Critical Movement Analysis for Shared Left Turn Lanes

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This paper analyzes critical movements for left turn lanes that are shared by through traffic. It shows that the critical conflict volume along a given approach is the sum of the left turns, the opposing traffic, and the blocked proportion of the through traffic in the shared lane. A set of impedance or blockage factors is derived as a function of the left turns per cycle. When two left turns per cycle occur, 60 percent of the through vehicles in the lane are blocked. When five left turns per cycle exist, 80 percent of the through vehicles in the shared lane are blocked. Thus, for all practical purposes, five or more left turns per cycle will pre-empt the shared lane. From this it follows that short signal cycles are desirable where shared left turn lanes predominate. The paper addresses shared lanes in both single and multilane approaches. It contains guidelines for computation of critical movement volumes in practice.

The left turn problem at signalized intersections has been a persistent and pervasive one for more than three decades (*1*, *2*). A consensus exists that adjustments are needed to compensate for the longer headways (time spacings) by left turns and to reflect the additional delays or time requirements resulting from conflicts with through traffic. In addition, the impeditive effect (blockage) of through vehicles in shared left turn lanes is increasingly recognized.

This paper shows how left turns, through vehicles, and opposing traffic interact. It analyzes critical movements for a single "shared lane" approach and extends the result to the multiple lane approach case. It derives adjustment factors for use in critical lane analysis and contains illustrative examples of how the proposed procedures can be applied. In many respects it represents an extension of the planning analyses set forth in NCHRP Report 212 and the 1985 *Highway Capacity Manual* (*3*, *4*).

GENERAL CONCEPT

The critical lane volumes across a conflict point represent the sum of the conflicting movements along the artery and cross street. The critical lane (or conflict) volumes along the artery represent the sum of the left turn movement, the opposing through movement, and the through movements that share the lane with left turns and are blocked by them. The proportion of through movement that follows left turns is susceptible to delay by them and depends on the number of left turns in the shared lane.

This basic model assumes that the opposing through traffic moves first and the left turns and blocked through traffic then move.

Basic Relationships

These interrelationships best can be understood by considering only the artery volumes along a two-lane road with left turns in one direction only. Accordingly, Figure 1 shows conflict volumes for such a two-lane shared artery. The conflict volumes for a two-lane road with separate left turn lanes are shown for comparative purposes. All volumes are shown in passenger car units. The through volumes are assumed to include right turns, even though under special cases (i.e., wide cross street or right turn island) they could be deducted from the through traffic.

The critical conflict volumes along a shared two-lane, with left turns in one direction, represent the greater of the two volumes obtained from the following formulas:

$$\text{Critical lane volume} = L_1 + V_o + K_{t_1} \tag{1a}$$

$$\text{Critical lane volume} = L_1 + t_1 \tag{1b}$$

where

t_1 = through volume in lane shared by left turns;
V_o = opposing volume; and
K = impedance factor that reflects the proportion of through vehicles that follow, and are blocked by the left turns.

These definitions assume that the right-turning traffic is included in the through traffic and in the opposing traffic flow. They apply throughout the paper.

The limiting case is a three-phase operation in which the critical lane volume equals $L_1 + t_1 + V_o$. Here the impedance factor, K, equals one. Conversely, if a left turn lane is provided, $K = 0$.

Thus, the left turn impedance or blockage factor, K, is important in computing critical lane volumes. It varies from 0, where no through vehicles are delayed, to 1.0 where all through vehicles follow left turns and are delayed. Figure 2 illustrates the positions of through and left turns in a shared lane for the cases where K = 0.0, 0.5, and 1.0.

Estimating *K*

For formulas 1, 2, and others like them to have meaning in practice, it is necessary to determine how the impedance fac-

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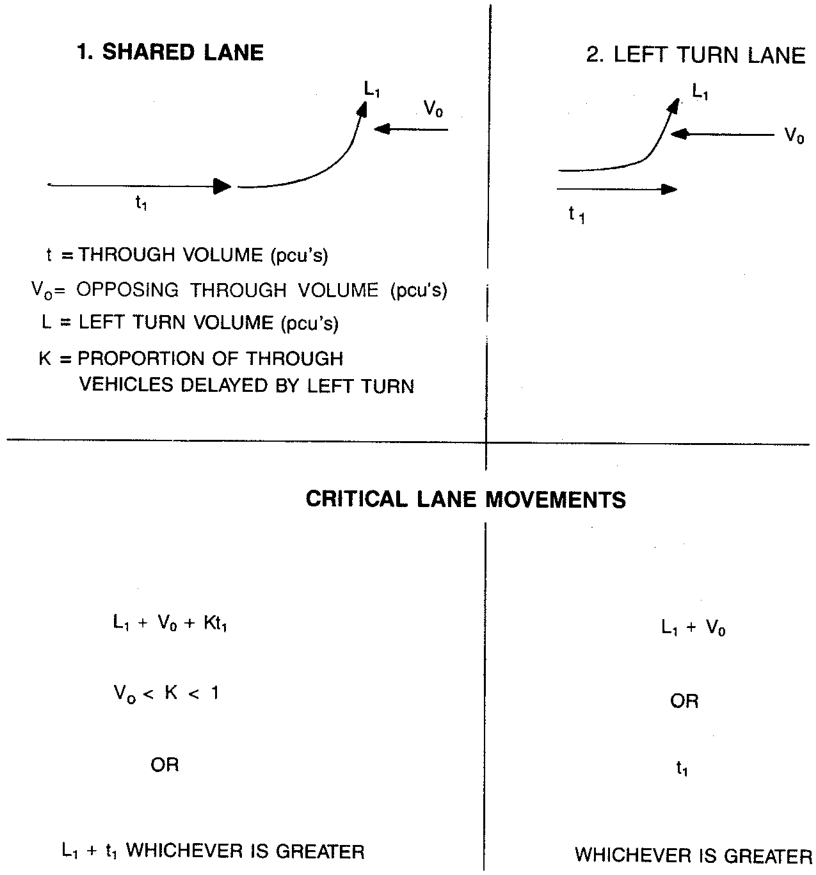


