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2004

Wong, Y. D., Ho, J. S., & Foo, H. Y. T. (2004). Left-Turn-On-Red traffic scheme in Singapore. ITE journal, 24-28.

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Left-Turn-On-Red Traffic Scheme in Singapore

**LEFT-TURN-ON-RED (LTOR),
THE EQUIVALENT OF NORTH
AMERICA'S UBIQUITOUS
RIGHT-TURN-ON-RED, WAS
INTRODUCED IN
SINGAPORE IN 1997.
PRESENTLY, MORE THAN 40
LTOR TRAFFIC CONTROLS
ARE IN OPERATION IN
SINGAPORE. AN
EVALUATION STUDY
REVEALED A SUBSTANTIAL
REDUCTION IN PEAK-HOUR
VEHICLE STOPPED DELAY
AS A RESULT OF LTOR
OPERATION. OVERALL,
THERE WAS A SMALL
INCREASE IN ACCIDENT
OCCURRENCES.**

BY Y.D. WONG, J.S. HO AND H.Y.T. FOO

INTRODUCTION

In Singapore, traffic signals are the predominant type of traffic control at major intersections. Conflicting movements are segregated by means of phased signal indications. More than 1,100 traffic intersections are under signalized operation.

Where left-turning volumes are high and land space permits, channelized left-turn slip roads are constructed at signalized intersections in Singapore. This allows vehicles to turn left and merge with the cross-flow under a "give way" control. It should be noted that Singapore operates a right-hand drive system similar to that in the United Kingdom.

In April 1997, the Singapore Land Transport Authority launched the left-turn-on-red (LTOR) scheme, a traffic management practice that is equivalent to right-turn-on-red (RTOR) in North America. LTOR traffic control permits motorists to turn left on a red traffic signal indication after stopping and giving way to conflicting vehicles and crossing pedestrians.¹

LTOR in Singapore began with two intersections. The scheme was progressively expanded to more than 50 intersections within a year, and more intersections were added in later years. LTOR was removed at certain implemented sites that subsequently experienced unfavorable conditions. Presently, more than 40 LTOR traffic controls are in operation.

This feature describes the implementation of the LTOR traffic scheme in Singapore. A brief review concerning the application of and issues surrounding RTOR/LTOR is presented. In addition, the results of an evaluation study on the vehicle stopped delay and accident experience at LTOR intersections are reported.

It should be noted that, in recent years, turning on red in the other direc-

tion (LTOR in the United States) has been permitted by some U.S. jurisdictions, although it has been applied strictly at the intersection of two one-way streets. Except for the distinction made here, this scheme will not be covered any further. In this feature, RTOR (in the United States), LTOR (in Singapore) and TOR are used interchangeably and refer to the same scheme.

TOR TRAFFIC CONTROL

The application of TOR traffic control originated in the United States, and most associated research studies have been based on the American experience with RTOR. The RTOR scheme was introduced in New York City in 1924 but was discontinued in 1937. Also in 1937, RTOR with an authorizing sign was permitted in California. In 1947, RTOR was changed to a generally permissive system that allowed motorists to turn right on red unless a sign prohibited such turns.

RTOR spread gradually to other states over the next 30 years.² It was widely adopted during the 1970s when the federal government linked RTOR implementation to eligibility for federal funding as part of an effort to put all possible energy efficiency measures into effect.³ By 1977, RTOR under the generally permissive rule was effective nationwide at a high percentage of signalized intersections.⁴

The application of RTOR has been extended further in some jurisdictions to allow part-time RTOR during periods when there are relatively few conflicts.^{5,6} The TOR scheme is touted as providing a number of benefits, including reduced delays (time savings); reduced pollution at intersections and less energy consumption (energy conservation); and small increases in intersection capacity and level of service, in some cases.

The implementation of RTOR in the early years, especially under the generally

LTOR is operated full-time under a sign permissive rule: A vehicle can make a LTOR movement only at those intersection approaches that are signed to permit LTOR (see Figure 1). In February 1999, the legend for LTOR signage was enhanced by replacing the previous "GIVE WAY—Left Turn On Red" with "Left Turn On Red—STOP Before Turning."¹²

This informs motorists in stronger terms to stop at the intersection before proceeding to perform the LTOR maneuver. Motorists failing to do so are liable to pay up to \$160 (U.S. \$93) for a pecuniary fine or up to \$180 (U.S. \$105) together with four or six driver demerit points for failing to give way to oncoming vehicles or pedestrians, respectively.

