Selection of Pedestrian Signal Phasing

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This paper presents a methodology for selecting alternate schemes for pedestrian signal phasing. The types of pedestrian phasing studied include (a) combined pedestrian-vehicle interval, (b) early release of pedestrians with respect to vehicles, (c) late release of pedestrians with respect to vehicles, and (d) scramble timing. Each alternative is weighed in terms of its impact on the safety of the pedestrian and on the delay to both pedestrians and vehicles. The results of the study indicate that the combined pedestrian-vehicle interval will almost always minimize overall pedestrian and vehicle delay. The only exception occurs for the case in which a pedestrian-vehicle conflict causes long queues of vehicles to form in a right-turning lane (or left-turning lane on a one-way street). In that case, the use of late release or scramble timing is preferable. Scramble timing is capable of increasing pedestrian safety by completely separating pedestrian and vehicular movements; however, this benefit is canceled if pedestrian compliance is low. The early release of pedestrians does not appear to significantly improve pedestrian safety and will always increase total delay at the intersection. A methodology for selecting the phasing for given pedestrian volumes and vehicle-turning movements is presented.

The combined pedestrian-vehicle interval is the most common form of pedestrian signal phasing in use today, and it is defined in a manual (1) as "a signal phasing wherein pedestrians may use certain crosswalks and vehicles are permitted to turn across these crosswalks." At most crosswalks, the necessity to share green time leads to conflicts between pedestrians and right- or left-turning vehicles. The signal phases that have been used in the past are designed to partially or fully separate the movements of pedestrians and vehicles. This paper discusses the practicality of using phasing schemes other than the combined pedestrian-vehicle interval. The research on which this paper is based was performed as part of a broader study that encompassed a number of areas in addition to pedestrian signal timing (2). The procedures that are too detailed to be treated in this paper are referenced for further information.

TYPES OF PHASING

Three basic schemes for pedestrian signal phasing were examined as alternatives to the combined pedestrian-vehicle interval. These schemes included two semiexclusive pedestrian phases and one totally exclusive pedestrian phase and are listed below:

1. Early release of pedestrians with respect to vehicles,
2. Late release of pedestrians with respect to vehicles, and
3. Scramble timing.

The early release of pedestrians is designed to allow pedestrians to leave the curb before the vehicles turn right. Through vehicles are allowed to proceed normally. The object of this type of signal phasing is to allow the pedestrians who travel in the same direction as the vehicles to pass the zone of conflict before the vehicles turn right. Thus, the pedestrians from the opposite end of the crosswalk enter the zone of conflict shortly after the vehicles are released. (This situation will vary, depending on street width.) In this case, the pedestrians are better equipped to react to the movement of right-turning vehicles because they have direct eye contact with the vehicles. However, this type of signal phasing necessitates a separate signal indication for right-turning vehicles. The length of this early release interval is generally in the range of 5 to 10 s.

The late release of pedestrians is defined as holding the pedestrians at the curb until several vehicles turn right and pass the crosswalk. The logic behind this type of signal phasing is to permit several vehicles to turn before there is a pedestrian conflict. This situation increases the capacity of the right-turning lane and reduces the vehicle delay. It would be desirable, although not necessary, to provide a green arrow for right turns for the initial vehicle interval. This arrow would then revert to the normal green indication several seconds before the pedestrian WALK sign informs the vehicles that they no longer have the right-of-way. The late release interval could be as short as 7 s or much longer, depending on the cycle length and time required for the minimum WALK and clearance intervals.

The use of scramble timing provides an exclusive signal phase so that pedestrians can cross the intersection from all directions, including the diagonal. Currently, the most frequent use of scramble timing occurs in shopping and business districts where pedestrian volumes are high and at school crossings where safety is of utmost concern. The exclusive phase is normally timed with a 7-s WALK interval, and a minimum clearance interval is timed by using a walking speed of 1.22 m/s (4.0 ft/s), which covers the distance between the diagonally opposite curbs.

STUDY APPROACH

The study approach was to evaluate these three types of pedestrian signal phasing in terms of pedestrian and vehicle delay and safety. The delay and safety effects of these types of phasing were then compared to the effects of a combined pedestrian-vehicle interval.