FIGURE 1 Critical movements—single lane.

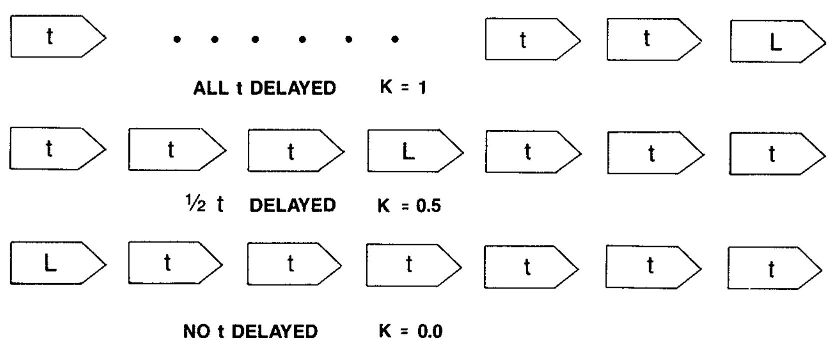


FIGURE 2 Examples of *K*.

tor K varies as a function of the left turns, L_1. Accordingly, values for K were obtained by two methods: (a) simulation by random numbers tables; and (b) computations based on positional probabilities assuming sampling with replacement.

Simulation

Random number tables were used to generate the positions of left turns and through vehicles in 10-car platoons. Fifty platoons were analyzed for each of the four cases where left turns represented 10, 20, 30, and 40 percent of the total traffic in the platoon, respectively. The average number of through vehicles and the proportion of through vehicles delayed were then computed.

Positional Probabilities

Probability theory was used to estimate the likelihood of the first, second, third, and ith vehicles in line being left turns. Conditional probabilities were computed, assuming that the first left turn is the ith car in line based on sampling with replacement. The probability that the first $i - 1$ cars are through vehicles and the ith vehicle is a left turn, p_i, is given by the formula:

$$p_i = \left\{\frac{t_1}{L_1 + t_1}\right\}^{i-1} \cdot \left\{\frac{L_1}{L_1 + t_1}\right\} \qquad (2)$$

where

$L_1/(L_1 + t_1)$ = left turns as proportion of total traffic;

TABLE 1 COMPUTED VALUES FOR K

LEFT TURNS AS PERCENT OF TOTAL TRAFFIC IN SHARED LANE	LENGTH OF PLATOON (Veh/Cycle) 5	10	15	20
1	.029	.053	.076	.094
10	.247	[.322] .388	.495	.576
20	.390	[.607] .584	.690	.757
30	.527	[.647] .694	.783	.834
40	.608	[.747] .761	.834	.874
50	.670[a]	.806	.866	.900
60	.720	.838	.889	.916
70	.770	.860[a]	.905	.929
80	.800	.880	.917	.938
90	---	.900	.929[a]	.945
95	---	---	---	.950

[SIMULATION]
[a] COMPUTED VALUE ADJUSTED SLIGHTLY.

$t_1/(L_1 + t_1)$ = through vehicles as proportion of total traffic;
L_1 = left turns; and
t_1 = through vehicles.

