Advance Route Turn Markers on City Streets

LAWRENCE D. POWERS, *Highway Research Engineer, Traffic Operations Research Division, U.S. Bureau of Public Roads*

Although much attention has been given to directional signing for rural areas, particularly on expressways, the problems of route signing on city streets remain. For cities such as Washington, D. C., where tourists abound, the problem is a vital one.

To evaluate the effectiveness of route turn directional markers and advance turn markers, test drivers negotiated a fictitious route through downtown Washington. The 12 intersections at which turns were to be made were chosen so as to be as nearly alike as possible. The test variables, on which an analysis of variance was made, were (a) the number of advance turn markers, (b) the direction of turn, and (c) the distance between successive turns.

The results indicate that it is desirable to provide at least one advance turn marker in advance of a turn. In addition, inferences are drawn relating to route marker design and placement.

• MANY CITIES without facilities for bypassing through traffic or carrying it on freeway-type facilities must continue to rely on the urban street system to carry marked routes. Even where major through routes in cities are carried on expressway-type facilities or on bypasses, secondary marked routes will probably still be carried through smaller towns and suburban communities. It has come to be recognized that more and more attention needs to be given to the adequate advance warning and guidance of traffic, but most of the emphasis has been on high-speed facilities. In urbanized areas, where there are numerous intersections, marginal conflicts, complex traffic patterns, and many competing signs and confusing backgrounds, the need for adequate advance signing is equally important.

As an example, there is a certain turn marked by a single turn directional marker at an intersection. A certain approaching driver is aware of the impending turn in the route, perhaps because he has driven it before and is familiar with it. He may therefore drive along in confidence at his desired speed, get into the proper lane in advance of the turn, signal his intentions, and generally proceed along the route just as though it were not marked at all.

The driver who has driven the route before, but who is not familiar with it, perhaps, may remember that he is in the vicinity of a turn, but may not be sure of its exact location. Conse-

quently, he may tend to drive more slowly in order to avoid overshooting the turn and he may pay less attention to traffic conditions because he is searching for the turn marker.

A driver traveling the route for the first time, however, may have to rely completely on route markers. He has to divide his attention continually between driving and searching for markers. If he arrives at the turn and sees the directional marker, he may not have sufficient time or maneuvering distance to make the turn safely.

To assist the driver who needs to follow the route markers, a turn marker is placed in advance of the intersection warning him that the route is going to turn. He is informed of the impending turn and still has time to safely decelerate and prepare for the maneuver. However, the many distracting backgrounds and competing signs in urban areas may pose a problem. What if he misses the advance marker? His attention may be taken up by traffic, or the marker may be obscured by large vehicles. Perhaps another such marker should be placed in advance of the first one for insurance. How much justification is there for the second advance turn marker, or for the first one, for that matter?

To answer this question, a controlled study was made of the effect of the presence and number of advance turn markers on the ability of drivers to negotiate a route in an urban area.

DESCRIPTION OF STUDY

The route involved was a fictitious one, with many turns, through the downtown area of Washington, D. C. The number of advance turn markers was varied at each intersection. Test