For both early and late release, a hypothetical location that is typical of an intersection in a central business district (CBD) was used to develop the values for vehicle and pedestrian delay. The delay impacts of scramble timing were examined for a hypothetical intersection that was best suited for the use of scramble timing. A special study that used time-lapse photography was conducted for the delay analyses. For the safety analysis, a pedestrian compliance study was performed for late release phasing, and compliance trends were observed for scramble timing.

DATA COLLECTION

The data required for the analysis of the schemes for pedestrian signal phasing included studies of vehicle delay, pedestrian arrival rates at intersections, pedestrian delay, and pedestrian compliance. These are briefly discussed below.

The impact of phasing on vehicle delay was determined by developing a relation between right-turning vehicle delay and pedestrian volume on the crosswalk. Although some studies concerning this relation have been performed, none were sufficiently detailed for use in this analysis. Consequently, a field study that used time-lapse photography was undertaken for this project. For the purpose of this study, delay was defined as the difference between the time required for a right-turning movement with pedestrians in the crosswalk and the time required for a right-turning movement without

pedestrians in the crosswalk. Thus, this definition of delay does not include any effect of the traffic signal itself.

Films from the cities of Washington, D.C.; Cambridge, Massachusetts; Phoenix, Arizona; and Akron, Ohio, were used. The data base included 68 h of approach that translated into approximately 2000 h of right-turning vehicles for a wide range of pedestrian volumes. The specific data collection and analysis procedures are found in another report (2). The delay relation that evolved from this study is shown in Figure 1. This relation is applied to intersection approaches where the intersecting street is less than 18.3 m (60 ft) wide, i.e., the parallel crosswalk is less than 18.3 m (60 ft) long.

The analysis of pedestrian delay required a preliminary study of pedestrian arrival rates at intersection crosswalks. The details of this study can also be found in another report (2). Briefly, it was found that the arrival rate of pedestrians at a signalized intersection crosswalk is highest during and just before the WALK interval. This rate drops off to approximately half the rate of the former after the flashing DONT WALK sign is displayed because the pedestrians who wish to reach the diagonal curb have a choice of streets to cross. To minimize their delay, the pedestrians will cross from the crosswalk that is displaying or will soon display the WALK interval. The arrival rate of pedestrians at a crosswalk that was assumed for computing the pedestrian delay in this study is shown in Figure 2.

Other data collection included a field study in Sioux City, Iowa, to observe pedestrian compliance at late release installations. For over 10 years, late release has been used at many of the intersections in downtown Sioux City. Most of these late release phasings are at intersections on one-way streets. These installations use a right-turn arrow for vehicles that is displayed for all but the last 2 to 3 s of the total interval for the late release of pedestrians (9 to 10 s). The pedestrian compliance rates at scramble-timing installations in Washington, D.C., were also used. No field studies were made at locations where the phasing for the early release of pedestrians is used.

EARLY PEDESTRIAN RELEASE

Analysis

The delay analysis for the early release phasing was performed under several assumptions. The characteristics of the intersection and the assumptions include the following:

1. Perfect pedestrian compliance,
2. The pedestrian arrival distribution shown in Figure 2,
3. The distribution of right-turning vehicle delays shown in Figure 1,
4. A 3-s headway for right-turning vehicles and a 2-s headway for through vehicles at saturation flow,
5. A 15.9-m (52-ft) crosswalk,
6. An 80-s cycle with a 50-50 split,
7. All right-lane vehicles in the queue at the beginning of green, and
8. Various combinations of through and right-turning vehicles to simulate the total range of difference in delay between early release and standard timing.

A 7-s interval for early release of pedestrians (vehicles are stopped in the right-turning lane during this time) was also used. The signal timing that results from the above assumptions is shown in Figure 3.

The specific analysis procedures used in computing vehicle and pedestrian delay can be found in another report (2). Basically, pedestrian delay was computed for pedestrian volumes of between 2 and 20 pedestrians/cycle. The delay for right-turning vehicles resulting from pedestrians was computed for a range of 2 to 8 vehicles/cycle and between 2 and 20 pedestrians/cycle who crossed the street into which the vehicles were turning. Two different arrival patterns for through and right-turning vehicles in the right lane were examined: one favored early release, and the other favored standard timing.

Results

The results of the delay analysis in person-seconds per cycle for the two arrival patterns are given in Table 1. The pedestrian delay does not increase with the early release of pedestrians, since the length of the WALK interval is the same as that with standard timing. Overall, and in comparison with standard phasing, early pedestrian release will always result in additional total person delay at an intersection.

