

# Improved Protected-Permitted Left-Turn Signal Displays—The Texas Approach

BY GERRY DE CAMP AND RICHARD W. DENNEY, JR.

Over the past several years, two advanced techniques have emerged in the operation of protected left-turn signals at signalized intersections in many jurisdictions. One is the use of protected-permitted left-turn operation, which permits left-turn traffic to turn on an unprotected basis during opposing through traffic intervals in addition to providing a protected left-turn phase. The other is operating one of an opposing pair of left-turn phases in a lagging sequence, wherein the left-turn phase is serviced immediately after the opposing through movement rather than immediately before it.

## Advantages of Protected-Permitted Left-Turn Operation

Where they can be operated with no significant compromise to traffic safety, protected-permitted left-turn signals offer several advantages in operating efficiency over conventional restrictive (nonpermitted) left-turn signals. Among them:

- Except when opposing through traffic is so heavy as to provide no acceptable gaps for left-turn traffic during the through green signal phases, protected-permitted left-turn signals often provide a considerable reduction in average delay per left-turn vehicle.
- Especially when opportunities to turn left during the permitted period are frequent, protected-permitted left

turns can often provide a substantial reduction in the amount of green arrow time that the left-turn volume requires at the expense of other signal phases.

- On actuated left-turn phases, any of several delay timing techniques may be used to keep the controller from immediately terminating through traffic greens in response to detection of left-turn vehicles. These vehicles can often make their turns on the permitted green if given a few seconds to do so. In a nonpermitted left-turn phase operation, however, the controller must cycle and service the left-turn phase every time one left-turning vehicle is detected on the approach, even in very light traffic conditions.
- In extreme cases of very light or very heavy opposing traffic, it is sometimes possible to omit a protected left-turn phase altogether during parts of the day when providing it is unnecessary, impractical, or inefficient.

## Advantages of Lead-Lag Left-Turn Sequencing

Likewise, operating certain protected left-turn signal phases in a lagging sequence where those phases immediately follow rather than precede their opposing through movements can provide considerable improvement in signal operating efficiency in specific applications.

Typical examples include:

- Coordinated arterials where the pro-

gressive platoons in each direction do not pass through the signal at exactly the same time. Selection of leading and lagging left-turn phase sequences to optimize arterial signal progression has been a specific feature of the PARSER II<sup>1</sup> progression program since its inception.

- Intersection approaches not having a separate left-turn pocket, especially where presence detection at the stopline with delay timing could be used to distinguish vehicles waiting in a shared lane for the left-turn phase from through vehicles.
- Situations where the left-turn volume is so heavy as to overfill the left-turn pocket, and it becomes desirable to bring up the left-turn phase only when the concurrent through traffic is also being serviced.
- Small intersections where paths of the opposing left turns physically interfere with each other.

## The Conflict

Although either of these operating modes can be used individually, a problem, usually called the left-turn "trap" problem, often arises when the two techniques are combined. Drivers experiencing the trap are those attempting to make a permitted left turn opposing the lagging protected left-turn phase. Those motorists can be misled by the display of the yellow for the adjacent through movement, which immediately precedes the opposing lagging left-turn phase,

and erroneously assume that the through traffic opposing them is also being terminated (Figure 1). If the scarcity of gaps in the opposing flow requires them to wait to make their turn during the clearance interval, they are stranded, because the opposing through movement remains green. This phenomenon results in driver confusion and has generated numerous complaints in addition to being associated with increased accident potential.

## A Solution

Traditionally, the trap problem is avoided by not using protected-permitted and lead-lag phasing at the same time. Not wanting to be restricted to the benefits of only one or the other of these techniques, signal experts in Dallas, Texas, including one of the authors, developed an alternative operation and display for protected-permitted left-turn

signals used concurrently with lead-lag phasing. This alternative method, developed in 1978, allows the waiting left turner to see ball indications which clear at the same time as the opposing through traffic, and therefore drivers do not make false assumptions.