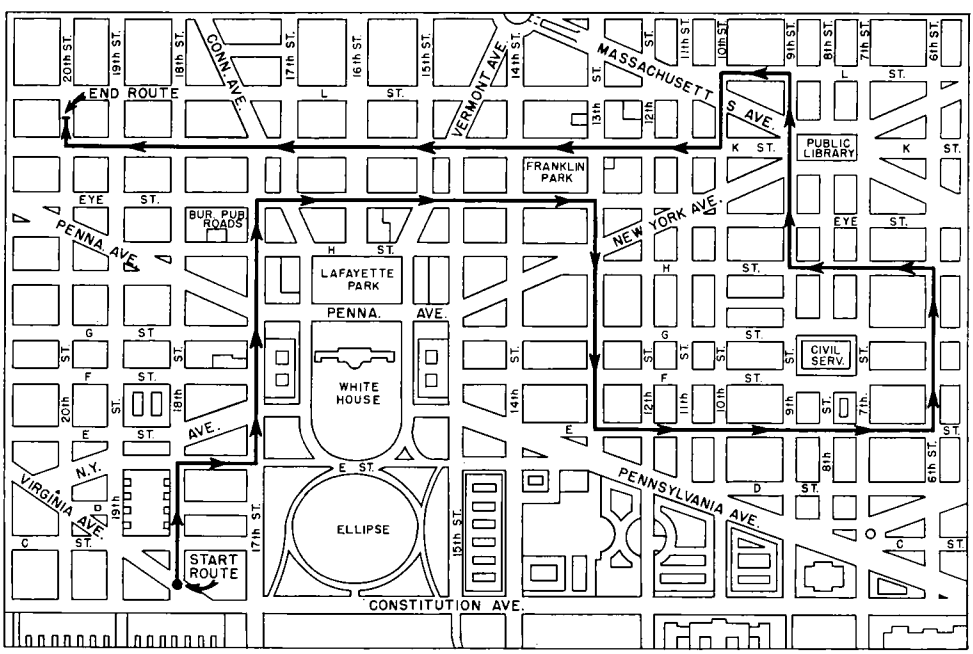

Figure 1. Map of downtown Washington, D. C., showing test route.

subjects driving over the route were observed for: (a) the number of turns they missed, (b) the distance from the intersection at which the test subject entered the proper lane from which to turn, and (c) the distance from the intersection at which the test subject gave the proper turn signal.

The test route (Fig. 1) was approximately 4 mi long and had 12 turns in it. The selection of intersections for turns was based on the following criteria: (a) a minimum block length of 400 ft in advance of the intersection, (b) signal control, (c) absence of islands or channelized movements, (d) four legs at right angles, (e) at least two moving lanes on the intersection approach. Of the twelve turns, six were to the right, and six were to the left. For each direction of turn, three turns were a short distance (1 to 3 blocks) from the preceding turn, and three were a long distance (over 3 blocks). It would have been more desirable to have had all intersections unsignalized; however, this was impossible to attain in the downtown area. To have them as much alike as possible, therefore, all chosen intersections had signal control.

A directional assembly with a horizontal arrow was mounted on the far right corner of each intersection where the route turned. The number of advance turn markers (none, one, or two) was varied at each intersection on the three test days. A balanced design was selected so that each subject saw each marker combination twice for each direction of turn. The number of long and short turns was, unfortunately, not balanced with marker combinations for each subject.

The design of the route marker was chosen to conform to the standards in the Manual on Uniform Traffic Control Devices for Streets and Highways (1961 edition). The route marker consisted of a 16-in. white circle on an 18-in. black square (Fig. 2). The designation 00 in 9-in. black series C numerals was centered in the circle. Appropriate marker assemblies were made up using this route marker and an appropriate arrow. The size of the arrow plates was identical with the 13- by 10-in. arrow plate which was the standard size in the previous edition of the Manual. The material used was white, nonreflectorized cardboard.

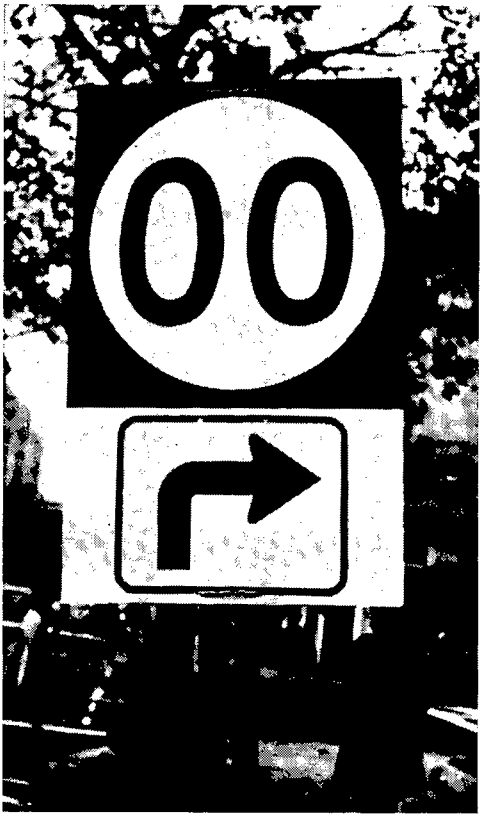

Figure 2. Close-up of advance turn marker assembly.