LATE PEDESTRIAN RELEASE

Analysis

The analysis of vehicle and pedestrian delay resulting from the late release of pedestrians was conducted in much the same way as the early release analysis. The timing diagram for late release and its relation to standard timing is also shown in Figure 3. The same intersection characteristics and assumptions were used for late release as had been used for early release. A 7-s advance green for right-turning vehicles that is relative to the pedestrian WALK interval was also used. This interval permits 2 to 3 vehicles to turn right before the pedestrians are released. Similar to the analysis of the early release, the vehicle-delay analysis was performed for two different arrival patterns; one favored late release, and the other favored standard phasing.

The analysis of the pedestrian compliance data collected in Sioux City consisted of determining the percentage of pedestrians who begin to cross during each pedestrian interval. Of particular interest was the percentage of pedestrians who begin to cross during the late release interval.

Results

The results of the delay analysis for various pedestrian and vehicle volume levels are given in Table 2. The total delay is always increased by the use of late release for low volumes of vehicles; however, the results for higher volumes are mixed. Thus, it appears that, for the case in which almost all vehicles are making right turns and pedestrian volumes are heavy, the use of late release significantly reduces the vehicle delay. This is the case because the first several vehicles are allowed to proceed in an unobstructed manner. The use of late release also increases the capacity of the right-turning lane to some extent by concentrating pedestrian movements into a shorter period of time, which increases the time available for free vehicle movement. The potential increase in the capacity of the right-turning lane would be even more significant, if a longer late release interval were used. Thus, one application of late release phasing would be to alleviate a congestion problem in the right-turning lane.

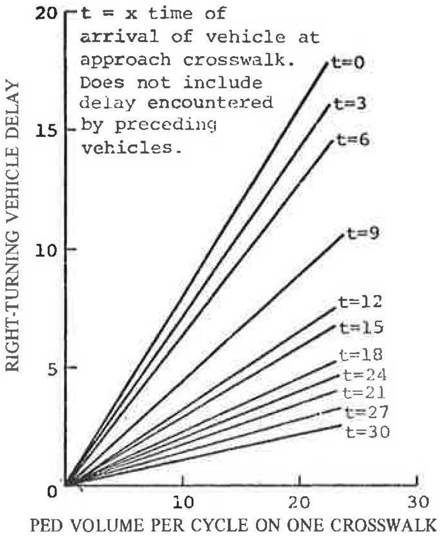


Figure 1. Relation between pedestrian volume and right-turning vehicle delay.

Note: 1 m = 3.3 ft.
These curves apply only to those crosswalks that are less than 18.3 m long.

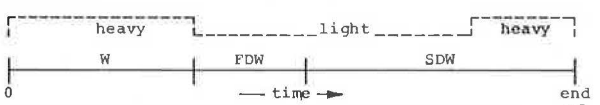


Figure 2. Typical distribution of pedestrian arrival at an intersection crosswalk.

Notes: W = WALK interval; FDW = flashing DONT WALK interval; and SDW = solid DONT WALK interval.
Light arrival rate = 0.5 x heavy arrival rate.

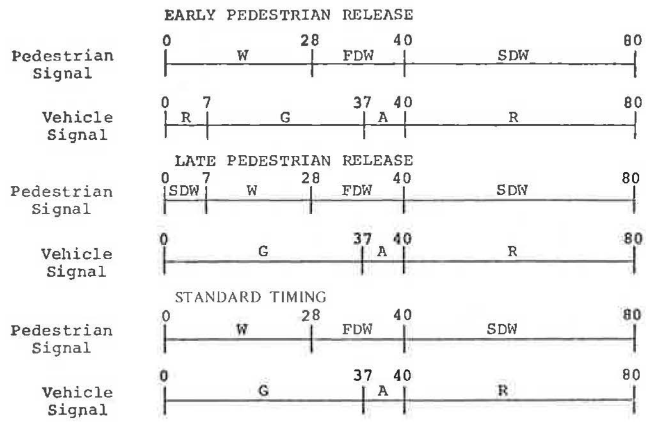
The capacity of the right-turning lane that exists with late release timing can be approximated by the following formula:

$$LRC = LRT - 3 + x \quad (1)$$

where

LRC = late release capacity per cycle (number of vehicles),
LRT = time allocated to the pedestrian late release interval (seconds),

Figure 3. Timing used in the analysis of early and late release of pedestrians.