Computed values of K are shown in Table 1 and Figure 3 for 5-, 10-, 15-, and 20-car platoons. These exhibits show how K varies as a function of platoon length and left turns as a proportion of the total approach traffic. They indicate that simulation and random sampling with replacement give similar results. Salient findings are as follows:

1. The K-values increase with increasing proportions of left turns (p) in traffic, but they never reach 1.00. For 5-vehicle groups, the maximum is 0.80 when $p = 0.80$; for 10-vehicle groups, 0.90; and for 20-vehicle groups, 0.95.
2. The values of K increase faster than the proportions of left turns in the shared lane. For example, when the left turns account for half of the vehicles in the shared lane, then from 67 percent to 90 percent of the through vehicles in that lane would be delayed, depending on the platoon (queue) length.
3. The values of K increase with queue length for any given proportion of left turns in the lane. This suggests that a shorter traffic signal cycle length would reduce delays whenever left turns share a lane with through vehicles. For example, a lane that carries 480 through vehicles and 120 left turns in an hour (p = 20 percent) would result in a K-value of .584 for a 60-second cycle (10 vehicles per cycle) and .690 for a 120-second cycle (20 vehicles per cycle). The number of through vehicles that would be delayed would be 280 and 331, respectively.
4. The curves follow a formula of the form $K = [A(p)]$; pilot analysis suggests that $K = p^{(.55-0.020)}$ where Q = estimated vehicles/lane/cycle in the queue and p = proportion of left turns in the shared lane.

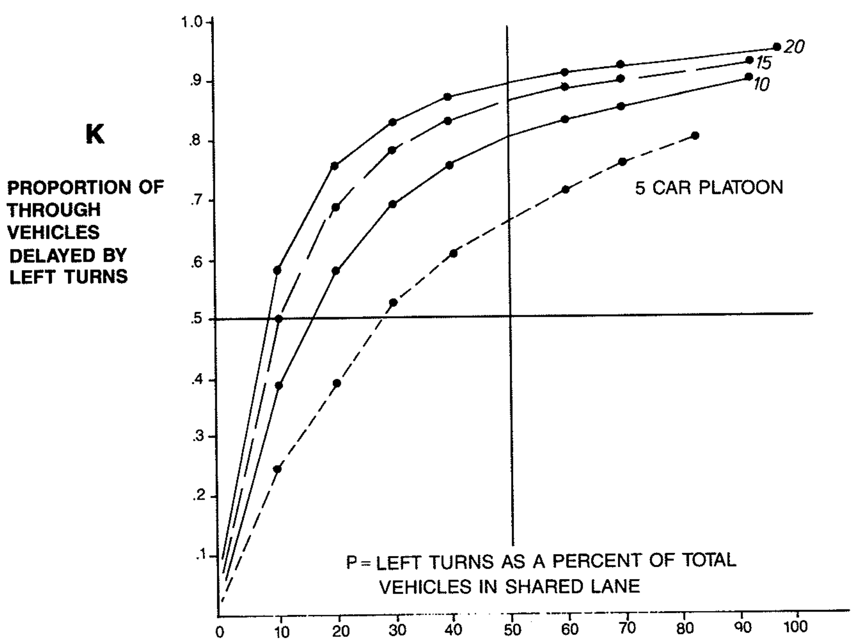


FIGURE 3 ***K* as a function of *p*.**

TABLE 2 SUGGESTED K-VALUES FOR APPLICATIONS

Left Turns Per Cycle	Computed	Suggested Value Rounded
0.5	0.25	0.25
1	0.39	0.40
2	0.58	0.60
3	0.69	0.70
4	0.76	0.75
5	0.81	0.80
6	0.84	0.84
7	0.86	0.86
8	0.88	0.88
9	0.89	0.89
10	0.90	0.90

Source: Computed

K-Values for Application

Table 1 shows that the K-values can be represented by a single set of numbers that are a function of the number of left turns per signal cycle or platoon. The suggested K-values are shown in Table 2 and Figure 4. They provide a reasonable approximation of left turn blocking for most practical conditions, and they significantly simplify the computational procedures, especially for multilane approaches.

The curve shown in Figure 4 can be approximated by the formula: $K = 1 - e^{-.75\sqrt{L_1}}$. It also is interesting to note that $K \leq L_1/(L_1 + 1)$. In both formulas, L represents the left turns per cycle. The values of K increase rapidly at first and then begin to taper off in the following situations:

- When one left turn per cycle occurs, approximately 40 percent of the through vehicles in the shared left turn lane would be blocked.
- When three left turns per cycle occur, approximately 70 percent of the through vehicles in the shared left turn lane would be blocked.
- When five left turns per cycle occur, approximately 80 percent of the through vehicles in the shared left turn would be blocked.

The K-values should be applied directly to the through traffic in the shared lane, and the product should be added to the opposing through volume and left turn volume to obtain the critical lane volumes for the artery. They also should be used for the cross street; the total critical lane movements at an intersection would represent the sum of the critical artery and cross street movements.

The application of these K-values is straightforward. If there are 12 through vehicles per lane per cycle, three left turns, and eight opposing vehicles, the critical movement would be estimated as follows:

$$\text{Critical movement} = 3\ (\text{left}) + 8\ (\text{opposing}) + 12\ (\text{through}) \cdot (K)$$

Since $K = .70$, the critical movement would be 11 + 8.4 or 19.4 vehicles per cycle.

This analysis does not take into account the added time required by each left turn. Thus, if the computed critical lane flows (for the artery) are $L + V_o + K_{t1}$, L should be increased by a factor of F to account for the increased headway.