All markers were placed on the right-hand side of the street, and an approximate spacing of 150 ft was

maintained between all markers at any one intersection. For ease of mounting the markers were placed on light poles, signal poles, existing sign posts, trees, or portable stanchions. The height of the signs varied from 7 to 11 ft from the sidewalk. The higher limit was sometimes necessary to avoid other signs, signals, parked and moving vehicles, and other obstructions.

PROCEDURE

Subjects were told only that the aim of the study was to observe driver characteristics in a downtown environment and that to have a consistent basis of comparison they were all going to drive over the same course. It was explained that the observer who sat in the car would not give directions; instead, the subjects were to follow the course that was marked out. It was hoped this would somewhat satisfy their curiosity and at the same time give them a plausible reason for following the route, though major emphasis was not laid on the route or markers themselves being the object of the study.

The subjects were further instructed to drive normally and to obey all traffic laws, such as signaling for turns, turning from the proper lane, and obeying speed limits.

The 53 subjects were divided into two groups of 18 and one of 17; one group per day was tested. Runs were made between noon and 3:00 PM. Markers were put up in the morning and taken down in the afternoon. Drivers started out at 5-min intervals to prevent them from overtaking each other. Each subject drove the course once.

An observer seated in the subject car recorded the following data: the distance, estimated in car lengths, from each turn at which the driver entered the proper turning lane; the distance at which the proper turn signal was given; and any errors made. Any distances estimated as longer than 15 car lengths (approximately 300 ft) were recorded as 15 car lengths. When a subject missed a turn he was returned to the route at the point where he would have been had he made the proper turn. Additional remarks were recorded by the observer when necessary.

RESULTS

Errors

The desired situation is that where the driver makes the correct turn and does so without creating a hazard. For the purposes of this study, missed turns and turns that were correct but which created hazardous conditions were considered errors.

The condition where only the directional marker at the intersection was present with no advance turn markers resulted in 19 errors, 9 percent of the possible 212 turns for this condition (Table 1). For all practical purposes, no errors occurred where there were advance turn markers. One other error occurred where there were two advance turn markers, but this was attributed to extraneous factors. A χ^2 test performed on the frequencies of errors for the different test conditions indicated that there was less than one chance in a thousand that such a disproportionate

TABLE 1
ERRORS IN FOLLOWING ROUTE

No. of Advance Turn Markers	Possible No. of Turns	Errors (No.)	Errors (%)
0	212	19	9.0
1	212	0	0.0
2	212	1	0.4

number of errors could have occurred by chance.

Fourteen of the 19 errors occurred at left turns and 9 of these occurred at one particular intersection where a combination of topography and traffic density was deemed responsible for the high error occurrence. As a total of 18 drivers encountered this intersection under the condition where no advance turn markers were present, these 9 errors represent a 50 percent error occurrence. (This intersection will be discussed later.)

Proper Lane and Use of Turn Signals

Another measure of the effectiveness of advance turn markers was felt to be the distance from the turn at which the driver entered the proper lane to make the turn. A third measure of effectiveness and of the driver's awareness of the presence and direction of the turn was assumed to be the distance from the turn at which he displayed the proper turn signal. These distances were estimated by the observer to the nearest car length. All subsequent data analysis was also carried out in terms of car lengths.

For convenience in the field, distances greater than 15 car lengths were recorded as 15. For distances in the proper lane, values of 15 averaged 11 percent with no advance markers, 25 percent with one advance marker, and 33 percent with two. For turn signals, the respective figures were 1, 8, and 9 percent. Because many of the distances recorded as 15 may actually represent greater distances, and because they represent a substantial percentage of the field entries for the lane data, the average distances and the variability of the distribution of lane distances are probably higher than were computed.

Table 2 gives the average distance, in car lengths, from the intersection at which the driver was in the proper lane for the turn, by number of advance turn markers. The data have been analyzed with respect to whether the turn was to the right or to the left and also as to whether the distance from the preceding turn was long or short. Figure 3 shows the same analysis for the average distance from the intersection at which the proper turn signal was given.