Notes: W = WALK interval; FDW = flashing DONT WALK interval; SDW = solid DONT WALK interval;
G = green indication; A = amber indication; and R = red indication.
Numbers indicate time (seconds) from beginning of the cycle.

Table 1. Increase in delay from early release timing over standard timing.

Pedestrian Volume per Cycle	Pedestrian Delay (person-s)	Vehicle Delay (person-s/cycle) 2 Veh/Cycle Max	Min	4 Veh/Cycle Max	Min	6 Veh/Cycle Max	Min	8 Veh/Cycle Max	Min	Total Delay (person-s/cycle) 2 Veh/Cycle Max	Min	4 Veh/Cycle Max	Min	6 Veh/Cycle Max	Min	8 Veh/Cycle Max	Min
0	—	21	0	42	0	63	0	84	0	21	0	42	0	63	0	84	0
2	0	18	0	36	0	54	0	72	0	18	0	36	0	54	0	72	0
5	0	18	0	36	0	54	0	72	0	18	0	36	0	54	0	72	0
10	0	15	0	30	0	45	0	60	0	15	0	30	0	45	0	60	0
20	0	12	0	24	0	36	0	48	0	12	0	24	0	36	0	48	0

Notes: Based on vehicle occupancy rate of 1.5 persons/vehicle.
Maximum possible increase in vehicle delay for early release versus standard timing occurs when the first vehicle turns right and the remaining vehicles go through the intersection. Minimum increase occurs when at least the first three vehicles and possibly all vehicles go through the intersection.

Table 2. Increase in delay from late release timing over standard timing.

Pedestrian Volume per Cycle	Pedestrian Delay (person-s)	Vehicle Delay (person-s/cycle) 2 Veh/Cycle Max	Min	4 Veh/Cycle Max	Min	6 Veh/Cycle Max	Min	8 Veh/Cycle Max	Min	Total Delay (person-s/cycle) 2 Veh/Cycle Max	Min	4 Veh/Cycle Max	Min	6 Veh/Cycle Max	Min	8 Veh/Cycle Max	Min
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	9	0	-8	2	-20	6	-32	12	-44	9	1	11	-11	15	-23	21	-35
5	21	0	-15	3	-36	12	-57	21	-78	21	6	24	-15	33	-36	42	-57
10	41	0	-29	5	-68	21	-107	42	-146	41	12	46	-27	62	-66	83	-105
20	83	0	-53	8	-139	26	-185	165	-312	83	30	91	-56	109	-102	248	-229

Notes: Based on vehicle occupancy rate of 1.5 persons/vehicle.
Maximum possible increase in vehicle delay for late release versus standard timing occurs when the first three vehicles go through the intersection and the remainder turn right. Minimum increase (maximum decrease) occurs when the first three vehicles turn right and the remainder go through the intersection.
Negative sign indicates that vehicle delay decreased with late release.

3 = approximate average vehicle headway for right turns, and
x = capacity of remainder of the phase after pedestrian release (number of vehicles).

The value of x depends on the time allocated to the WALK and clearance interval and on the pedestrian volume. The approximate capacity of the right-turning lane for a range of interval times and pedestrian volumes that was developed for this study is based on the delay curves shown in Figure 1. These capacity values for an exclusive right-turning lane are given in Table 3.

The results of the compliance study in Sioux City, Iowa, indicate that most pedestrians comply with the late release interval. At the locations studied, only about 3 percent of all pedestrians began their crossing in the 9 to 10-s late release interval.

It is difficult to judge the effect of the late release phasing on pedestrian behavior in other cities without actually installing such a system. Late release phasing has been used in Sioux City over a long time period and in a number of locations so that both the pedestrian and driver are quite familiar with its operation, which possibly contributes to the high compliance rate. However, if such installations were introduced in other cities, the acclimation period would probably be long. If a new installation is used for late release phasing, signs should be placed at the crosswalk to inform pedestrians that they cannot leave immediately with the vehicle green phase.