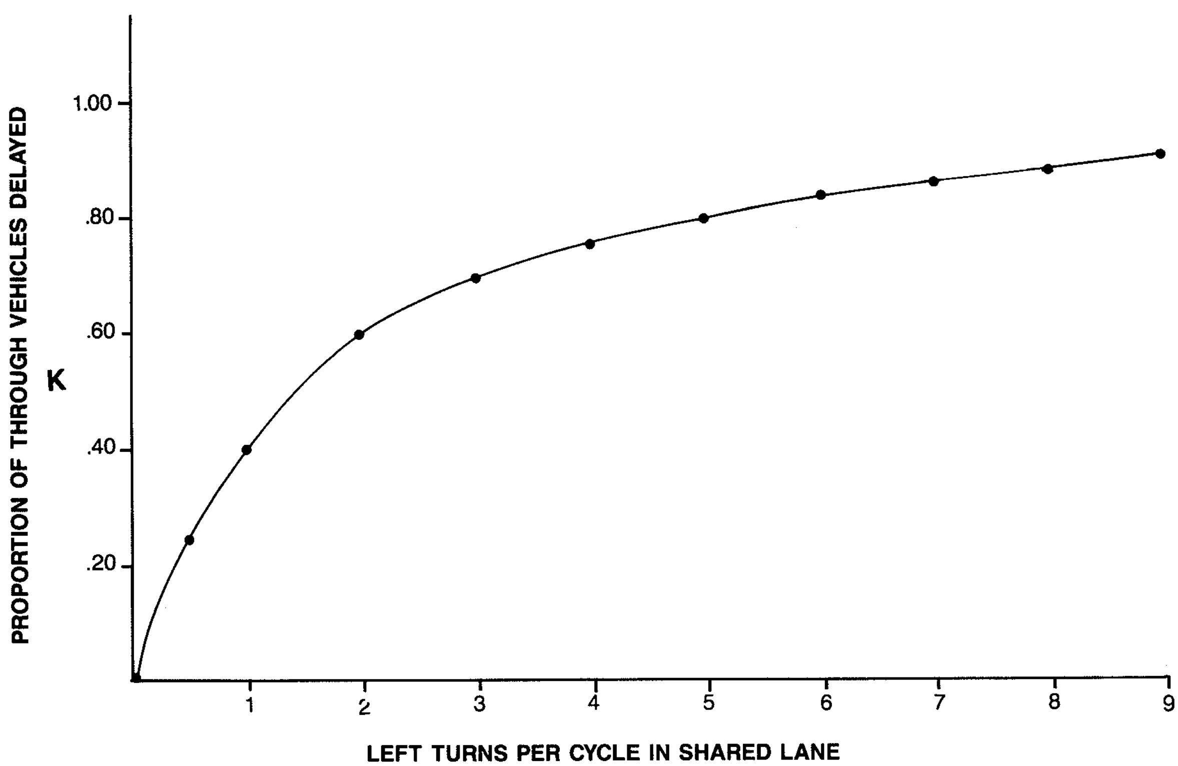


FIGURE 4 Left-turn impedance factor (K).

APPLICATIONS

The application of the impedance factor will vary depending on the specific geometric configuration of the intersection.

- On two-lane roads with left turns in each direction, the intersection of opposing left turns will reduce the blockage that otherwise would occur.
- On multilane approaches, through traffic will distribute among the lanes to minimize delays and queue lengths. This is a reasonable assumption consistent with current critical lane computational procedures.

The following sections show how critical lane volumes can be computed for the following cases:

1. Single-lane approach
   - Left turns in one direction only
   - Left turns in both directions
2. Two-lane approach
   - Left turns in one direction only
   - Left turns in both directions
3. Multilane approach
   - Left turns in one direction only

Single-Lane Approach—Left Turns in One Direction Only

The analysis for a single-lane approach with left turns in one direction only along a two-lane artery is straightforward. It involves the following steps:

1. Develop flow rates.
2. Obtain the vehicles per cycle on each approach.
3. Determine and apply K-values and obtain critical lane volumes per cycle.
4. Translate results into vehicles per hour.

Another way to estimate critical lane volumes is to work directly in vehicles per hour. In this case, the K factors are obtained by estimating the left turns per cycle on each approach. These then can be applied directly to the hourly flow rates.

Figure 5 shows how the critical lane movements can be obtained for a shared two-lane artery, with left turns in one direction only (Example 1).

Single-Lane Approach—Left Turns in Both Directions

Computations of critical conflict volumes must take into account the nullifying effect of the opposing left turns. This leads to considering only the opposing through movement in the critical lane analysis. Figure 6 gives the various formulas that should be tested—three for each approach. Illustrative examples are shown in Figure 7 (Example 2).

Two-Lane Approaches—Left Turns in Both Directions

Critical lane computations based on the K factor are more complex for two-lane and multilane approaches. They call for assumptions regarding the distribution of through traffic to each lane on any given approach. This can be done by judgment or by formula (Figure 8).

