Right Turn on Red Signal

SEWARD CROSS
Traffic Engineer
Fort Wayne, Indiana

INTRODUCTION

The subject of right turn on red signal (RTOR) is somewhat unfamiliar to traffic and safety officials in the State of Indiana since RTOR is prohibited in Indiana. Therefore, consider a national report compiled by the National Institute of Traffic Engineers, Committee 3-M 65. In order to fully appreciate the scope of study of the committee, segments of their preliminary report and a few comments are presented.

The purpose of this national study was to determine the desirability of allowing RTOR indications as the basic rule.

The committee was charged with examination of accident experience and capacity relationships at locations where RTOR signals are permitted and to make comparisons with similar locations where they are not. Also, they were to do the same for left turns on red from one way streets.

FACTORS EFFECTING RTOR

Factors from the national study indicated as being responsible for the rejection of RTOR, as indicated by questionnaire, are as follows:

1) Vehicles, when turning right against a red signal are in direct conflict with pedestrians crossing with the green light on the opposite phase.
2) Vehicles abuse the full stop requirements.
3) RTOR results in a certain number of accidents involving pedestrians.
4) Either through deliberate abuse or poor judgment of what constitutes a safe gap in the cross street traffic, right turning vehicles which are relatively slow moving often force severe braking action to be taken by drivers proceeding along the cross street. Inevitably, semibroadsides or rear collisions will occur when such braking action is not sufficient to remedy such conflict.
5) In the C.B.D. of our cities during the peak hours of intersection use, the full effect of permitting vehicles to turn right against
the red signal sometimes results in an actual decrease in intersection capacity.

6) In the case of five- and six-point intersections, offset intersections, special pedestrian phases, split phases, and multi-phase signal systems, it is often necessary or desirable to prohibit all or some approaches from turning right against the red signal. However, a sign reading “No Right Turn on Red Signal” is often difficult to position at these locations so that it will be easily observed and obeyed at all times by the driver.

7) RTOR as a basic rule is contrary to the meaning of both the Canadian and the United States manuals on uniform traffic control devices.

8) Permitting vehicle operators to make right turns during the showing of the red indications without a modifying arrow weakens the single meaning of the red indication.

9) A traffic signal system should be complete in and of itself. It is wrong to impart one meaning to the motorist with a traffic signal and countermand that signal with a sign.

Factors which support the use of RTOR are as follows:

1) RTOR prevents delay which is irritating to the motorist.

2) RTOR expedites the flow of traffic, thereby increasing intersection volume capacity and reducing congestion.

3) RTOR is not significantly hazardous, since accidents which involve vehicles turning right against the red signal comprise a small percentage of total accidents at signalized intersections.

4) There occurs along major arterial routes with traffic signal progression in operation, the opportunity for vehicles turning right from the various side streets against a red signal indication to enter immediately into the green band of the main street progression. Whereas, those vehicles which turn to the main street during the side street green phase will be confronted with a red signal at the next signalized intersection along the main street after which they will enter into the progressible movement.

Common factors considered to support both the rejection and the approval of RTOR are accidents and capacity. To substantiate these factors, questionnaires were prepared and mailed to 58 state and provincial traffic engineers and 117 city traffic engineers in the United States and Canada. A 44 percent return was received from the states and provinces and a 72 percent return was received from the cities.

On the North American Continent the western states unanimously concur in use of RTOR as the basic rule, but a goodly portion of the
midcentral states have the RTOR prohibited. The eastern and the midwest states are intermingled as to general use of RTOR.

PRESENT PRACTICE OF STATES AND PROVINCES

State and provincial jurisdictions reported 57 percent utilized some form of RTOR. RTOR as a basic rule was utilized by 21 percent. This practice has occurred from 5½ years in Washington to 24 years in Ontario. Seven of the eight jurisdictions using RTOR as a basic rule indicated that a stop was required prior to turning right. Of the 12 jurisdictions permitting RTOR with a sign, eight required a stop prior to turning on red. Those jurisdictions requiring a stop prior to turning right on red indicated that this requirement was not complied with 100 percent, but was satisfactory.

Seven answers indicated that compliance ranged between 94.4 and 100 percent. The state of Hawaii estimated a 75 percent compliance.

The practice permitting RTOR, both with a sign and as a general rule in conflict with pedestrian indications, receives a variety of treatments in the different jurisdictions. Sixty percent reported that they do not permit conflicting right turn movements with pedestrian indications, while 40 percent indicated that they did.