SCRAMBLE TIMING

Analysis

The analysis of the delay difference between scramble and standard timing was designed by using conditions favorable to scramble timing. Previous research suggests that these conditions include high pedestrian volumes, low through-vehicle volume, heavy right-turn volumes, and narrow street widths (3). Specifically, the following assumptions were used:

1. Perfect pedestrian compliance;
2. Uniform pedestrian arrivals for scramble timing and the distribution shown in Figure 2 for standard pedestrian timing;
3. A 12.2-m (40-ft) street with parking on both sides, which allows one lane of traffic in each direction;
4. An 80-s cycle with a 50-50 split;
5. A 3-s average headway for right-turning vehicles at saturation flow;
6. All vehicles making right turns, and
7. Cycles with 8 vehicles/cycle and 20 pedestrians/cycle.

The timing schemes analyzed for scramble and standard phasing are shown in Figure 4.

The analysis of pedestrian delay was based on a ratio of 2:1 of pedestrians using the parallel crosswalk to those using the diagonal crosswalk. This ratio represented the travel characteristics at several scramble-timed locations in Washington, D.C. For this example, the 20 pedestrians/cycle translate into 13 pedestrians using the parallel crosswalk and 7 pedestrians using the diagonal crosswalk. For the nonscramble timing alternative, the pedestrians desiring to cross diagonally were presumed to use the WALK intervals on which they would incur the least delay.

The difference in vehicle delay between scramble and standard timing was assessed by using two arrival patterns. One pattern was based on the uniform arrival of vehicles, and the other was based on all vehicles in a platoon arriving at the beginning of the green phase. Such conditions are uncommon in everyday experience, but probably form the two extremes of possible arrival patterns.

Results

The results of the vehicle and pedestrian delay analyses for the given assumptions are presented below:

1. The pedestrian delay under scramble timing was 650 person·s compared with the 200 person·s for standard timing, an increase of over 200 percent;
2. The vehicle delay for the uniform arrival assumption was reduced with scramble timing by 300 person·s/cycle; and
3. The vehicle delay for the platoon arrival assumption was reduced with scramble timing by 400 person·s/cycle.

The large increase in pedestrian delay is primarily due to the additional delay encountered by pedestrians on the parallel crosswalks. However, the results also indicate that the delay is increased not only for those using the parallel crosswalks but also for those using the diagonal crosswalks. Thus, the use of scramble timing is at a distinct disadvantage with respect to pedestrian delay.

Although vehicle delay was reduced for the assumptions used, it should be emphasized that these combinations of intersection and traffic characteristics are favorable to the use of scramble timing. It is rare that such conditions exist in reality, particularly with such a high turning percentage. A lower turning percentage or lower traffic volume would reduce the vehicle delay advantages of scramble timing substantially. If fewer vehicles turn, or if the street is wider, then the use of scramble timing would more than likely increase vehicle delay rather than reduce it.

The prime advantage of scramble timing would accrue to vehicles by increasing the capacity of the right-turning lane under the conditions of heavy pedestrian and right-turning vehicle volumes. For cases in which a queueing problem exists in the right-turning lane, the use of scramble timing may be a means for alleviating this problem and would be particularly useful when such problems exist for both vehicle phases. The use of late release may be more applicable for the cases in which queueing problems exist for only one phase.

Despite its drawbacks and from the standpoint of delay, the use of scramble timing does have a number of possible applications because of its safety features. Under the assumption that the scramble-timing indications are obeyed, the use of scramble timing can completely separate pedestrian and vehicle movements, thereby reducing the potential for pedestrian accidents. If violations are frequent, the use of scramble timing may be more of a safety hazard than an accident prevention measure. Observations of pedestrians at several scramble-timing locations revealed that violations are more frequent at narrower streets, which is the geometric criterion for which scramble timing is the most applicable. Most of these violations were found to occur during the vehicle phase that is normally used by pedestrians under standard timing. A lack of right-turning maneuvers generally encourages the most violations at these locations.

Scramble timing and similar exclusive pedestrian phases have been widely applied to school crossings, and justifiably so, regardless of their impact on

delay. Crossing guards are sometimes present at these locations to supplement the signal. Scramble timing may also be helpful at T-intersections where vehicles from the side street must turn and, in so doing, either reduce the gaps available to pedestrians or incur substantial delay themselves. If scramble timing is selected for use at an intersection, it is usually desirable to provide it on a pedestrian-actuated basis.

Table 3. Capacity of an exclusive right-turning lane by pedestrian volume in crosswalk during a cycle.