Apart from the LTOR signage, an additional sign reminds LTOR motorists to give way to pedestrians and main road traffic. Signs also alert cross-flow motorists and pedestrians to the presence of LTOR vehicles. These signs are classified as regulatory and have white lettering on a blue background, except for "STOP Before Turning," which shows black lettering on an amber background.

Given the novelty of the scheme, the Singapore Land Transport Authority implemented an elaborate set of signs to alert road users to this new traffic management practice. The signage appears wordy but, given the low speed environment, legibility is not a problem. Clarity of meaning using word messages serves to educate road users on the LTOR scheme. The signs are repeated to reinforce the message.

The positioning of signs for LTOR motorists is effective. There are two roadside LTOR signs (one close to the curbside primary signal pole) for motorists on the approach. Another LTOR sign adjacent to secondary signal pole is targeted at motorists in the vicinity of the stop line. This elaborate signage has a potential advantage in the sense that when these multiple signs are dismantled due to decommissioning of LTOR at particular locations, their absence is quickly noticed and the change is effectively communicated.

Apart from the comprehensive on-site signage, the scheme was publicized heavily when it was implemented, including the following:

- Media release the day before launch and press report the day after launch;
- Monitoring and guidance during the first week by on-site enforcement officers from the Land Transport Authority and traffic police;
- Distribution of leaflets to residents living nearby;
- Dissemination of information to students at nearby schools;
- Publicity by neighborhood community centers;
- Publicity in Singapore Automobile Association's magazine and Web site; and
- Publicity in Singapore National Safety Council newsletter.

Subsequent to the implementation of LTOR control, 17 LTOR traffic controls were removed as a result of changed site conditions and/or unsatisfactory performance. Increases in pedestrian traffic, low left-turning vehicular traffic and feedback from road users (some on printed mass media) also led to the removal of LTOR traffic schemes. As of early 2003, a total of 44 LTOR traffic controls were operating at 43 intersections.

EVALUATION STUDY AND RESULTS

An evaluation study was conducted to study the impact of the Singapore LTOR scheme in terms of peak-hour vehicle stopped delay and before-and-after accident counts. The vehicle stopped delay data were collected at the LTOR approaches of three intersections using the ITE method, whereby stopped vehicles along each LTOR approach were enumerated at short intervals (15 seconds in this study).¹³

Stopped vehicle delay was studied for three periods: within a month before (before, in 1997); between 6 to 12 months after (shortly after, in 1997/1998); and several years after (long after, in 2001) LTOR implementation. Each observation period lasted for one peak hour (5:00 p.m. to 6:00 p.m.) on a typical weekday under dry weather conditions.

The results are shown in Figure 2, which shows that traffic on the LTOR approach experienced a significant reduction (73 to 86 percent) in stopped delay after LTOR implementation, followed by minor changes in the long run, as shown

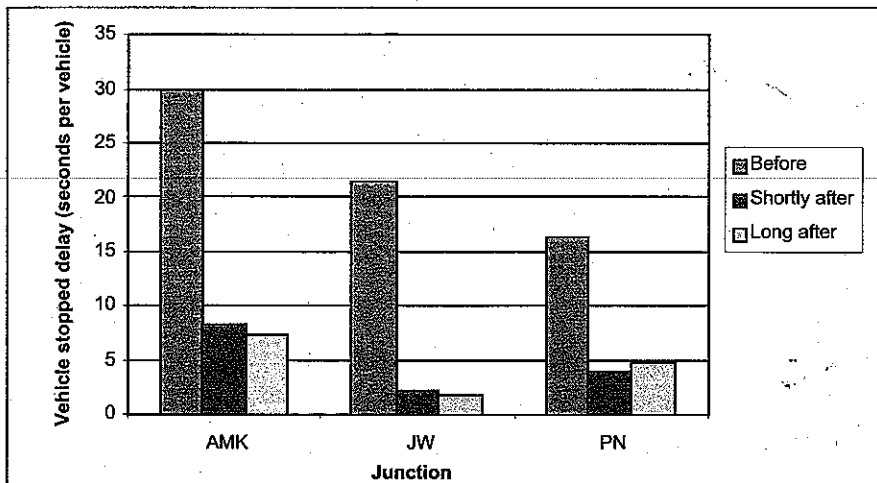


Figure 2. Comparison of vehicle stopped delay at three intersections in Singapore (5:00 p.m. to 6:00 p.m.).

Table 1. Vehicle stopped delay shortly after (in 1997) and long after (in 2001).

Junction	LTOR volume			Cross-street through vehicle volume			Vehicle stopped delay (seconds per vehicle)		
	Shortly after	Long after	Percent change	Shortly after	Long after	Percent change	Shortly after	Long after	Percent change
AMK	68	71	+4	146	216	+48	8.1	7.3	-0.8
JW	58	66	+8	57	69	+12	2.2	1.8	-0.4
PN	40	86	+116	170	286	+116	3.9	4.7	+0.8

in Table 1. The three studied intersections were typical LTOR sites.