It is reasonable to assume that traffic approaching an intersection will equalize, that is, each lane on any given approach would have a queue of approximately the same length. Using this criteria, manual simulation analyses were performed for

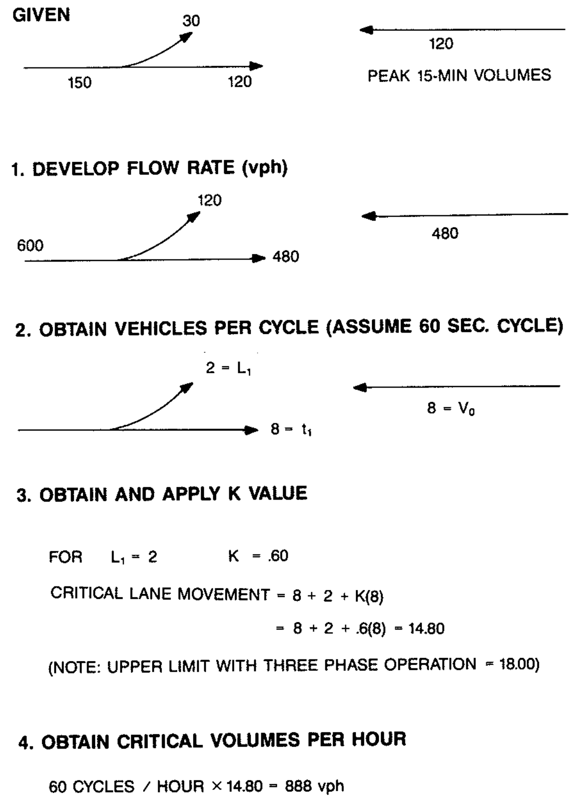
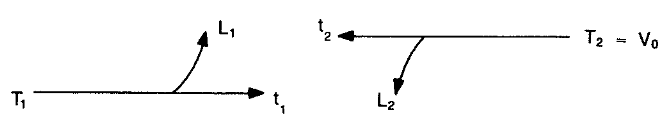


FIGURE 5 Example 1—single-lane approach.



CRITICAL LANE VOLUMES - EASTBOUND

(1) $L_1 + t_1$ .... V_0 is very light or zero

(2) $L_1 + K_1t_1 + t_2$ .... $L_1 > L_2$

(3) $L_2 + K_1t_1 + t_2$ .... $L_2 > L_1$

CRITICAL LANE VOLUMES - WESTBOUND

(4) $L_2 + t_2$ .... T_1 is very light or zero

(5) $L_2 + K_2t_2 \quad t_1$ .... $L_2 > L_1$

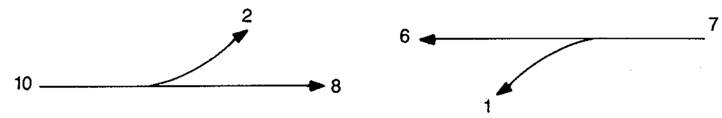
(6) $L_1 + K_2t_2 \quad t_1$ .... $L_1 > L_2$

UPPER LIMIT - "3 PHASE OPERATION"

(7) $L_1 + t_1 + L_2 + t_2 = T_1 + T_2$

FIGURE 6 Critical lane volumes—shared lanes with left turns in both directions, two-lane roads.

(A)



EASTBOUND

(1) $L_1 + t_1 = 10$

(2) $\boxed{L_1 + K_1t_1 + t_2 = 2 + .6(8) + 6 = 12.8}$ ← $(L_1 > L_2)$ CRITICAL

(3) $L_2 + K_1t_1 + t_2 = 1 + .6(8) + 6 = 11.8$

WESTBOUND

(4) $L_2 + t_2 = 7$

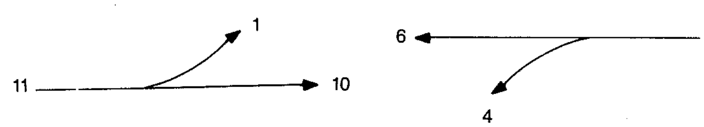
(5) $L_2 + K_2t_2 + t_1 = 1 + .4(6) + 8 = 11.4$

(6) $L_1 + K_2t_2 + t_1 = 2 + .4(6) + 8 = 12.4$ ← $L_1 > L_2$

UPPER LIMIT

(7) $L_1 + t_1 + L_2 + t_2 = 17$

(B)



EASTBOUND

(1) $L_1 + t_1 = 11$

(2) $L_1 + K_1t_1 + t_2 = 1 + .4(10) + 6 = 11$ $\quad L_1 < L_2$

(3) $L_2 + K_1t_1 + t_2 = 4 + .4(10) + 6 = 14$

WESTBOUND

(1) $L_2 + t_2 = 10$

(2) $\boxed{L_2 + K_2t_2 + t_1 = 4 + .75(6) + 10 = 18.5 \quad L_2 > L_1}$

(3) $L_1 + t_1 + K_2t_2 = 1 + 10 + .75(6) = 15.5$

UPPER LIMIT - 3 PHASE OPERATION

$11 + 10 = 21$

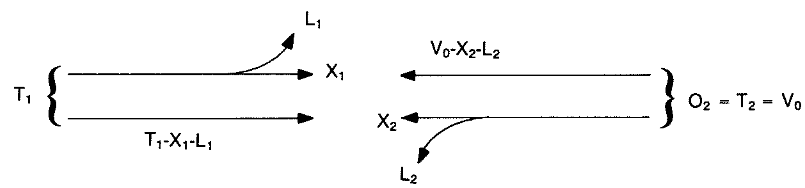
FIGURE 7 Example 2—single shared lanes, left turns on both approaches.