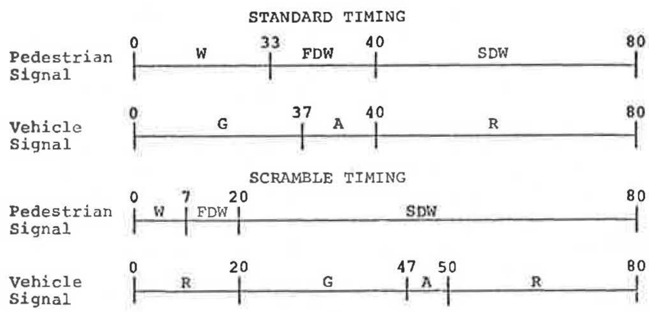
Green Phase Time (s)	Number of Vehicles: 0 Pedestrians	2 Pedestrians	5 Pedestrians	10 Pedestrians	20 Pedestrians
20	6	5	4	3	2
25	8	6	5	4	2
30	10	7	6	5	3
35	11	9	8	6	4
40	13	12	10	7	5
45	15	13	11	9	6
50	16	15	13	11	8
55	18	17	15	12	10
60	20	18	16	14	11

Notes: 1 m = 3.3 ft.
The data are applicable only for the case in which the exit crosswalk is less than 18.3 m (60 ft) long.

SELECTION OF PEDESTRIAN SIGNAL PHASING

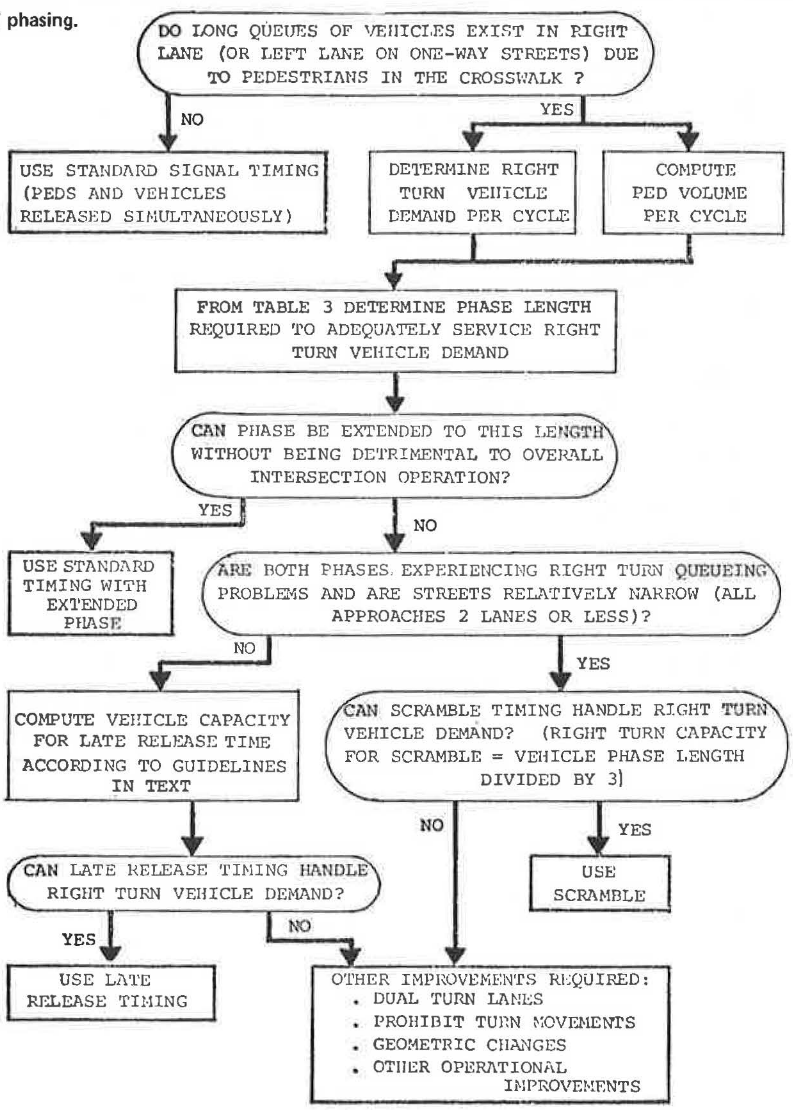
The methodology for selecting pedestrian signal phasing is shown in Figure 5. This flow chart is formulated primarily on the basis of pedestrian and vehicle delay. Safety justification for the various types of phasing is discussed below.