The basic concept involves: (a) having at least two signal heads for through traffic in addition to the five-section protected-permitted left-turn signal, because with the following modifications the left-turn signal can no longer be considered a shared indication for through traffic on the approach; (b) restricting the visibility of the circular indications of the five-section left-turn signal such that they may be readily seen only by left-turn vehicles, usually through the use of louvers or optically programmable indications, usually requiring the left-turn head to be installed on a post top, mast arm, or other rigid support such that the restricted displays may be aimed

with adequate precision and durability; and (c) modifying the restricted-visibility indications so that they continue to display a circular green to left-turn traffic through the opposite left-turn movement's lagging protected intervals, and displaying the amber for the permitted left turn only when the amber is on for opposing through traffic also (Figure 2).

In more refined implementations of this concept, wiring the modified displays to an overlap output is preferred so that the circular green for the left turn can be shown during all of both through movements on the street in question. Where the additional load switch positions necessary to do that are not available in the controller cabinet, however, the effect may still be achieved by simply hard wiring the restricted displays to their respective opposing through movement red, amber, and green ball outputs, rather than to the adjacent through movement displays as in a conventional setup.

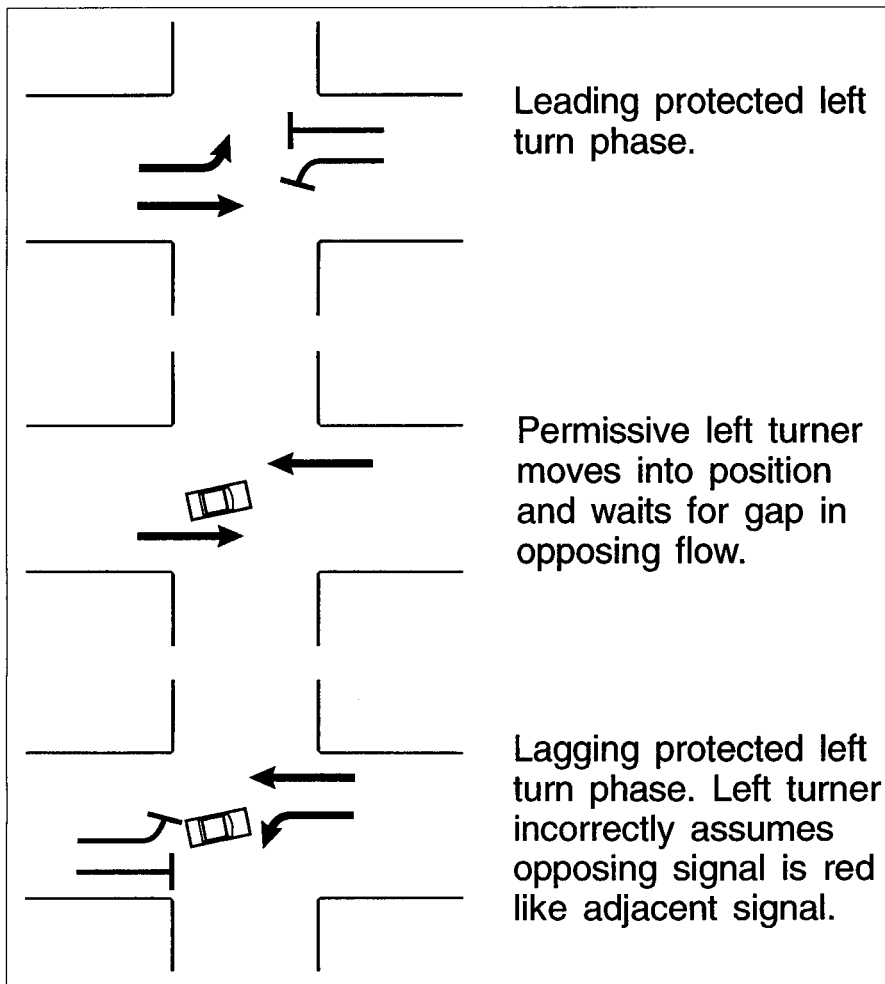


Figure 1. The trap problem with lead-lag protected-permissive turns.

