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Improved driver responses at intersections with red signal countdown timers

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ABSTRACT

Traffic Signal Countdown Timers (TSCTs) are innovative, practical and cost effective technologies with the potential to improve efficiency at signalized intersections. The purpose of these devices is to assist motorists in decision-making at signalized intersections with real-time signal duration information. This study focused specifically on driver responses in the presence of a Red Signal Countdown Timer (RSCT). A Linear Mixed Effect (LME) model was developed to predict the effect of RSCT on the headway of the first vehicle waiting on a red signal. The model predicted 0.72 s reduction in the headway of the first queued vehicle resulting from the presence of RSCT, while the observed difference in mean headway was 0.82 s. This result is suggestive of a reduction in start-up lost time at signalized intersections, i.e., an improvement in signalized intersection efficiency when an RSCT is present.

1. Introduction

1.1. TSCT operations

Traffic Signal Countdown Timers (TSCTs) are clocks that digitally display the time remaining for a particular signal indication, i.e., red, yellow, or green. They provide drivers with real-time information to potentially improve driver decision-making and vehicle control. A red signal countdown timer (RSCT), for example, alerts the driver to an oncoming green signal and reduces the time lost due to driver reaction at the beginning of the green signal. Similar TSCT displays can be shown for a green or yellow signal as well.

A sizeable portion of all signalized intersections in the United States, 272,000 in 2008 (FHWA, 2012), have fixed-time signals. The timing plans for fixed-time signals allocate green time based on prior observation of vehicle volumes (turning movements, vehicle classification, pedestrian volumes, etc.) and are not responsive to real-time traffic demand. Actuated signals utilize vehicle detection and additional timing parameters (minimum green, passage time, maximum green, etc.) so that the green time is allocated in response to real-time traffic demand. Typically, the final determination is made 1–4 s (Tarnoff and Parsonson, 1981) before the indication changes (e.g., green to yellow, or red to green), providing a limited interval for the countdown to be displayed. Therefore, application of TSCT has the greatest potential for green, yellow, and red indications at fixed-time signals and for the predictable yellow change intervals of actuated signals.

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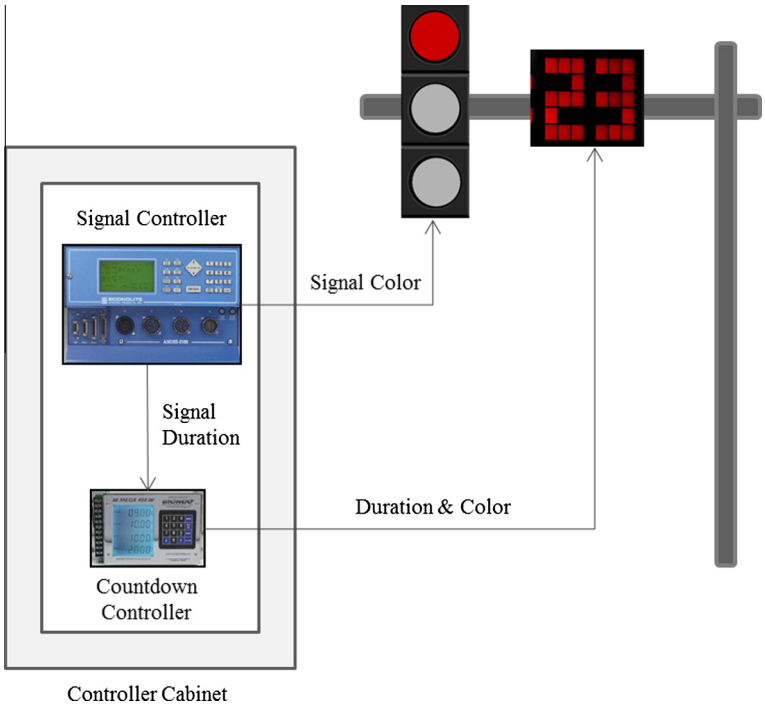

Fig. 1. Diagram of a TSCT that operates via signal and countdown controllers.

Fig. 1 illustrates the concept of operations for a TSCT. "The countdown time display panel is under the control of a countdown controller that runs in step with the signal controller. When a signal is counting down for a specific phase, the countdown control system shows the remaining time for that phase (Chen et al., 2009)".

As illustrated in Fig. 1, the signal controller feeds the countdown controller with signal duration information, which then displays the information in the form of a countdown timer.

1.2. TSCT efficiency

Most studies have attempted to quantify the operational efficiency benefits of TSCT with the performance measures of delay and throughput. TSCT are generally expected to reduce vehicular delay at signalized intersections (Chiou and Chang, 2010; Limanond et al., 2010, 2009; Sharma et al., 2009), and increase the throughput capacity by more efficiently discharging the queue (Chiou and Chang, 2010; Limanond et al., 2010; Sharma et al., 2009; Ibrahim et al., 2008; Liu et al., 2012). Chen et al. (2009) conducted a comprehensive study of the available literature on both vehicular and pedestrian countdown timers. RSCTs were found to be the only type of countdown devices with a positive influence on traffic safety and delay. However, occasional increases in travel time and decreases in capacity were also reported.

1.3. Reduction in intersection delay due to TSCT

RSCTs inform drivers about when the red signal will turn green, and thus, are expected to reduce the start-up lost time of the standing queue. On the other hand, green and yellow signal countdown timers (CTs) have the potential to reduce "clearance lost time" (i.e., the unused portion of the change or clearance interval) by displaying the amount of time remaining before the signal changes to red, which could reduce the overall delay at the intersection.

Limanond et al. (2009) found that the RSCT in Bangkok, Thailand slightly increased the capacity of the intersection by reducing the start-up lost time. Forty-eight hours of data were collected at an intersection; 24 h while the RSCTs were active, and 24 h while the RSCTs were inactive. The results of the study found that RSCTs reduced the start-up lost time by 1.00–1.92 s per cycle, equivalent to a time savings of 17–32%. This time savings represents an increase in capacity of approximately 8–24 vehicles per hour.

Further investigation by Limanond et al. (2010) in Bangkok, Thailand found a 22% reduction in the start-up lost time at the beginning of the green phase. Chiou and Chang (2010) also reported a similar reduction in the start-up lost time and saturated headway in presence of RSCTs in China. Sharma et al. (2009) investigated the effect of countdown timers on headway distribution in Chennai, India and found that RSCTs effectively reduced the start-up lost time.