Figure 4. Timing alternatives evaluated for standard and scramble timing.



Notes: G = green indication; A = amber indication; R = red indication; W = WALK interval; FDW = flashing DONT WALK interval; and SDW = solid DONT WALK interval.
Numbers indicate time (seconds) from the beginning of the cycle.

Figure 5. Selection of pedestrian signal phasing.



The principles on which the methodology is based are

1. Standard pedestrian phasing (combined vehicle-pedestrian phase) almost always minimizes total intersection delay;
2. Early release of pedestrians always increases overall intersection delay;
3. Late release of pedestrians can be used to alleviate a capacity problem in the right-turning lane, but this phasing should only be used when such a problem exists; and
4. Scramble timing is best used, from the perspective of delay, when both phases are experiencing queueing problems in the right-turning lane because of pedestrian conflicts and relatively narrow street widths.

The decision for selecting the appropriate phasing scheme begins by determining whether a problem of vehicle queueing in the right-turning lane exists for any hour because of vehicle-pedestrian conflict. This condition will usually require heavy pedestrian and right-turning vehicle volumes. If this condition does not exist, delay considerations dictate that standard timing be used. If this condition does exist then the pedestrian volume per cycle should be computed and the demand for right-turning vehicles estimated. The phase length required to service the right-turning vehicle demand under standard timing can be determined by using Table 3. If the phase can be extended to that length, standard timing should be used.

If standard timing is unable to service the right-turning vehicle demand, then other phasing schemes should be examined. If both phases are experiencing queueing problems, scramble timing is suited for these conditions. If only one phase is experiencing problems, then the late pedestrian release should be used. The capacity in the right-turning lane for both scramble timing and late release can be determined by using the methodologies shown in Figure 5. If neither scheme solves the problem, then the situation will have to be tolerated or other solutions such as dual-turning lanes, turn prohibitions, or geometric changes will be required.

To select the appropriate type of signal phasing, one must consider safety as well as delay. Scramble timing would appear to be the safest type of phasing because vehicle and pedestrian movements are completely separated. However, the level of safety afforded to pedestrians is contingent on the degree of compliance with the signal indications as previously discussed.

Scramble timing may have some application to intersections where the characteristics of the pedestrian population require special consideration. For example, it may be used at locations where there are many elderly pedestrians or young school pedestrians. These locations should be carefully selected so that the violation rates do not increase or that serious traffic congestion results.

CONCLUSIONS

1. The early release of pedestrians significantly increases vehicle delay without reducing pedestrian delay. It may provide some measure of additional safety, but the benefits were not precisely determined in this study.
2. The late release of pedestrians tends to increase the overall delay at intersections (sum of vehicle and pedestrian delay) at most traffic volume levels. However, for a vehicle queue that consistently exists in a right-turning lane, late release is a good means for increasing the capacity of that lane, and, with certain combinations of pedestrian and vehicle volumes, late release will reduce the overall delay at intersections.
3. Compliance with the late release of pedestrians in Sioux City was remarkably high with less than 3 percent of pedestrians in violation. However, it is expected that, if a late release installation is provided in a city where this has not been used, pedestrian acceptance and the resultant compliance may be low. In this case, it is recommended that signs be provided to inform pedestrians that they are not permitted to begin their crossing with vehicles.
4. Scramble timing always increases pedestrian delay. For the example used in this study, pedestrian delay was increased by over 200 percent.
5. Scramble timing may be able to increase the capacity in the right-turning lanes; however, its use will increase delay on the through lanes. The delay effects are minimized if the streets are narrow and the right-turning volumes are high.
6. Scramble timing creates an exclusive pedestrian phase that, if obeyed, can completely eliminate pedestrian-vehicle conflicts, thus improving the level of safety. However, in this study, it was observed that violation rates for scramble timing were generally higher on narrow streets, which is the most suitable condition from the delay perspective.

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REFERENCES

1. Manual on Uniform Traffic Control Devices for Streets and Highways. Federal Highway Administration, U.S. Department of Transportation, 1971.
2. C. M. Abrams and S. A. Smith. Urban Intersection Improvements for Pedestrian Safety: Signal Timing for the Pedestrian. Federal Highway Administration, U.S. Department of Transportation, Vol. 3, Aug. 1976.
3. R. D. Dier. Pedestrian Scramble Control. Traffic Engineering, Aug. 1954, pp. 413-414.

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