various distributions of through and turning vehicles for each approach on a four-lane arterial with left turns in both directions. The results of this simulation, shown in Table 3, provide a basis for the guidelines that follow.

In practice, the following steps will prove useful in dealing with two-lane approaches when left turns occur from each approach:

1. Divide the volumes on each approach equally by lane.
2. Compute the critical lane volumes on each approach based on the assumed lane distribution. The computations are as follows: Left turns + opposing through traffic in the shared lane (or + the opposing outside lane volume) + K (same direction through traffic in the shared lane). This will yield a critical conflict volume for each of the two approaches.
3. Select appropriate critical lane volumes based on the following criteria:

Case 1: Equal volumes on both approaches (including equal left turns)	Use critical lane volume for either approach
Case 2: Unequal through volumes but equal left turns on both approaches Case 3: Heavy total volumes and heavy left turns on one approach	Use heavier critical lane volume
Case 4: Equal total volumes on both approaches with unequal left turns Case 5: Light total volumes with heavy left turns on both approaches	Use average critical lane volume for both approaches



K_1 = IMPEDANCE FACTOR FOR L_1
K_2 = IMPEDANCE FACTOR FOR L_2

'EQILIBRIUM SOLUTION'

$$\underbrace{L_1}_{\text{(LEFT TURN)}_1} + \underbrace{V_0 - X_2 - L_2}_{\text{OPPOSING}} + \underbrace{K_1 X_1}_{\text{DELAYED THROUGH}} = L_2 + (T_1 - X_1 - L_1) + K_2 X_2 \quad (1)$$

SOLVING FOR X_2

$$X_2 = \frac{2(L_1 - L_2) + (V_0 - T_1) + X_1(1 + K_1)}{1 + K_2}$$

CONSTRAINT - $\boxed{X_2 \geqq 0}$

IF $T_1 \geqq T_2$, IT CAN BE SHOWN EXPERIMENTALLY

THAT $X_1 = \frac{T_1}{2} - L_1$. THIS MAKES IT POSSIBLE TO SOLVE FOR X_2.

FIGURE 8 General formula—two-lane approach with left turns.

Figure 9 illustrates critical lane computations for two-lane approaches with shared left turn lanes (Example 3). Critical movements are also computed based on a signal operation that has each direction move on a separate phase; this represents the worst case or upper limit of the critical lane movement.

This example represents a Case 3 condition. The critical lane volume of 990 vph compares with a worst case condition of 1,080 vph.

Multilane Approaches—Left Turns from One Direction Only

These cases can be solved directly by formula assuming equal queues in each lane on the multiple lane approach (Figure 10). Formulas are given in Table 4 for estimating the through vehicles in the shared lane. The through vehicles in the other lanes can be computed; these flows will equal the critical lane volume. Figure 11 illustrates this procedure (Example 4).

CONCLUSIONS AND EXTENSION

This paper analyzes the impact of left turns on through traffic where they share a common lane. It applies an impedance or blockage factor to estimate the proportion of through vehicles that would be delayed and, therefore, must be considered in the critical lane computations. In this respect it represents a logical extension of earlier capacity analysis, and it is consistent with ongoing approaches.

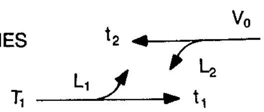
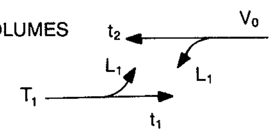
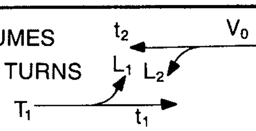
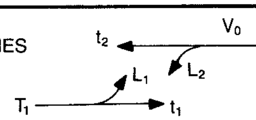
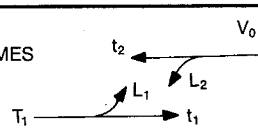
The left turn blockage factor (*K* factor) eliminates the need for left turn equivalent factors. In other respects, the procedures are generally similar to the critical lane computational procedures set forth in the 1985 *Highway Capacity Manual*. Right turns, for example, might be excluded from critical movement analyses under certain geometric conditions.

Several findings are significant: (a) Left turns in a shared lane block through vehicles in that lane; (b) When there are more than five or six left turns per cycle, for all practical purposes, they pre-empt the shared lane; and (e) Short traffic signal cycles are desirable where shared left turn lanes predominate.