TABLE 2
AVERAGE DISTANCE FROM INTERSECTION AT WHICH SUBJECT WAS IN PROPER LANE FOR TURN

Type of Turn	Average Distance (car lengths)		
	0 Markers	1 Marker	2 Markers
Short left	5.6	7.4	9.1
Short right	7.0	9.0	10.0
Long left	6.6	11.9	11.7
Long right	6.5	8.6	8.4
All left	6.1	9.6	10.4
All right	6.8	8.8	9.1
All short	6.3	8.2	9.5
All long	6.6	10.2	10.0
Average	6.4	9.1	9.7

In almost every case, there appears to be some benefit from the use of an advance turn marker. When distance in the proper lane is the criterion (Table 2) for both right and left turns, some additional benefit may be derived from two advance markers when the turn is a short distance from the preceding turn, whereas one advance turn marker seems sufficient for long turns. When turn signal distances are analyzed (Fig. 3), however, the situation is just the opposite. For both right and left turns, no additional benefit is seen for short turns, whereas there appeared to be some for long turns.

To further isolate the factors influencing the effectiveness of the route marker installations, an analysis of variance was performed on

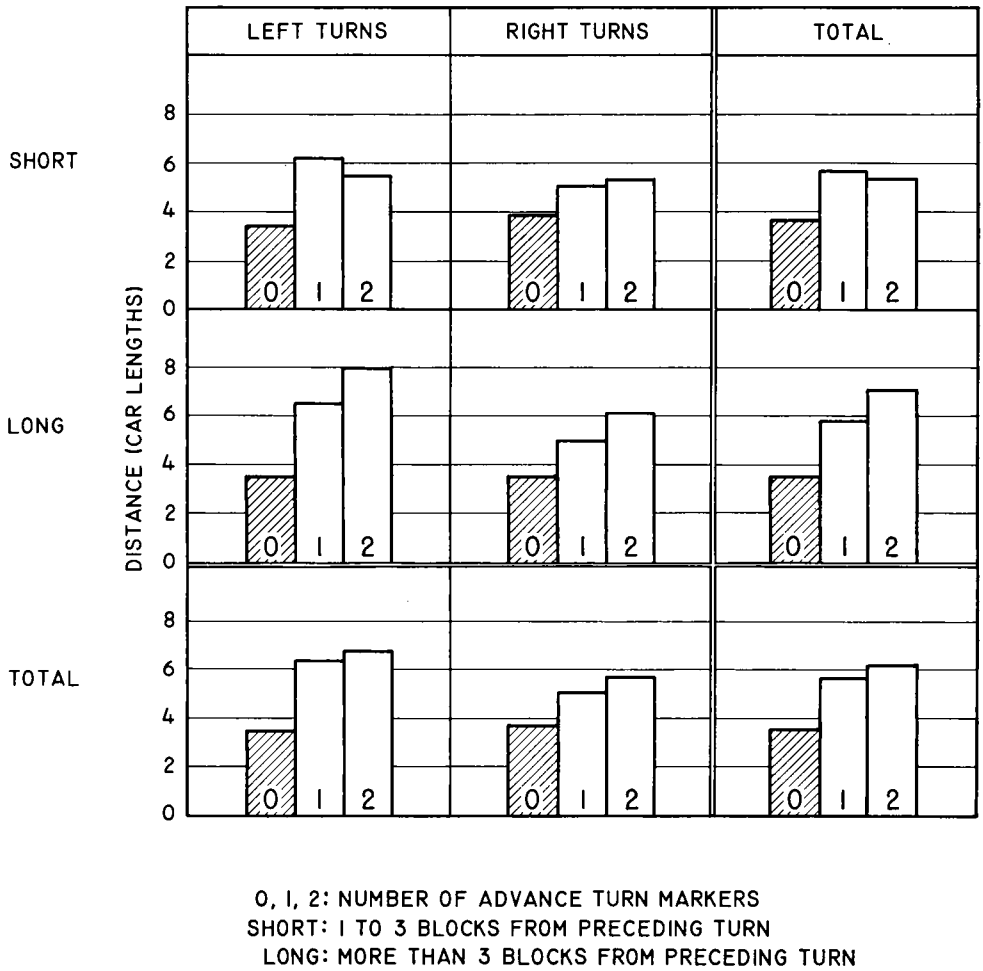

Figure 3. Effect of number of advance turn markers on use of turn signals.