In regard to the future action of states and provinces there was complete uniformity between those which now prohibit the movement and those which permit it as a basic rule. Of the 12 which prohibit it 11 indicated that they would continue to prohibit it. Those jurisdictions which now permit RTOR as a basic rule indicated that they would continue the use of RTOR; however, those jurisdictions which now permit the movement at specific locations when indicated by a sign, were split approximately 50-50 in their opinion.

While not included in the scope of the national study, the warrants for permissive RTOR when signed, were requested. Several jurisdictions answered this question; however, no definite warrants were reported.

PRESENT PRACTICE OF CITIES

Of the 85 cities reporting, 37 percent prohibited RTOR in any form. Thirty-eight percent permitted RTOR with the display of a sign, and 30 percent permitted the use as a basic rule. Seventeen percent of the cities permitted a left turn on red either by signing or as a basic rule when entering a one way street. Those cities permitting RTOR with a sign averaged permitting this movement at approximately two percent of their intersections. Where RTOR was permitted as a basic
rule, the cities did not allow this movement at four percent of their intersections.

The city survey also indicated that cities are using RTOR in 22 states and provinces where the movement is not provided for by state or provincial law. Eighty-eight percent of all cities investigated, permitting some form of RTOR, require the vehicle to stop prior to making the movement. All cities checked, permitting any form of RTOR, except one, required all vehicles making the movement to yield to other vehicles and pedestrians within the intersection.

Indiana as represented in the national study, informed the committee that RTOR is prohibited. However, I would like to read from the Indiana manual:

"Permitting vehicle operators to make right or left turns during the showing of the red signal without a modifying arrow or sign is not recommended. If turn arrows are shown when thru movement is stopped, they should always be illuminated in conjunction with the red signal they modify. Shown alone, they create doubt as to whether further movements are forbidden during the indicated interval. Furthermore drivers approaching an arrow indication may mistake it for the circular green indication.

"The utility of arrow indications depends considerably upon there being a lane available for the movement indicated. Such lanes should be clearly marked at all times."

The foregoing quotation from the Indiana manual is identical to the national uniform manual and of course gives the same inherent right to utilize the right turn on red in local jurisdictions. The national report shows the use of RTOR is varied across the nation and, as in the case of school safety, indicates that there are many different opinions on this subject and a certain lack of unity.

EVALUATION OF FACTORS

General

In considering the application of RTOR as a basic rule, it must be conceded that certain intersections are not applicable to this type of operation and, therefore must be restricted.

Accidents

The accident experience of those cities incorporating RTOR as a basic rule should provide an indication as to the hazards involved in the adoption of RTOR.

In three cities in California 75 intersections were analyzed in regard
to pedestrian accidents as a result of RTOR. This report analyzed over 3,000 accidents of all types occurring over a period of three years. Pedestrian accidents as a result of right turn vehicles amounted to 18 of this total number, four of which were the result of RTOR. To equate this ratio with the exposure rate numerous traffic counts were taken during the AM-PM and off-peak periods. The RTOR traffic volume as a percentage of the total right turn traffic was the same for all periods, 18.1 percent.

A comparison of right turn accidents involving pedestrians indicated that 22.2 percent of the pedestrian accidents involved in RTOR accidents is 4.1 percent. The author indicated that this is not significant when considered on a 98 percent confidence level, and further study of pedestrian accidents would make this figure more accurate.

A further breakdown of the same study lists the accident distribution according to total right turns, right turn accidents vehicle-vehicle, right turn accidents vehicle-pedestrian, and injury accidents for both RTOR and RTOG. Volume counts indicated that RTOG amounted to 81.9 percent of the total right turn volume, and RTOR amounted to 18.1 percent. To equate the RTOR accidents in each category to the RTOG, they are multiplied times 4.5 to make them numerically equal. Total right turn accidents in the 3,338 accidents investigated indicated that the chances of having an accident on RTOR are 45 percent less than when making a RTOG. Checking right turn accidents which result in a vehicle-pedestrian type accident, indicates that right turns on red are 28.6 percent safer for the pedestrian than RTOG. In checking injury accidents it was determined that RTOG are 20 percent safer than RTOR. All of these percentages are significant; however, it should be remembered that they comprise a very small portion of the total accidents.

This accident experience would appear to be significant and indicate that RTOR as a basic rule is not particularly hazardous and should satisfy all factors considered in RTOR, except for vehicle delay, gap in traffic capacity, and state code.

One report submitted from Jacksonville, Florida where RTOR is employed as a basic rule, indicated that of approximately 1,800 accidents, 74 percent could be attributed to RTOR as a basic rule. This percentage is approximately twice that derived as weighted averages for the western United States. It should be mentioned that RTOR as a basic rule was not authorized by state code.