Accident situations were examined for LTOR intersections (36 total) that had accident data for at least 12 months after LTOR implementation. The accidents were reported fatal and injury (KI) crashes located within 20 meters of the intersections, as extracted from the traffic police computerized accident database. Because accident details such as pre-crash movements or signal indication status were not coded, the KI crashes were analyzed at the intersection level only.

For each intersection, the maximum "after" duration (with respect to its LTOR implementation date) was identified and an equal "before" duration was applied. The changes in accident rate (accident counts per year per intersection) for the 36 LTOR intersections are shown in Figure 3. The "before" accident rate is scaled by the ordinate (vertical axis) and the amount of change in the accident rate by the abscissa (horizontal axis). It should be noted that LTOR intersections generally had relatively low accident occurrences. On average, about three in five intersections experienced an incremental increase in accident occurrences after adopting LTOR.

The accident counts at the LTOR intersections also were stratified by severity and nature of collision, as shown in Figures 4 and 5. The (average) annual accident counts for the aggregate sample of 36 LTOR intersections increased by 17 percent after LTOR adoption. Slight injury accidents increased by 22 percent; serious injury accidents were reduced by 62 percent. Fatal accidents comprised approximately 3 percent of all KI accidents in the "after" period.

The distribution of accidents by nature of collision shows that collisions between moving vehicles increased substantially, at about 39 percent after LTOR adoption. There was, however, a noticeable decrease in accidents between vehicles and pedestrians, at about 43 percent.

DISCUSSION

The American experience with RTOR shows that TOR implementation usually started off on a limited scale. Then, as road users became more familiar with the prac-

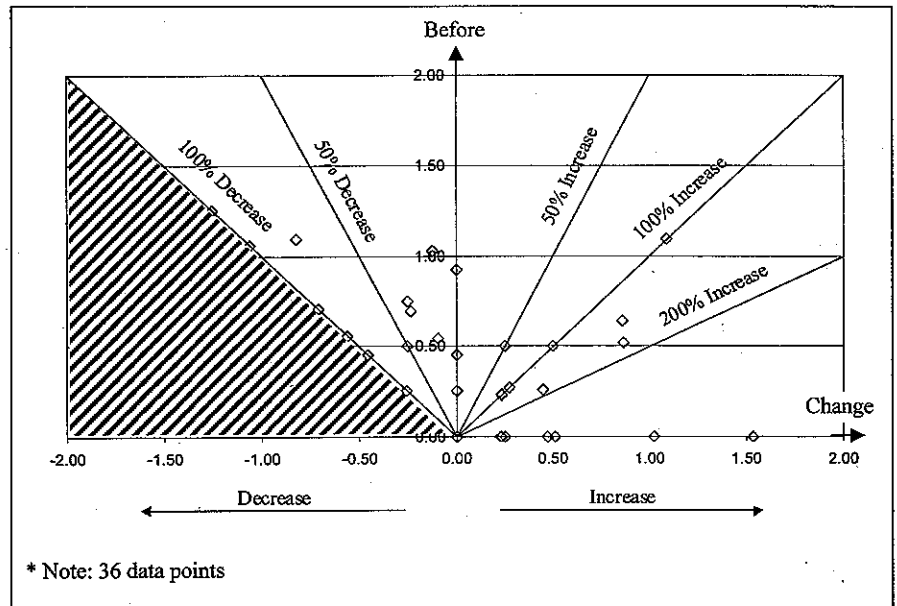


Figure 3. Changes in accident rates at LTOR intersections in Singapore.