each major dependent variable (Table 3). For the variable of distance in proper lane, the number of advance turn markers was a significant factor; however, the direction of turn did not seem to have an appreciable effect. There was also a high variability in magnitude of response among subjects. However, all the interaction terms involving subjects were not statistically significant; therefore, it is concluded that the relative response between conditions with different numbers of advance markers was not significantly different from one subject to another. It is believed that the possible higher actual variability due to the 15-car length cutoff would not have affected these results.

For the variable of proper turn signal, the number of advance turn markers is again a significant factor in difference of response. In this case, however, the direction of turn seems to make a difference, possibly because

TABLE 3

SUMMARY ANALYSIS OF VARIANCE FOR VARIABLES INDICATED

Source	Degrees of Freedom	Distance in Proper Lane			Distance at Which Turn Signal Given		
		Sum of Squares	Mean Square	F	Sum of Squares	Mean Square	F
Number of advance turn markers	2	1,302	651	32.6[a]	833	417	37.9[a]
Direction of turn	1	32	32	1.6	78	78	7.1[a]
Subjects	52	2,449	47	2.4[a]	3,963	76	6.9[a]
Number of advance turn markers:							
By direction of turn	2	106	53	2.7	75	38	3.5[b]
By subjects	104	1,666	16	0.8	1,073	10	0.9
Direction of turn by subjects	52	925	18	0.9	406	8	0.7
Number of advance turn markers by direction of turn by subjects	104	1,742	17	0.9	790	8	0.7
Error	318	6,331	20	—	3,466	11	—
Total	635	14,553	—	—	10,684	—	—

[a] Significant at 0.01 level. [b] Significant at 0.05 level.

drivers are more likely to signal for a left turn, which involves a greater probability of conflict, than for a right turn. This is reflected in Figure 3. In addition, because the interaction of number of advance markers with direction of turn leads to statistical significance, it is concluded that certain combinations of number of advance markers and the direction of turn have a different effect than others, which can also be seen in Figure 3. As in the case of the lane data, there was a high variability in magnitude of response among subjects. Again, because all the interaction terms involving subjects were not statistically significant, it is concluded that the relative response to different numbers of advance turn markers was not significantly different from one subject to another.

Combining the nonsignificant interaction terms with the error term and recomputing the ratios of the mean squares did not affect these results.

ANALYSIS

It might be argued that the test subjects were not typical of the average driver. All were graduate engineers who had worked for the Bureau of Public Roads from six months to three years. Their experience in the field of highway and traffic engineering might have tended to result in somewhat higher performance in the study. However, this study was concerned with the relative effects of various numbers of advance turn markers, and such relative effects would be reflected in the performance of this group. Perhaps the observed effects would have been more pronounced with more typical subjects.

The number of errors that occurred was lower than had been expected. The reasons for this small number of errors are subject to conjecture but there are three factors believed to be responsible: (a) the group of subjects were all graduate engineers and possibly more alert and more aware than average drivers; (b) the target value of the sign was important, which is discussed later, and (c) the directional markers at the intersections were always mounted on the far right corner which is also a location for

Figure 4. Advance turn marker installation largely hidden from view of approaching driver by truck on extreme right.

traffic signals in the District of Columbia. For convenience, these turn markers were often mounted on the signal poles, usually very close to the signal. It is presumed that most, if not all, drivers were looking for the signal and therefore had more of a chance to see the marker. Those stopped for the traffic signal also had much more time to see it. However, the chances for being stopped for a traffic signal were the same regardless of the number of advance markers. Therefore, the fact that almost all the errors occurred when there were no advance turn markers indicates that the presence of an advance turn marker was beneficial in reducing errors in following the route.