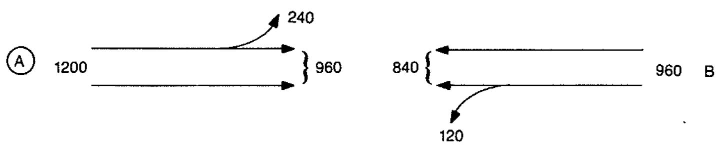
The left turn impedance or blockage factor, *K*, provides an important input into deriving an intersection capacity formula that directly reflects the capacity losses due to blocked vehicles. Such a formula has been developed including an approximation for practical application.

The impedance factors are based on probability and simulation analysis. They can be modified based on local experience or field tests without invalidating the methods. Additional field studies are desirable to verify the analyses and to adjust them as needed. Further refinements for right turns and for advance or trailing greens also are desirable.

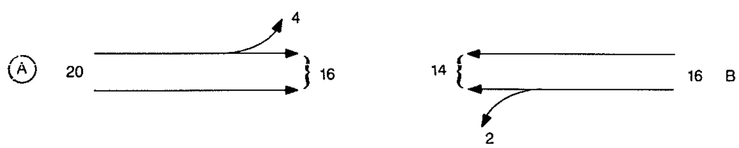
TABLE 3 GUIDELINES FOR ALLOCATING THROUGH TRAFFIC TO SHARED LEFT-TURN LANE—TWO-LANE APPROACH

CASE 1	EQUAL VOLUMES EQUAL LEFT TURNS		1. DIVIDE APPROACH VOLUMES EQUALLY BY LANE 2. COMPUTE CRITICAL VOLUME ON EACH APPROACH
CASE 2	UNEQUAL VOLUMES EQUAL LEFT TURNS	 $t_2 < t_1$	1. DIVIDE APPROACH VOLUMES EQUALLY BY LANE 2. COMPUTE CRITICAL VOLUMES ON EACH APPROACH 3. USE HEAVIER VALUE (1-5% OVERSTATEMENT)
CASE 3	HEAVY VOLUMES HEAVY LEFT TURNS	 $L_1 > L_2$ $T_1 > V_0$	1. DIVIDE APROACH VOLUMES EQUALLY BY LANE 2. COMPUTE CRITICAL VOLUMES ON EACH APPROACH 3. USE HEAVIER VALUE (1-3% OVERSTATEMENT)
CASE 4	EQUAL VOLUMES UNEQUAL LEFT TURNS	 $T_1 = V_0$ $L_1 < L_2$	1. DIVIDE APPROACH VOLUMES EQUALLY BY LANE 2. COMPUTE CRITICAL VOLUMES ON EACH APPROACH 3. USE AVERAGE VALUE (1-2% UNDERSTATEMENT)
CASE 5	LIGHT VOLUMES HEAVY LEFT TURNS	 $T_1 > V_0$ $L_1 < L_2$	1. DIVIDE APPROACH VOLUMES EQUALLY BY LANE 2. COMPUTE CRITICAL VOLUME ON EACH APPROACH 3. USE AVERAGE VALUE (2-5% UNDERSTATEMENT) NOTE: IN SOME CASES HEAVY LT WILL PRE-EMPT 1 LANE

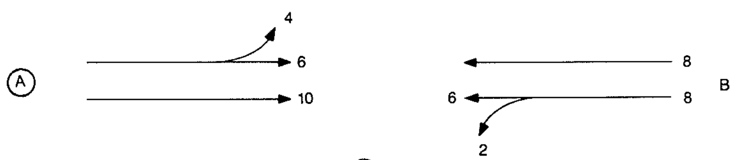
1. HOURLY FLOW RATES



2. VEHICLES PER CYCLE: 60-SEC CYCLE



3. CRITICAL LANE VOLUMES - EQUAL LANE USE



K

A $4 + 8 + .75(6) = 16.5$

B $2 + 10 + .60(6) = 15.6$

4. SELECT CRITICAL LANE VALUE TO BE USED: SINCE BOTH LEFT TURNS AND TOTAL TRAFFIC IS HEAVIEST ON APPROACH A, THIS IS CASE 3 THEREFORE USE HEAVIEST VOLUMES , 16.5

5. COMPUTE HOURLY VOLUME

$16.5 \times 60 = 990$ vph

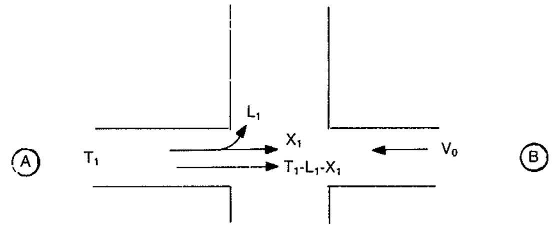
6. CHECK "WORST CASE"

THIS ASSUMES THAT EACH DIRECTION OPERATES ON A SEPARATE PHASE:

$$\frac{20}{2} + \frac{16}{2} = 18.0/\text{CYCLE}$$

$$18.0 \times 60 = 1080/\text{HOUR}$$

FIGURE 9 Example 3—two-lane approach.