Information submitted involved before and after studies of four intersections in Fort Lauderdale where RTOR was permitted by a
sign revealed that accidents increased by 21 percent on those approaches where the movement was permitted.

Information regarding the City of Colorado Springs, Colorado where RTOR was introduced through use of signing revealed that no accidents resulted in a one year period of RTOR.

In summary, RTOR as a basic rule as practiced in the western United States has very little effect on the total accident experience at the signalized intersections. The practice appears to be a deterrent to right turn accidents of the vehicle-vehicle type which comprises 76 percent of the RTOR accidents, but increases the vehicle-pedestrian type, and as such, tends to increase right turn injuries.

**Vehicle Delay**

To determine the effects of RTOR on vehicle delay and travel time, two reports were received. One was a study in Berkeley, California over a two-mile course in which the vehicle passed through 14 traffic signals, making right turns at seven of the signals. A similar study in New York over a rectangular course incorporated three traffic signals making right turns at each of the signals. It was determined in both reports that RTOR has no significant results on running time but is instrumental in reducing delay at traffic signals.

A California report also investigated the effect of pedestrians on RTOR delay as compared to RTOG. It concluded that there were no significant differences in their effect as each vehicle making a right turn whether on green or on red, will encounter one cross walk legally occupied by pedestrians. The California report indicated that the advantages of RTOR are apparently reduced as traffic volumes increase.

**Gaps in Traffic**

The question of available gaps in traffic to permit RTOR has been investigated by several people. Sobert found in his research that the median acceptance time for right turns was 7.30 seconds. (Indiana). Bissel obtained median gap acceptance time of 5.25 seconds. (California and Virginia). At stop sign intersections, the minimum acceptable time gap for right turning movements is found to be about 6.1 seconds. (Connecticut).

A study by the Arizona State University determined that a six second gap was the minimum acceptable gap on a street with a speed limit of 35mph.

Also they found that there were no differences in the gap-length acceptance for both right turn and left turn movements by both in-state
and out-of-state drivers. It was also proven in one study that informing the public of the legality of the red maneuver improves the acceptance of the law.

The installation of informational signs increased the acceptance of Arizona drivers from 65 to 75 percent and from 63 to 89 percent for drivers from other states where the law is illegal. A special signal indication would overcome objections it was felt, that the RTOR as a basic rule weakens the meaning of the red indication.

An acceptable gap in Seattle was determined to be 4.25 seconds, while the New York study indicated 4.30 seconds as being acceptable. This comparison indicates that there is no appreciable difference in gaps accepted by drivers in the east or in the west. Evidently motorists are conditioned to this traffic tool regardless of the part of the country from which they originate.

**Capacity of RTOR**

For this study the national committee chose material from Van Gelder's studies.

"The driver making the RTOR will either have to enter a queue or fall in at the end of it between subsequent arrivals. Headways of platooned vehicles are less than six seconds. This limits the RTOR to the end of the queue which is quite logical and the way that the movements are observed in the field. The amount of green time available after the queue has cleared is basically dependent on three factors—volume, cycle length, and cycle split."

From his studies Van Gelder developed means to calculate capacities of RTOR under various side street conditions. If the length of time to clear a queue is subtracted from the total main street green, the time available for RTOR may be determined. During this remaining time the intervals will approximate a random distribution. The maximum number of RTOR is then calculated from the number of gaps and the maximum right turns into these gaps.

"At this point it is evident that the departure headways of right-turn vehicles are also a factor. As the main street volume decreases the length of time at the end of the queue increases. The average number of main street arrivals is less; therefore the number of gaps to be accepted is less. The average minimum departure headway will be a constant as all vehicles are required to make a stop before turning. This headway was determined to be near 4.5 seconds.

"The line representing the theoretical maximum RTOR can be
achieved only when a continuous backlog of RTOR vehicles are present.

"The condition on either street will not change when the main street operates at capacity. When it operates at a level of service other than E and F, it will have an effect of changing the operating conditions by increasing the G over C ratio for the right turn lane on the cross street, thereby making it possible to change from one level of service to one less congested. This would explain the claims that RTOR decreases congestion."

SUMMARY

The following summary is quoted from the report of the national committee.

"Traffic engineers generally desire uniformity regarding RTOR. At present 57 percent of the states and provinces and 68 percent of the cities reporting are using some form of RTOR. RTOR as a basic rule is required by eight states and two provinces. Seventeen percent of the cities using RTOR also permit left turns on red when entering a one way street.