## Effectiveness

The Dallas staff's early fears of significant motorist confusion quickly proved to be unfounded. In an effort to ensure against any confusion for traffic approaching in the inside through lane, engineers did make it a practice to sign the modified display head with an R10-10L "left turn signal" sign. More recently, the use of that sign has been replaced with the one shown in Figure 3, which is a combination of the above sign and the new R10-12 "left turn yield on green [ball]." Since then, because of the lack of complaints received by engineers who have implemented this approach, motorist understanding of the modified display in Dallas and elsewhere appears to have been quite good.

The Texas Department of Transportation (TxDOT) conducted an internal evaluation of the safety and effectiveness of the operation.<sup>2</sup> They investigated accidents for a two-year period before and after implementation of the modified left-turn operation. At the 27 intersections in their study, which were all in the Dallas area, accidents dropped by 23 percent overall, including a 25 percent reduction in off-peak periods and a 17 percent reduction in peak periods. In graduate research, Collins used the TEXAS Model for Intersection Traffic,

a microscopic, stochastic simulation model, to evaluate the delay effectiveness of the operation.<sup>3</sup> He compared lead-lag operation with and without permitted left turns under a wide variety of conditions and showed that under all conditions delay is reduced. Favorable results showing the effectiveness of the operation were also reported in an HPR research report developed by the Texas Transportation Institute.<sup>4</sup>

As a result, the modified protected-permitted left-turn signal display has become the method used for most dual and quad left-turn signal applications in Dallas. The technique is also in use in a number of other Texas cities, including Richardson, Plano, Arlington, and Austin, generally with satisfactory results.

### Limitations of the Technique

This approach to solving the left-turn "trap" problem cannot, of course, be used in all situations. Inappropriate uses include:

- Span wire or free-swinging mast arm signals, where the left-turn signal face cannot be mounted securely enough to provide proper aim of the louvered indications at all times.
- Signal approaches where left-turning vehicles share a common lane with through traffic, because optically limited indications could not be aimed so as to be readily visible only to left-turn traffic.
- A protected-permitted left-turn signal modified as described in this article will not improve safety where the accident experience is high for reasons other than the "trap" problem. These are usually still best addressed with more traditional techniques, such as converting the left-turn signal to conventional nonpermitted operation or prohibiting that left-turn movement.

Further, there are many situations where this method would not provide any actual benefit, such as at "T" intersections, one-way streets, or the inside left turns at typical diamond interchanges.

### MUTCD Conformance

The applicable wording of paragraph 6 of Section 4B-6 of the 1980 Texas Manual on Uniform Traffic Control Devices