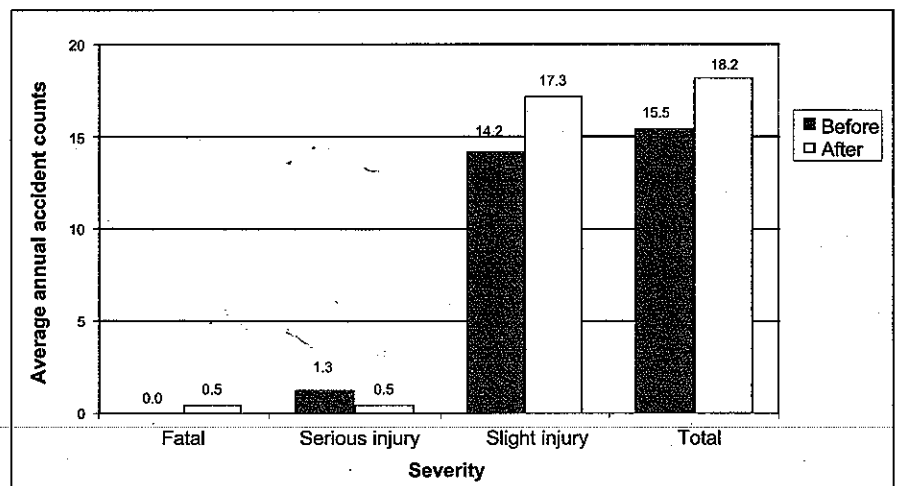


Figure 4. Before and after accidents at LTOR intersections in Singapore (by severity).

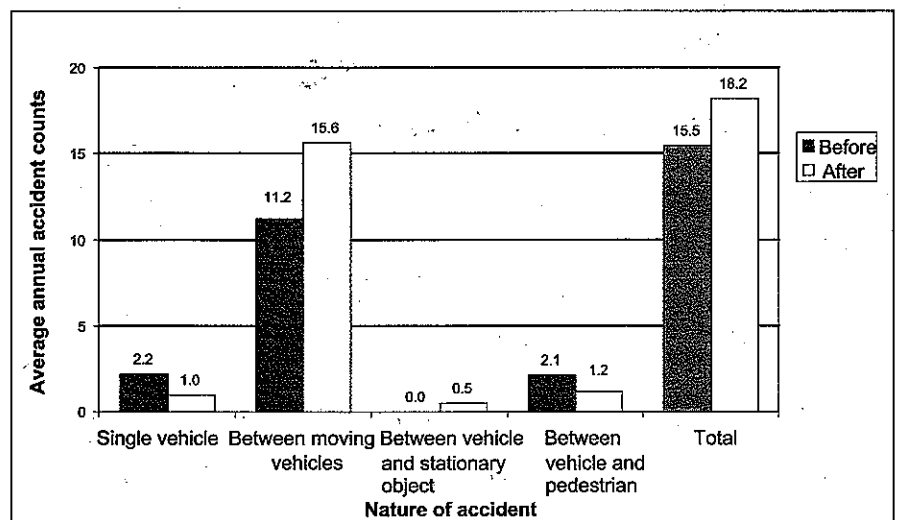


Figure 5. Before and after accidents at LTOR intersections in Singapore (by nature of collision).

tice over a period of time and its advantages were seen, it was followed by widespread application.

In Singapore's context, the LTOR scheme is basically a new traffic management practice. Its operation in the last few years can be considered a protracted trial. Because it is relatively new, the performance of the LTOR scheme should be researched carefully to assess its impact on various users.

The results of this study show that tangible benefits can be accrued in the form of reduced stopped delay for LTOR vehicles, which was found to be maintained over time. However, on-site observations revealed incidences of LTOR motorists not observing the mandatory stopping requirement and/or pedestrians using the crosswalk when the pedestrian signal was not in their favor. A small-scale perception survey found that pedestrians, as compared to drivers and bus commuters, tended to be more critical of the LTOR scheme. Future studies should cover the behavior of motorists and pedestrians and their interactions.¹⁴

LTOR control was installed principally at the side roads of T-intersections. The average annual count (in the pre-implementation period) was about 0.4 crashes per LTOR intersection compared to about 0.7 crashes for the population of 400 signalized T-intersections.

Hence, LTOR intersections were inherently sites with relatively low accident counts which, coupled with the small intersection sample size, made definitive assessment of the safety situation rather difficult. Although there was a small increase in accident occurrences, the accident risk from LTOR operation remains unclear.

CONCLUSIONS

LTOR has been in operation in Singapore for about five years. In a broad sense, LTOR has resulted in substantial time (and energy) savings from reductions in vehicle stopped delay. There has been a small increase in accident occurrences.

This means that there is merit in continuing to monitor the impact of the scheme to establish its feasibility for continued application and possible expansion. It is recommended that future studies

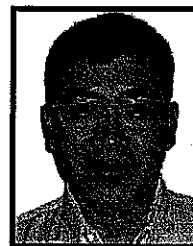
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ACKNOWLEDGMENTS

The work reported in this paper was performed at the School of Civil and Environmental Engineering, Nanyang Technological University. The authors would like to thank the Land Transport Authority and the Traffic Police Department for providing the information in support of the study. The results and interpretation of data analyses are, however, completely the views of the authors. ■

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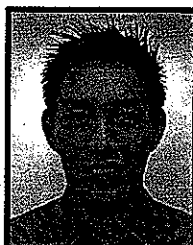
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