"Specific numerical warrants to permit RTOR have not been developed. General practice requires all vehicles to stop before making a RTOR and then yield to all vehicles and pedestrians in the intersection. Cities using RTOR as a basic rule employ it to a much larger degree (96 percent) than those cities permitting the movement by signing (2 percent). Reasons for restricting RTOR as a basic rule at 4 percent of the intersections are multi-leg, multi-phase, and offset intersections, high pedestrians volumes, etc.

"RTOR as practiced in the western United States appears to decrease the total number of accidents. However, it does tend to increase vehicle-pedestrian type accidents approximately 25 percent, thereby increasing injury accidents approximately 20 percent. Accident experience where RTOR is permitted by a sign varies from no accidents to a large percentage increase, depending on the selection of locations to be signed. RTOR does not materially effect running time; however, will it reduce a delay of the individual driver by 9/15 seconds per RTOR, thereby reducing travel time by an amount directly related to the amount of RTOR turns a driver is able to negotiate. Pedestrians do not materially increase the individual driver delay when negotiating a RTOR as compared to RTOG."
"The length of gap a driver will accept for a turn on red does not change appreciably for a left or a right turn. Neither is there any difference in gap acceptance between drivers in the eastern and western United States.

"The establishment of an indication notifying drivers that they can make a RTOR, even though it is acceptable as the basic rule, will materially increase the benefits of the maneuver.

"RTOR provides a means whereby the level of service can be changed from one level to one less congested provided a sufficient number of right turn vehicles are available to fill gaps in main street traffic. Additional study will be required to determine if this is ever accomplished and to what extent. It appears that very little, if any, advantage can be realized from RTOR when the main street is operating a level of service E or F.

"Studies indicated that approximately 2.5 percent of the total traffic can negotiate a RTOR when employed as a basic rule. By utilizing right turn lanes, indications are that this percentage can be increased considerably."

CONCLUSION AND RECOMMENDATION

In conclusion, it is pointed out that the national committee in filing their final report with the national board, are recommending that a basic rule be adopted, but that further study ensue as to warrant fixation.

It appears the committee was strongly influenced by I.T.E. members from the western states. We in the Midwest do not want the basic rule. We heartily agree that RTOR is a very valuable tool and that it should be used. I think that if the basic rule were adopted there would be extensive violation of its use.

It appears that we do require an option; RTOR should be treated as we treat speed limits nationally—*primo facie* and *absolute*. RTOR should be permissive, as our Indiana manual reads now.

If the basic rule were good for all, there would not be such high (50 percent) non-use or very limited use. Our laws have to be flexible. The question of uniformity for uniformity sake should be examined in the light of hardships imposed.

I believe a west coast driver in Indiana can apply his good judgement to our intersections where we do not have RTOR.

Recommendations

I believe Indiana should recognize RTOR as a tool by permissive legislation at the state level. Further, I would recommend that the
Indiana Section of I.T.E. adopt warrants and guidelines for its use on a permissive basis for submission to legislators prior to the conclusion of the 1969 session.

To start the ball rolling, I would propose that the following guidelines are those that must be utilized in formulating RTOR warrants.

**RTOR Warrants**

1) A steady or flashing green or red arrow in accord with the national manual, shall be displayed with the red signal which it modifies. It shall be in alignment with the traffic it serves and may consist of a single unit.

2) A sign stipulating “Right Turn On Red After Stop,” shall be required, placed adjacent to the appropriate signal head or on the near-right pole location.

3) RTOR is never to be used in conflict with pedestrian indications except where pedestrian-storage channelization places an island between the RT vehicle and the pedestrian.

4) There shall be, preferably, channelization to accommodate the RT.

5) RTOR should never be used where the velocity of cross-street traffic exceeds 40mph except when an acceleration lane is provided for the RT vehicle.

6) RTOR can be utilized when the RT is 10-20 percent of the total approach volume. Serious consideration should be given for the use of RTOR when the RT is over 20 percent.

7) When the RT exceeds 20 percent, RT storage becomes mandatory for use of RTOR.

8) RT on a simple radius without RT storage is not to be used unless the RT is in excess of 25 percent of the total approach volume, the cross-street volumes do not constitute service level E or F more than three hours per day, and the pedestrian conflict occurs less than once per cycle.

9) RTOR is not to be used when during peak hours main street green cycle utilization is significantly high, which in judgement of traffic officials, would lead to error in driver judgement of gaps, or when, after a trial period, the accident and injury rate has been found not to increase significantly.