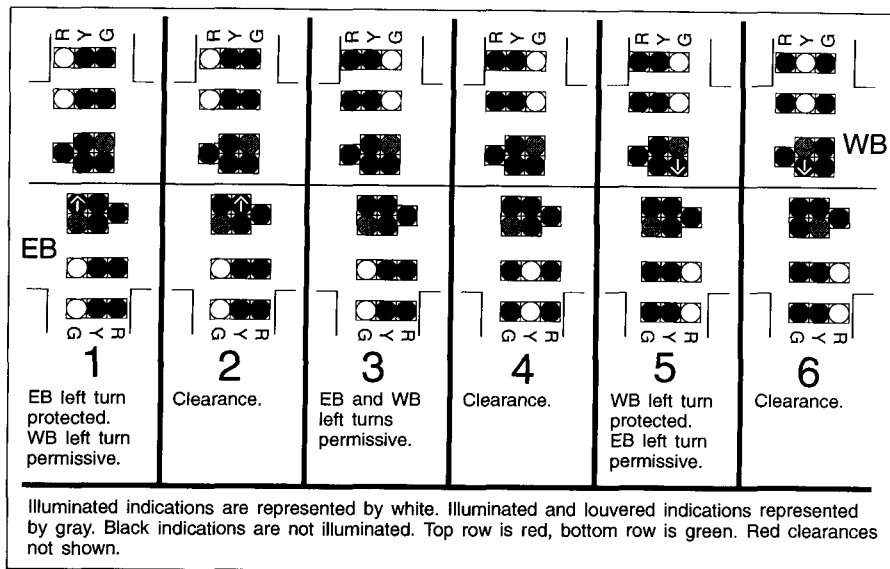


Figure 2. Interval sequence for a solution to the left-turn trap problem.

(MUTCD) was very carefully reviewed by several Dallas traffic engineering staff members before any modified left-turn signal displays were implemented in the field.<sup>5</sup> It was their conclusion that the wording then in effect did not prohibit the above described operation. Since that time, engineers in other cities have also reviewed the Texas MUTCD and have also not found a problem.

As of this writing, the Texas MUTCD has not been updated since 1987. Some supplementary wording added to the national MUTCD in its 1988 revision requires the display of all circular indications in protected-permitted left-turn signals to match those of the through signals on the same approach,<sup>6</sup> thus prohibiting direct users of that manual from using this sort of technique to avoid the "trap" problem. Because the benefits of using lagging left-turn phases and protected-permitted heads in combination are widely recognized in the Texas traffic signal engineering community, TxDOT is considering language adjustments for the next update of the Texas MUTCD that would avoid making a similar prohibition. The content and implementation of those changes is still under consideration.

### Recent Developments

In connection with TxDOT's efforts, the University of Texas at Arlington is currently conducting research for TxDOT into motorist understanding of various

possible displays for protected-permitted left-turn signals.<sup>7</sup> Some findings they have reported indicate that certain dual-indication displays currently required by the national MUTCD, particularly the circular red indication shown together with the left green arrow, have a low percentage of understanding, as reflected in a motorist survey. They also found that the R10-12 left turn yield on green (ball), which is the basis for the signing proposed herein, was the most effective sign for use in protected-permitted applications. The final report of that study

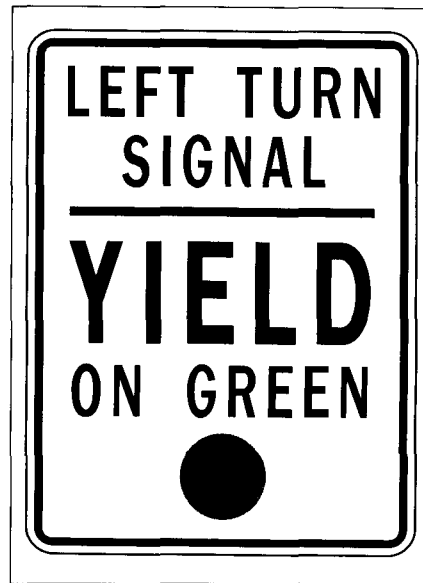


Figure 3. Combined R10-10 and R10-12 sign, known as R10-12a.

## Save Thousands of Dollars!

Gain the information for transportation decisions.

Use the *breakthrough program* with a unique **Easy Design and 1-Stroke Analysis**

**Raosoft<sup>®</sup> SURVEY**, for survey and statistical research,

a **POWERFUL and EASY TO USE** **NEW**

statistical database for research analysis shown at the 1992 ITE Conference.

