amber phase simultaneously with the solid green phase, a few seconds before the onset of the solid amber phase. This offers drivers longer decision periods to make an appropriate decision for the upcoming phase change. It is conceivable that such devices would improve safety and reduce the frequency of accident occurrences at signalized intersections. However, a laboratory simulation study by Mahalel et al. (1985) found that the flashing green phase led to a higher number of improper stopping decisions, and thus increased the frequency of rear-end collisions at the intersection. Simulation studies on the flashing amber phase during the last seconds of the solid green by Mussa et al. (1996) and Newton et al. (1997) showed similar results. The anticipation system tends to widen the time period during which drivers are indecisive, and could thus result in an increase in rear-end collisions. Nevertheless, their investigations found that the flashing amber phase potentially reduces severe decelerations and decreases the occurrences of red-light violations.

TLCAS was finally studied in the field in the investigation of Koll et al. (2004). The researchers conducted a survey at 10 intersections in Switzerland, Austria and Germany that used a flashing green phase. The results confirmed the findings of earlier simulation studies; the flashing phase results in a longer time period of indecision, thus tending to increase the frequency of rear-end collisions. However, the system increases the number of early stops, which in turn, reduces the occurrence of right-angle accidents.

A more recent version of TLCAS is the green phase countdown device. It is a countdown timer that displays nil for most of the cycle time, but shows the time remaining before the onset of the solid amber phase as a single digit number in seconds (from 9 to 0). This device not only warns drivers of the upcoming phase change, similar to the flashing phases, but also notifies drivers of the exact instance when the onset will occur. Lum and Halim (2006) conducted a before-and-after study of this type of device at an intersection in Singapore. The study found a 65% decrease in red-light violations 1.5 months after the device was installed, but after 7.5 months the number of red-light violations had rebounded to the average level before the installation. The device also increases the number of vehicular stops within 2 s into the red signal, and this effect seems to be sustained over a long period.

Another ATIS device that is capable of influencing drivers in a similar fashion is the pedestrian countdown signal. Although the real purpose of the pedestrian countdown signals is to offer information for pedestrians crossing the intersection, local commuters usually utilize the information from the pedestrian crossing phases to assist their decision making. Drivers can estimate the time remaining until their signal changes by considering the time remaining in the corresponding pedestrian signal countdown. Albeit most of the pedestrian countdown research primarily investigated its impacts on pedestrian behavior (Kim et al., 2002; Keegan and O'Mahony, 2003; PHA Transportation Consultants, 2005), there is at least one study exploring the impact of the pedestrian countdown signal on driver behavior. Huey and Ragland (2006) compared driver behavior at two intersections in Berkeley, CA; one with the installation of pedestrian countdown signals, and one without. It was found that the countdown signals resulted in fewer vehicles entering the intersection at the end of the amber phase. This could be due to the extra information from the pedestrian countdown signal assisting drivers to make better decisions on whether to speed up to cross the intersection before the amber phase ends, or to slow down and stop at the intersection.

In summary, there are a few TLCAS applications that have been applied for improved traffic control, for example the flashing green or flashing amber phases, the green signal countdown device, and also the pedestrian signal countdown. Most of the previous studies focused on the accident prevention and road safety aspects of these devices, and primarily investigated the TLCAS's impacts on driver behavior during the onset of the amber phase and the beginning of the red phase. The results of previous studies on these devices supports the idea that the anticipation system reduces the frequency of red-light violations and thus right-angle collisions, but could increase "indecision zone" and thus increase the frequency of rear-end accidents.

Continuous countdown timers have been employed for less than a decade but have already become widespread in traffic-congested cities in Thailand, Malaysia and China. Thus far, to the author's knowledge, there have been only two studies (by the same research team) that have attempted to investigate the impact of the signal timer on the discharge of queued vehicles during the beginning of the green phase. Kidwai et al. (2005) analyzed vehicular discharge at a non-CBD intersection in Malaysia, before and after the installation of the countdown timer. The study found the unexpected result that the average throughput (in units of pcu/h) reduced after the installation, which contradicted the presumption of the researchers. However, the statistical tests performed show no significant difference between the "without timer" and the "with timer" conditions at a 95% confidence interval. The researchers concluded that the countdown timers cause "very little effect" on the intersection capacity, without further explanation.