Because any distance over 15 car lengths was reported as 15, the average distances for the condition where one or two advance turn markers were present were very likely higher than those calculated since many of them are recorded as 15 car lengths. Other factors that may have affected the data are that the subjects were not specifically told the purpose of the study, and did not receive specific instructions relating the proper lane and the use of the turn signal to their knowledge of the impending turn. They may have been in the proper lane due to chance. Conversely, they may have turned on their turn signals when close to the intersection even though the markers had been seen further back. However, it is felt that the net result of these factors tended to minimize the observed differences.

ADDITIONAL OBSERVATIONS

The field crew, consisting of junior engineers of the Bureau of Public Roads, made additional observations pertinent to this report.

At several intersections topography, alignment, or physical obstructions (such as transit buses or double parked trucks) obscured to some extent the driver's view of the turn

Figure 5. Intersection where route turns left is just beyond stanchion in center of street. When no advance turn markers were present, 50 percent of subjects missed this turn.

markers. Figure 4 shows a type of situation in which two advance turn markers might prove of value.

Errors

A large percentage of the missed turns came from one such intersection in the heart of the downtown area, shown in Figure 4. The block on the approach to the intersection was on a downgrade, whereas the intersection itself and the preceding one were level. Neither the intersection nor the directional marker could be seen until the driver had passed through the preceding intersection. While he was on the downgrade, the directional marker, mounted as it was on the far side of the level intersection, was not in his direct line of sight. Because he was not aware of the impending left turn until he was close to the intersection, the heavy traffic often prevented him from getting into the proper turn lane.

Where no advance turn markers were posted, drivers repeatedly had near misses due to being positioned in the wrong lane (Fig. 5). The driver often held up traffic near or at the intersection in an attempt to position himself in the correct turning lane. This situation was considered by the observer to be an error if the turn created a hazardous condition.

When the density of traffic was low on one-way streets, there was frequently no realization on the part of the driver that the street was one-way. Consequently, on left turns the driver would often signal and turn from the wrong lane. For purposes of analysis this was not treated as an error because no actual hazard was created due to the light density of traffic; however, these subjects were not credited with being in the proper lane.

Figure 6. White route marker on black square shows up well against both dark and light background.

Design of Markers and Arrows

One possible reason for the low number of errors is the high target value of the design used for the route marker. Observation in the field showed that the white circle on black square design, based on the new standards in the Manual on Uniform Traffic Control Devices, was visible at a much greater distance than was expected, and long before the numerals were legible. It could be easily picked out from the array of other signs visible along a street (Fig. 6).

With respect to the arrows that were used, it was observed that for the directional marker at the intersection it was difficult to determine which direction the horizontal arrow was pointing except at relatively short distances away from it (Fig. 7). The direction in which the advance turn arrow was pointing could be determined at a somewhat greater distance because the position of the vertical part of the shaft gave a clue to its orientation. It would seem, therefore, that the old 13- by 10-in. arrows are insufficient even for low-speed urban usage.

Some of the test drivers were not aware of any difference in meaning between the bent advance turn arrow and the horizontal directional arrow. This was particularly evident in situations where two advance turn markers were used and a short block length

Figure 7. Difference in legibility of marker numerals and arrow apparent when photo is viewed at various distances.

preceding the turn made it necessary to place the first marker seen by the driver close to the preceding intersection. Some drivers, unaware of the difference in arrows, became confused and almost turned a block too soon.

CONCLUSIONS

There is a need to have at least one advance turn marker placed in advance of an urban intersection where a route turns. The lone directional marker at the intersection gives the driver too little time for response and, in doing so, may create confusion, congestion, and possible hazard.

There seems to be little evidence from this study that a second advance turn marker is of much value except possibly in cases where alignment or large vehicles may obstruct the driver's view, or where heavy traffic or other distractions may cause him to miss seeing the one advance marker. There is also some slight evidence from the turn signal data to show that two advance turn markers may be advantageous where there is a long distance between successive turns.

ACKNOWLEDGMENTS

The cooperation of the District of Columbia Department of Highways which prepared the route markers

and arrows used in this study is gratefully acknowledged.

The following engineers, during their period of training as junior engineers in the Washington office of the Bureau of Public Roads, conducted the field work, performed the preliminary data analysis, and submitted a preliminary report: David M. Ham, Thomas E. Knisely, Gardner M. Rice, George A. Rodes, Albert E. Stone, and John R. Webster.