- **Origin/Destination Surveys**
- **Commuter Studies**
- **Vanpool Feasibility**
- **Travel Patterns**
- **Transit Usage**
- **Satisfaction Studies**
- **Transportation Statistics**
- **Carpool Lists**

**For Everyone!**—1-stroke analysis—easy design—forms based entry—mouse or push-button—Sample Size—easy Query, reports, and mailmerge—graphs—Summary—hot-key interrupt entry for phones—intuitive Stats—Hypothesis testing—unlimited size—networkable—**More!**

**For PC's: Order now or Ask for a FREE Demo!**  
30-day money-back guarantee!

**Raosoft, Inc.**, 6645 NE Windermere Road, Seattle, Wa. 98115-7942  
Tel (206) 525-4025  
Fax (206) 525-4947

\$495 **Raosoft<sup>®</sup> SURVEY**  
\$195 **Raosoft<sup>®</sup> SURVEYFirst<sup>™</sup>**  
\$249 **SURVEY-Entry**  
\$50 **UFILL<sup>™</sup>**

is expected to considerably influence the eventual wording of the next Texas MUTCD update.

## Conclusion

Given the benefits to traffic signal operational efficiency, which can be realized by using protected-permitted displays and lead-lag left-turn phase sequencing, some appropriate left-turn treatment needs to be provided in the MUTCD so that the two techniques can be used simultaneously without creating the so-called "trap" problem. The combined permitted lead-lag left-turn technique presented in this article has been widely implemented in Texas. Based on the reaction (or lack thereof) by the public, and on studies conducted by TxDOT, this technique appears to be an effective tool for safely combining protected-permitted operation with lead-lag phasing.

## References

1. Messer, Carroll J., Daniel B. Fambro, et.al. Progression Analysis and Signal System Evaluation Routine (PASSER), trademark for a series of traffic signalization computer programs. College Station, TX: Texas Transportation Institute, 1974-1991.
2. Brookes, Joni, Rick Collins, and Herman Haenel. "Study of MUTCD and City of Dallas Permitted/Protected Lead/Lag Left-Turn Phasings." Internal paper. Austin, TX: Texas Department of Transportation, 1990.
3. Collins, Rick. "A Comparative Analysis of Left-Turn Delay Associated with Two Different Lead Lag Phasing Arrangements." Master's thesis. The University of Texas at Austin, 1988.
4. Fambro, Daniel, and Gilmer Gaston. "Comparison of Two Protected-Permitted Lead-Lag Left Turn Phasing Arrangements." HPR Research Report 2-18-89-989-1. College Station, TX: Texas Transportation Institute, 1990.
5. Texas Department of Transportation. *1980 Texas Manual on Uniform Traffic Control Devices for Streets and Highways*. Austin, TX: Texas State Department of Highways and Public Transportation, 1980, with current revisions.
6. U.S. Department of Transportation. *Manual on Uniform Traffic Control Devices for Streets and Highways*. Washington, DC: Federal Highway Administration, 1988.
7. Williams, James C., Siamak Ardekani, and Seth Adu Asante. "Motorist Understanding of Left-Turn signal Indications

and Auxiliary Signs." TRB Preprint, 71st Annual Meeting. Washington, DC: Transportation Research Board, 1992. ■



**Gerry de Camp** is Manager of the Las Vegas Area Computer Traffic System (LVACTS). He has more than 16 years of professional experience, including positions as traffic signal engineer with the City of Austin, and head of the traffic signal operations engineering section of the City of Dallas, where he specialized in implementation of advanced arterial signal progression and diamond interchange signal phasing techniques. He also serves as a consultant to other local agencies in these areas. He holds a bachelor of engineering degree from Lafayette College, Easton, Pennsylvania, an M.S.C.E. from the University of Texas at Arlington. He is a registered professional engineer in Texas and a member of ITE.



**Richard W. Denney, Jr.**, is the signal systems engineer for the City of San Antonio, Texas. Past positions include the Texas Department of Transportation and the City of Austin as the traffic signal engineer. He is active in TRB committees and serves in various TexITE and District 9 posts. Denney has published numerous papers, participated in two section technical award-winning projects, and has developed popular computer software packages. He received his B.S.C.E. from Texas A&M University and his M.S. Eng. from the University of Texas at Austin. He is a registered professional engineer in Texas and a Member of ITE.