LET:

T_1 = TOTAL TRAFFIC (ON APPROACH A)

L_1 = LEFT TURNS (ON APPROACH A)

X_1 = THROUGH VEHICLES IN SHARED LANE (APPROACH A)

V_0 = OPPOSING VOLUME (APPROACH B)

K_1 = LEFT TURN IMPEDANCE FACTOR

CONSIDERING THE TWO LANE CASE:

THE CRITICAL LANE VOLUME IS EITHER

$$T_1\text{-}L_1\text{-}X_1 \quad (1)$$

OR

$$L_1 + \frac{V_0}{2} + K_1X_1 \quad (2)$$

FOR THE ASSUPTION OF EQUAL QUEUES, THESE VALUES ARE SET EQUAL

i.e. $T_1\text{-}L_1\text{-}X_1 = L_1 + \frac{V_0}{2} + K_1X_1$

SOLVING FOR X_1, THIS YIELDS

$$X_1 = \frac{T_1\text{-}2L_1\text{-}\frac{V_0}{2}}{1 + K_1}$$

PROVIDED THAT $X_1 \geqq 0$

IN THE THREE LANE CASE:

$$\frac{T_1\text{-}L_1\text{-}X_1}{2} \text{ IS SET EQUAL TO}$$

$$L_1 + \frac{V_0}{3} + K_1X_1$$

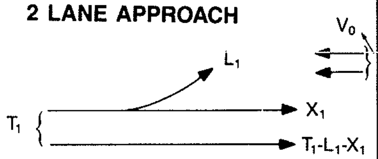
WHERE THERE ARE n_1 LANES ON APPROACH A, AND n_2 LANES ON APPROACH B,

$$\frac{T_1\text{-}L_1\text{-}X_1}{n\text{-}1} \text{ IS SET EQUAL TO } L_1 + \frac{V_0}{n_2} + K_1X_1$$

FIGURE 10 Derivation of formulas for shared left-turn lanes on multilane approach with left turns in only one direction.

TABLE 4 FORMULAS FOR MULTILANE ROADS (APPROACHES) WITH LEFT TURNS FROM ONE APPROACH ONLY—LANE DISTRIBUTION

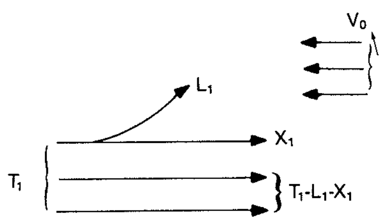
2 LANE APPROACH



$$X_1 = \frac{T_1 - 2L_1 - V_0/2}{1 + K_1} \qquad \text{(A)}$$

$$X_1 \geqq 0$$

3 LANE APPROACH

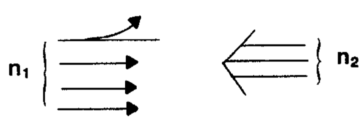


$$X_1 = \frac{T_1 - 3L_1 - 2V_0/3}{1 + 2K_1} \qquad \text{(B)}$$

$$X_1 \geqq 0$$

MULTI-LANE APPROACH

GENERAL FORMULA



$$X_1 = \frac{T_1 - n_1 L_1 - \frac{n_1 - 1}{n_2} V_0}{1 + (n_1 - 1)K_1} \qquad \text{(C)}$$

$$X_1 \geqq 0$$

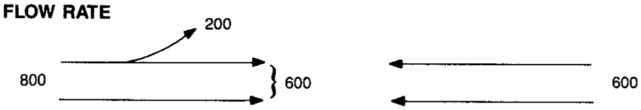
n_1 = NO. OF LANES ON APPROACH 1

n_2 = NO. OF LANES ON APPROACH 2

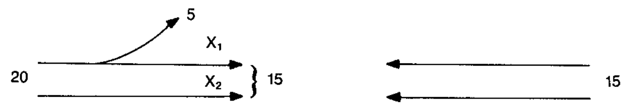
K_1 = LEFT TURN IMPEDANCE FACTOR (DIRECTION 1)

TWO LANE APPROACH
LEFT TURNS FROM ONE DIRECTION ONLY

1. FLOW RATE



2. VEHICLES PER CYCLE - 90" CYCLE (40 CYCLES / HOUR)



3. COMPUTE X_1

$$X_1 = \frac{T_1 - 2L_1 - \frac{V_o}{2}}{1 + K}$$

$K = 0.80$

$$X_1 = \frac{20 - 2(5) - \frac{15}{2}}{1 + 0.80} = \frac{2.5}{1.8} = 1.4$$

$X_2 = 15.0 - 1.4 = 13.6$

$13.6 \times 40 = 544$

544 IS CRITICAL LANE VOLUME

NOTE: (CHECK) $5 + \frac{15}{2} + .80(1.4) = 13.6$

$13.6 \times 40 = 544 =$ CRITICAL LANE VOLUME

FIGURE 11 Example 4—two-lane approach, left turns from one direction only.

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