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Safety of the Las Vegas left-turn display

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ABSTRACT

This paper provides a safety evaluation of a special protected/permitted left turn signal control (Las Vegas LT Display) that has been implemented in the urbanized area of Las Vegas, Nevada. The Las Vegas LT Display eliminates the yellow trap condition for leading approach in lead/lag operation. It provides protected only left turns during certain times of day by suppressing the permitted green ball and yellow ball displays. Before and after studies were conducted using the crash data from 10 intersections. Results from the analyses indicated that no obvious safety concerns due to use of the special display.

1. Introduction

Protected/permitted left turn (PPLT) control has the advantages of both permitted only and protected only left turn controls by increasing left turn capacity and reducing delay at intersections. The protected left turn phase either precedes (leads) or follows (lags) the opposing through movement. The major operational concern for PPLT is the so-called "yellow-trap" condition if lead/lag phasing is used. As Brehmer et al. (2003) stated a yellow-trap occurs when a permitted left turn phase is terminated during the change from permitted left turns in both directions to a lagging protected left turn in the opposite direction.

The Manual on Uniform Traffic Control Devices (MUTCD) recommends the types of traffic control that can be used for left turn maneuvers (Brehmer et al., 2003). The MUTCD requires that the PPLT operation have a protected left turn interval indicated by a green arrow during part of the signal cycle and a permitted left turn interval indicated by a circular green indication during another part of the cycle when the left turn must yield to opposing traffic. The MUTCD also states that all same color circular indications in all signal faces on an approach must be simultaneously illuminated when PPLT operation is used. However, if a separate signal head is provided for PPLT operations and the circular green and circular yellow indications in this head are visibility-limited from the adjacent through movement, the left turn signal head is removed from this requirement.

The MUTCD allows the use of variable left turn modes, in which the protected only mode occurs during one or more periods of day and the permitted only or the combined protected permitted mode occurs during the remainder of the day.

Several transportation agencies in the United States have designed and implemented unique PPLT phasing arrangements and displays to eliminate the yellow-trap condition (Brehmer et al., 2003). Examples of such special displays include the Dallas Phasing, Arlington Phasing, and the emerging Flashing Yellow Arrow. Recognizing the limitations of the standard MUTCD PPLT display, the City of Las Vegas has deployed a unique PPLT display (referred to as the Las Vegas LT Display) to eliminate the yellow trap condition and improve progression during the peak periods. The Las Vegas LT Display eliminates the yellow trap condition for leading approach in lead/lag operation. The Las Vegas LT Display provides protected only left turns during the peak periods of day by suppressing the permitted green ball and yellow ball indications. During other time periods, the signal resumes standard five-section protected/permitted operations. Internal signal controller logic is used to implement protected only left turn control during certain time-of-day operations.

Table 1 compares the operation of a standard 5-section MUTCD display with the Las Vegas LT Display during a leading left turn phase. As can be seen in the table, the green and yellow arrow indications of the Las Vegas LT Display are followed by a red arrow or louvered red ball when operating in the protected only mode.

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Table 1
Leading left turns for standard MUTCD and Las Vegas LT Displays.

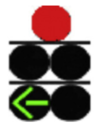
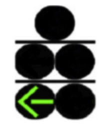
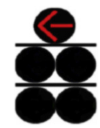
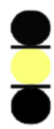
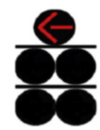
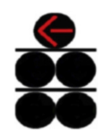
Interval	Standard MUTCD PPLT Display			Las Vegas LT Display (protected-only)		
	Description	Protected/Permitted left turn	Adjacent through	Description	Leading protected left turn	Adjacent through
1	Protected leading left turn			Protected leading left turn		
2	Clearance interval for protected left turn			Clearance interval for protected left turn		
3	Permitted left turn phase begins following the protected phase			Red arrow or louvered red ball ends protected left turn phase		
4	Clearance interval for permitted left turn			Red indication remains lit through normal permitted left turn phase		
5	Red indications on the approach during conflicting cross-street phase			Red indications on the approach during conflicting cross-street phase		

Fig. 1 shows an actual signal display operating with the Las Vegas control. These pictures show the clearance interval of a leading left turn while the signal is operating in protected only mode. As shown in the figure, the green ball and yellow ball of the Las Vegas LT Display are dark while the adjacent through movement has a green ball indication.

The primary objective of this paper is to assess whether the Las Vegas LT Display results in any safety concerns through examination of before and after crash records. Although the Las Vegas LT Display runs protected only left turns during the peak periods and many researchers concluded that protected only left turn control is the safest left turn control, driver understanding of the Las Vegas LT Display needs to be studied. The remainder of the paper is organized as follows: first, a comprehensive literature review is presented pertaining to the major methodologies used in conducting before-and-after traffic safety studies. The data analysis section then documents the details of the data collection and analysis process. Finally, results from the data analyses are provided in the summary and conclusion section.

2. Review of major methodologies for before–after safety studies

The purpose of conducting before–after studies is to estimate the effectiveness of a treatment by comparing the crash statistics before and after the treatment. Hauer provides a systematic description of conducting before–after studies, including the following three major before–after study methods: (1) simple or naïve before–after study; (2) before–after study with comparison group; and (3) before–after study with Empirical Bayes (EB) method. The three methods have been widely accepted by researchers and engineers (Haselton et al., 2002). Another useful factor named *crash reduction factor* (CRF) can also be obtained from the before–after crash data (Gan et al., 2005; Shen and Gan, 2003; Rimiller et al., 2003). CRF is defined as the percentage of the original crashes that is prevented by the treatment. The following discussions will focus on the principles of the three before–after study methods documented in Hauer's book. Literature specifically related to safety and operation of protected-permitted left-turn controls is also provided after discussing Hauer (1997)'s before–after study methods. Regardless of the methods to be used, there are two basic tasks for conducting a before–after study:

- Predict what would have been the crash frequency, π, in the "after" period had the treatment not been applied; and
- Estimate the actual crash frequency, λ, in the "after" period

Estimation of the actual crash frequency, λ, in the "after" period is always performed using the actual crash counts, i.e., $\lambda = L$, where L is the actual crash counts. It is the different ways of predicting what would be the crash frequency, π, that differentiates the three before–after study methods. A method is superior to another when a better prediction of the after crash frequency can be achieved.

2.1. Simple before–after study

The major assumption behind the simple before–after study is that nothing will change the safety performance except for the treatment, i.e., the "after" crash will be the same as the "before" crash had the treatment not been implemented. However, this assumption is likely false in most cases; therefore, the simple before–after study has significant limitations. But yet, it is still commonly used in practice due to its simplicity and fewer data requirements. The four-step process as described by Hauer 2003 for conducting a simple before–after study is outlined below: