APPENDIX N

ANNE ARUNDEL COUNTY

DEPARTMENT OF PUBLIC WORKS

Traffic Engineering Division

GUIDELINES FOR TRAFFIC IMPACT STUDIES

1. When is a traffic impact study required?

   - At final stage for any major subdivision.
   - At building permit stage for planned commercial complexes.
   - With any application for rezoning.
   - At formal development plan stage for any development (major or minor subdivision, building permit, planned commercial complex) within either the Odenton or Parole Town Center Growth Management Areas.
   - Before the hearing date for certain Special Exceptions (see Question 12).

2. What roads and intersections must be studied?

   - In Town Center Growth Management Areas:
     - Intersections from the site access(es) out to and including the intersection with the first arterial, major highway, or State roadway in each direction.
     - Key intersections as identified by the County during the informal concept plan review.
   - Elsewhere in the County:
     - Existing roads from the site out to and including the intersection with the first arterial, major highway, or State roadway in each direction.
     - Each of the first arterials, major highways, or State roadways in each direction to and including the intersection with the next arterial, major highway, or State roadway (in both directions).
     - Any intervening intersections designated by the County.
   - Notes:
     - If a site enters directly onto an arterial, major highway, or State roadway, that road qualifies as the first arterial, major highway, or state highway. Note that if

there is also an entrance onto a local or collector roadway, the analysis of that entrance route is as above.

- Analyses need not be carried past the County's exterior boundary or into the City of Annapolis (except on County maintained roadways, such as Forest Drive).

- Arterial roadways built within a subdivision will be considered as internal subdivision streets, not as the first arterial to be studied.

- A continuous arterial route consisting of more than one road name (New Cut Road to Gambrills Road, for example) shall be considered as one arterial if so shown on the County's road network and classification plan.

- At the request of the developer (with justification submitted by the developer), PACE may reduce or eliminate roadways from the study based on minimal impact or excessive distance. Distance is considered relative to the impact (size) of the development. PACE will not eliminate the Traffic Impact Study requirement for any development parcel expected to generate 100 or more trips per day.

  In the Odenton and Parole Town Center Areas, the County may relieve the developer of the need to conduct a formal traffic study where it can be demonstrated that the proposed development will have a minimal impact on roadways. PACE will not eliminate the need to conduct a traffic study for any development expected to generate 100 or more trips per day.

3. What traffic must be included in the study?

   - For developments within Town Center Growth Management Areas:

     - Existing Traffic;

     - Traffic to be generated within the Town Center Growth Management Area as a result of:

       a. Building permits that have been issued and are expected to generate more than 250 vehicle trips per day;

       b. Pending building permits expected to generate more than 250 vehicle trips per day that have had a Traffic Impact Analysis approved by PACE; and

       c. Approved Subdivisions.

     - Traffic to be generated outside the Town Center Growth Management Area that will impact intersections that are required to be studied and that is the result of:

       a. The issuance of all building permits expected to generate more than 250 vehicle trips per day; and

b. Approved Subdivisions; and

- Traffic projected to be generated from the proposed development.

- For developments elsewhere in the County:

  - Existing traffic volumes.

  - Traffic projected to be generated from building permits which will generate more than 250 trips per day.

  - Traffic projected to be generated from subdivisions for which final plats have been approved.

  - Traffic projected to be generated from subdivisions for which sketch plans have been approved.

  - Traffic projected to be generated from the proposed development. Studies for rezoning cases must consider the maximum trip generation possible for the proposed rezoning, regardless of any suggested development plan. Studies for industrial/business parks must consider the maximum trip generation allowed based on buildable acres within the park.

    Alternately, studies can determine an acceptable mix of uses. The design professional will be required to submit backup data to support any assumptions. Field surveys of existing developments in the area and information as to business types from the Permit Application Center will be required to support these assumptions. Once DPW has this information, they will meet with PACE to determine if these assumptions are acceptable.

    While all the preceding traffic must be included in the study, the determination of the need for road improvement will not include traffic projected to be generated from subdivisions for which only sketch plans have been approved. This may require analyses of several alternate scenarios assuming nearby sketch subdivisions proceed before or after the proposed development.

- Traffic from other proposed developments must be considered if it can reasonably be expected to impact the roads and intersections under study. At a minimum, this will include all other developments whose traffic impact study area would overlap or abut the proposed development's traffic impact study area. It may also include other development farther away.

4. How should the study be organized and presented?

- In an organized, logical, and neat fashion.

- With the project name and number clearly identified on the cover.

- With all assumptions clearly stated and documented.
- With all backup material provided.
- Required form:
  - Description of existing conditions, roads, and traffic volumes
  - Location map
  - Description of proposed development: scope, size, type of development, schematic map
  - Other nearby developments
  - Traffic generated by other development (amount, distribution, splits)
  - Traffic generated by proposed development (amount, distribution, splits)
  - Total traffic volumes (Note: It is helpful to provide a series of maps/diagrams showing (a) Existing traffic, (b) Other development traffic, (c) Total background (a+b) traffic, (d) Site traffic, (e) Total (c+d) traffic for both AM and PM peaks).
  - Required analyses:

    a. "Simplified" critical lane analysis (per McInerney/Petersen article) of all intersections (see also Question 2, "What roads and intersection must be studied?").

    b. Highway Capacity Manual (HCM) intersection analysis for any intersection with a total critical volume (see paragraph a. above) of 1300 or more.

    c. Signalization studies for intersections designated by the County. Such studies shall compare projected traffic volumes to signalization warrants contained in the Manual on Uniform Traffic Control Devices (MUTCD).

    For developments not within a Town Center Growth Management Area, the following analyses will also be undertaken:

    d. HCM capacity analysis for all roadway segments (must use HCM worksheets or FHWA software).

    e. AA County Road Rating analysis for all roadway segments.

  - Analyses will normally be required for morning and evening peak hours (based on the adjacent roadway peak). Where the development's peak occurs

at significantly different times than the adjacent roadways, other analyses may be required (midday, weekend, etc.).

- Description of improvements required to bring roads/intersections up to applicable standards (Note: Study may assume all State or County projects with 30% construction funding appropriated, not programmed - and all private developer projects covered by a PWA as being in place. However, the study must address the capability of these improvements to carry projected traffic.)

- Acceptable assumptions

  - The County will generally accept trip generation rates found in the latest edition of the Institute of Transportation Engineers' (ITE) Trip Generation Report. This report provides three methods to determine average trip generation for proposed developments: a weighted trip generation rate, a plot of actual trip ends versus an independent variable, and a regression equation.

    Design professionals will be required to use whichever method provides the best fit for the data. For example, if the regression equation for a particular use has a high correlation factor and the averaged trip rate for that use has a large standard deviation, the regression equation should be used. This will require a careful analysis of data for each use. Again, the design professional should determine which method provides the best fit for the type and size of the proposed development. Questions of interpretation should be directed to PACE, which will make the final determination of what method will be used.

  - Other sources for trip generation rates will be considered if sufficient documentation is provided. This will generally apply only to uses not covered by the ITE report.

  - Trip distributions for new traffic should be based on the proximity of trip generators and attractions and on existing travel patterns.

  - Existing traffic volumes should be based on current count information. Three to seven day machine counts should be used to determine daily and peak volumes along roadway segments, and peak hour turning movement counts should be used to determine peak intersection volumes. Counts from one to three years old must be increased by 4% per year. Counts older than three years may not be used (see also Question 11, "What information is available to assist in the preparation of a traffic impact study?").

  - Where peak hour counts are not available, the County will consider the use of an assumption that the peak volume equals 15% of the average daily traffic volume.

  - Peak hour counts should generally not be used to determine average daily traffic. In unusual cases, the County will consider the use of an assumption that the ADT equals 20 times the peak hour volume.

- The County will allow the assumption of intercepted pass-by trips for certain retail and service uses. General guidelines include:

    - Service Stations - up to 60% interception

    - Convenience stores - up to 60% interception

    - Retail (less than 100,000 s.f.) - up-to 50% interception

    - Retail (over 100,000 s.f.) - up to 25% interception

    These guidelines may be altered (by the County) for specific sites. If intercepted pass-by trips are assumed, care must be taken to properly route all trips through all affected intersections and roadways.

    Please note that the County will allow consideration only of intercepted pass-by trips; that is, trips that would already be on the adjacent roadway(s). Trips that would be diverted from other roadways must be considered as new trips.

5. What standards will apply?

    - Intersections must operate at Level of Service (LOS) D or better as determined by the critical lane method (critical lane volume of 1450 or less). Intersections with a total "simplified" critical lane volume of more than 1300 must also be analyzed using the 1994 HCM. This analysis is to determine if any approaches have individual unacceptable levels of service (E or F). If an approach does fail, the study must address what the development's impact is and what actions are required to improve the service level to D or better. PACE will review these analyses and make a recommendation regarding what improvements, if any, should be required of the developer.

    With the approval of PACE, intersections in the core of the Parole Town Center Growth Management Area may operate with a critical lane volume of less than 1600.

    - For developments not within a Town Center Growth Management Area, the following standards will also apply:

        - Roadway segments must operate at LOS D or better as determined by the 1994 HCM.

        - Roadway segments must have a County Road Rating system score of 70 or greater.

6. What if standards are not met?

    - For developments within a Town Center Growth Management Area:

- If the traffic generated to or from a site fails to meet the standards, a site may not be developed unless an applicant agrees to make improvements to each substandard intersection that bring the intersection's critical lane movements to an acceptable level or undertakes one or more of the actions listed below in the following order of preference, as directed by PACE:

    a. Construction of one or more roads that will have a positive effect on the substandard intersection and will bring the intersection's critical lane movements to an acceptable level;
    b. Contributions to a County Capital Project for road improvements and construction in the Town Center Growth Management Area;
    c. A significant Capital Improvement that will improve the County's ability to provide public transportation in the Town Center Growth Management Area; or
    d. An acceptable paratransit operation or ride-sharing program to mitigate traffic impact.

- For developments elsewhere in the County:

    - In most cases, failure to meet standards will result in a recommendation against the proposed development unless:

        a. The developer agrees to make those improvements necessary to meet standards, or

        b. A waiver to meeting Adequate Public Facilities (APF) standards is requested and granted through PACE.

    - In those cases where a roadway segment or intersection is failing due to regional traffic, the developer will only be required to provide improvements sufficient to offset the proposed development's impact. At intersections, this mitigation will be measured in terms of critical lane volumes. Along roadway segments, actual per lane volumes will be measured. Mitigation will be measured assuming background traffic including existing traffic and traffic from all subdivisions with final approval and traffic from approved major building permits. (Note: The waiver process is also available in this case.)

7. What is regional traffic?

    - Traffic will be considered to be "primarily attributable to regional development and traffic patterns" only if the developer shows that all of the following conditions are met:

        a. The roadway (or one roadway at an intersection) is a County arterial or State highway, and

        b. At least 70% of the peak hour traffic volumes are not bound to or from sites in the near (within three miles) vicinity, and

c. The roadway, or connecting County arterial or State highways, continue for at least five miles in each direction.

8. When will PACE support a waiver of APF requirements?

- PACE will support waiver requests only if one or both of the following conditions is met:

  a. PACE (and State Highway Administration, if applicable) believe the required numerical analyses do not accurately reflect operating conditions based on their field observations and professional judgment. It is anticipated that this condition will be met only in very rare instances.

  b. The improvements proposed by the developer will result in overall improvement in traffic operations even if some locations still fall short of standards. This will normally involve the provision of some improvements not required to meet standards in return for waiving of other improvements, which would be required. Examples might include providing 4-foot wide shoulders along an entire roadway instead of 8-foot shoulders in only one section, or elimination of a reverse curve with adverse cross-slopes instead of widening an entire roadway from 22 to 24 feet.

- In order for a waiver to be considered, the developer must address the following questions:

  1) What are the existing conditions?

  2) What improvements are required to meet standards (include cost estimate)?

  3) What, if any, improvements are proposed (include cost estimate)?

  4) What level of service will result?

- PACE is specifically prohibited from supporting waivers solely on the grounds of economic hardship.

9. When should the traffic impact study be submitted?

- For developments within a Town Center Growth Management Area, the traffic impact study must be submitted with the formal development plan submittal.

- For subdivisions outside of Town Center Growth Management Areas, the traffic impact study must be submitted with the final review submittal. PACE will not accept a final submittal that does not include a traffic impact study. The developer may submit the traffic impact study earlier, if desired, to identify any problem that need to be addressed. Early submittals may be made with the sketch submittal or directly to the Traffic

- Engineering Division (with a copy of the cover letter to PACE). Traffic Engineering will review and comment on early submittals, but will withhold approval of the traffic impact study until final stage in case changes occur.

- For planned commercial complexes outside of Town Center Growth Management Areas, the traffic impact study must be submitted not later than building permit submittal. In order to avoid problems and delays, it is preferable to submit the study directly to PACE before the building permit application is submitted. PACE will review and comment on the study, but withhold approval until the building permit application is reviewed. A copy of the study should be resubmitted with the permit application.

- For rezoning cases, the traffic impact study should be submitted as early as possible—preferably with the application. In any event, the study must be submitted four weeks in advance of the hearing date to assure adequate time for review, comments, and revisions.

10. For developments outside of Town Center Growth Management Areas, what is required at sketch stage?

    - At sketch stage, the developer must submit an estimate of the trips to be generated by the subdivision and a list of roadways and intersections to be studied. PACE will review and comment on the acceptability of this information. The developer is required to also submit a list of other nearby developments to be included in the study. This will help assure that the final study is not done without including required developments.

    - The submission of a full traffic impact study at sketch stage will satisfy these requirements.

11. What information is available to assist in the preparation of a traffic impact study?

    - Developers should contact PACE to review their subdivision activity map. This will identify other nearby subdivisions which may need to be included in the study.

    - Developers may request information from the DPW's Traffic Engineering Division. Traffic Engineering will provide copies of available turning movement and volume counts, as well as information from other approved traffic studies. If nearby developments do not yet have an approved study, the Traffic Engineering Division will supply information on anticipated traffic generation to the best of its ability. Traffic Engineering will also supply copies of Road Rating information. All requests for information from the Traffic Engineering Division should be made in writing. Every effort will be made to respond within one week. Developers and design professionals should not expect that they will be able to pick up information from the Traffic Engineering Division without advance notice.

- Inspections and Permits should be contacted for information about nearby major building permits.

12. What is required for Special Exceptions?

- Special Exceptions require (among other conditions) the recommendation of PACE and a finding that the proposed use will not conflict with an existing or proposed road (County Code, Article 28, Section 12-104). A traffic impact study may be required for particular proposed uses. In no case will the study requirements be more rigorous than those for studies required under the Adequate Facilities Ordinance. Applicants should discuss their proposed use with PACE well before the hearing date to determine what level of study is required. Any required study must be submitted at least four weeks prior to the hearing to assure that comments and recommendations are available at the hearing.

Intersection Capacity Measurement Through Critical Movement Summations: A Planning Tool

by Henry B. McInerney and Stephen G. Petersen

The critical movement technique discussed in this article, was improvised not to replace the analysis techniques in the **Highway Capacity Manual**, but to meet the need for presenting a picture to the layman of how an intersection operates without losing him in a discussion of peak-hour factors and G/C ratios. The method was valuable in examining a group of intersections to determine those most able to absorb the load from a new employment center. The evaluation of the most favorable routes from a capacity standpoint led, in turn, to the provision of routing maps to employees based on the parking lot to which they were assigned. Because the technique dissects the various turns and through movements, it is possible to quickly determine which intersection improvement will do the most for improving capacity.

Another use of the technique is to determine the increment of development which can be added as a result of each change in intersection configuration. Caution has to be exercised in this application because one is dealing in differences rather than comparing totals against a standard.

Use of the technique to date has been related principally to site planning, but two other diverse applications have been suggested. One is as an algorithm for capacity restraint traffic assignments. In a network for an urbanized area, intersections are much more likely to determine capacity than links, yet present programs state capacity as a function of link volume.

At the opposite end of the spectrum, the technique can be useful as a quick check on the level of service at the intersections in a street network and possibly even as a rough warrant for signalization. It could be applied in reverse to a congested intersection to determine if it is operating as efficiently as possible. In a large traffic operations study, early identification of potential problem areas can be done with limited data through use of this tool. This makes the data collection effort a more productive process.

The traffic engineer engaged in planning frequently must evaluate the impact on traffic of proposed changes in land use. Estimates of generated traffic distributed over a new or expanded street system often must be made without the refinements available when an existing condition is being observed. Capacities must be determined, and this generally concerns intersection capacity since, at least in urban considerations, intersection conditions usually fix the capacity of the street system. By means of what can be called a critical movement method, intersection capacities can be developed easily.

While the **Highway Capacity Manual** (1965) and **Public Roads**[1] (Nos. 9 and 10, Vol. 34, 1967) cover the procedure for making

HENRY B. McINERNEY (Junior Member, ITE) is Project Director, Airport Access Study, Department of Transportation Planning, Metropolitan Washington Council of Governments. Prior to joining COG he served as a traffic engineer with Alan M. Voorhees and Associates, McLean, Virginia. Mr. McInerney, in addition, has spent many years in the construction industry and in the service of the U.S. Army. He is a registered Professional Engineer, a member of Tau Beta Pi and Sigma Tau. He received his B.S.C.E. degree from the University of Oklahoma and a M.S. (Transportation Engineering) degree from Iowa State University.

This Traffic Engineering article results from the joint effort of the authors when Mr. McInerney was with AMV.

STEPHEN G. PETERSEN (Member, ITE) is an Associate with Alan M. Voorhees & Associates, Inc., transportation consulting firm of McLean, Virginia where he has recently been concentrating his efforts on site development studies. Prior to joining Voorhees & Associates, Mr. Petersen was with the Institute of Traffic Engineers, first as Staff Engineer and later as Executive Secretary. He holds a B.C.E. degree from Rensselaer Polytechnic Institute, a Certificate in Traffic Engineering from the Yale Bureau of Highway Traffic, and an M.C.E. degree from the Catholic University of America. He is a registered Professional Engineer and a member of the American Society of Civil Engineers.

Reprinted with permission from *Traffic Engineering*, January 1971. © 1971 Institute of Transportation Engineers, Washington, D.C. USA

capacity determinations of at-grade intersections, when dealing with future conditions overly conscientious involvement with estimates of street widths, G/C ratios, peak-hour factor adjustments, and percentages of turns and trucks is often beyond the accuracy of the base data. The critical movement method, on the other hand, provides results which are reasonably consistent with those which could be obtained through conventional capacity analysis if it were possible to count the traffic which will be using an intersection in some future year.

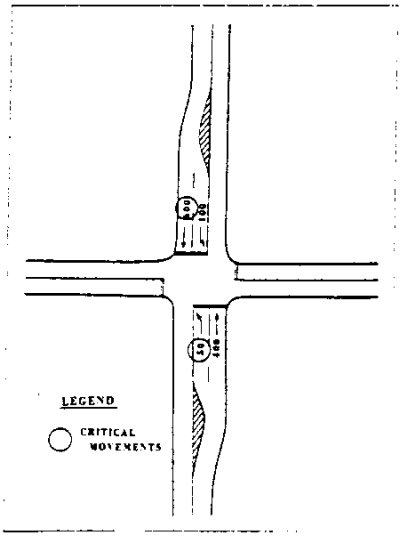
the technique

Basically, the critical movement method applies a technique similar to that used in the analysis of diamond interchanges to a simple intersection. Early works[2,3] on capacity analysis of diamond interchanges define a "critical volume" above which a diamond interchange will fail unless additional lanes are added. This "critical volume" was determined by field work to be the sum of the volumes on a per lane basis of the four extreme approaches to the two at-grade intersections, taken as a system, created by a diamond interchange.

This same technique can be used on a simple intersection. At a simple intersection, the "critical movements" are the highest total of the through plus its opposing left in one direction on an hourly per lane basis (Figure 1). This total determines the green time requirement for that direction. For example, in Figure 1, 600 + 50 is greater than 400 + 100—assuming single lane flows—and therefore establishes the portion of an hour required for the N-S movement. Similarly, in Figure 2, the total of E-W critical movements is 450.

FIGURE 1

NORTH-SOUTH CRITICAL MOVEMENTS



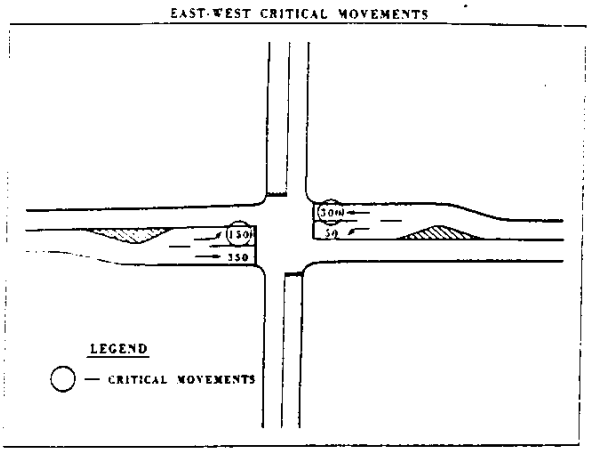
If the two directions are superimposed at an intersection, the total of the critical movements is 1,100.

The next problem is what to measure this number against. Several possibilities exist. A theoretical analysis in Matson, Smith & Hurd[4] set the maximum value of vehicles per hour passing over a given conflict point at 1,500, with 1,200 vehicles per hour set as the limit to avoid excessive cycle lengths.

A second possibility can be derived from a statement on page 126 of the **Highway Capacity Manual**: "Rarely can traffic move away (from a stop) at a rate greater than 1,500 vehicles per hour of green." If 50 percent of the traffic approaching a signal is stopped and has a departure capacity of 1,500 vehicles/hour/lane, and 50 percent is free flow at 2,000 vehicles/hour/lane, it is possible to cross 1,470 vehicles per hour over a given conflict point using a 50/50 split on the signal cycle and allocating 15 percent of the cycle to clearance intervals.

FIGURE 2

EAST-WEST CRITICAL MOVEMENTS



In addition to these, there are "rules of thumb" derived from experience. In one it is assumed each vehicle takes three seconds to clear the intersection—thus arriving at a capacity of 1,200 vehicles per hour. In another, through movements are estimated at 2.4 seconds per vehicle and turns at 3.6 seconds per vehicle. By multiplying vehicle volumes by these clearance values and comparing the total with 3,600, a measure is obtained.

The problem with these techniques is that they provide no measure against the **Highway Capacity Manual** and its "levels of service." The critical movement method, however, does.

correlating data

Data for this method were gathered at four heavily traveled intersections in the Virginia suburbs of Washington, D.C. Critical movement totals were developed for each intersection for levels of service "C" and "E" as shown below:

Intersection	Level of Service C (VPH)	Level of Service E (VPH)
I	1,225	1,475
II	1,205	1,445
III	1,185	1,455
IV	1,215	1,465

The average values for each condition are about 1,200 for level of service "C" and about 1,460 for level "E." In other words, if the volumes at an intersection are tabulated according to the rules set forth below, and the total of conflicting movements is around 1,200, it is reasonably safe to assume that the operation is at a "C" level of service or "design" capacity as defined by the American Association of State Highway Officials. If the total is in the 1,450 to 1,500 range, "E" level of service or "possible" capacity conditions can be expected. Between these two points, a value of 1,350 is a good indication of a "D" level of service. Over 1,500 there is little question of severe congestion and breakdown conditions.

Exclusive pedestrian phases, though, are one area for caution. These values are based on a full hour of movement through the

intersection, assuming ambers are part of green time. A pedestrian phase reduces movement time available for vehicles, and the standard values should be reduced by an amount equal to the percentage the pedestrian phase is of the total cycle. The same is true for an all red phase in the signal cycle.

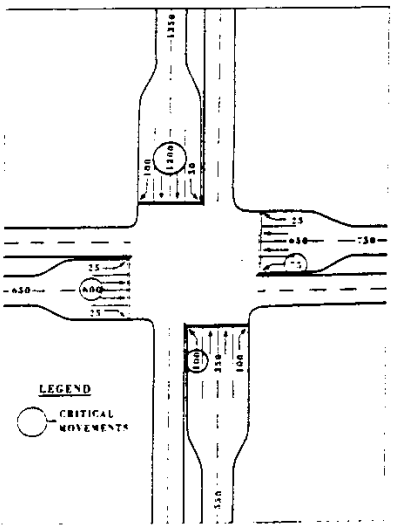
general rules of procedure

The engineer must know two things in order to proceed with a capacity analysis using this method: Turning volumes at the intersection under study and the number of lanes on each approach. Most important are the values for each critical movement, since these will give a good approximation of the level of service which can be expected with the given volumes and intersection configuration, assuming the signal controller and phasing will be efficient and result in minimum delay to all movements. It is best, in fact, not to think in terms of a specific signal phasing during the critical movement analysis, because it tends to restrict thinking about all the combinations of possible movements which will lead to a critical movement total. There is also no need to consider amber time since it is usually used to clear left turns. General rules for selecting conflicts, based on the sample volumes and intersection configurations in Figure 3, follow:

For north-south flow, (1) determine the volumes of through traffic (1,200 and 350 in this case); (2) compute the volume per lane for the through movement (600 and 175 for the two lane approaches shown); (3) determine opposite direction left turn volumes (100 and 50); and (4) add the through volume per lane and its opposing left turn (600 + 100 = 700, 175 + 50 = 225). The critical movements are the two which produce the largest sum —in this case, the southbound through and northbound left.

For east-west flow, the same procedure is followed. For Figure 3, volumes of through traffic are 600 and 650; volume per lane for through movement of the two approaches shown is 300 and 325; opposite direction left turn volumes are 75 and 25. The sum of the through volume per lane and its opposing left turn are 300 + 75 = 375 and 325 + 25 = 350. Therefore, the critical movements are the eastbound through and westbound left.

FIGURE 3
EXAMPLE OF CRITICAL MOVEMENTS



For the intersection, add the north-south and east-west critical movements (700 + 375 = 1,075), and compare with the standards for level of service. Since 1,075 is less than 1,200, the intersection in Figure 3 is operating at approximately level of service "B."

rules of procedure: other configurations

Intersections with turn lanes are the easiest to analyze by the critical movement technique, but other configurations also can be evaluated. Where the turn volumes are as light as those shown in Figure 3, and there are no turn lanes, the total approach volume is used. For example, if Figure 3 were a simple intersection of two 4-lane roads, the analysis would be as follows:

	N-S Flow		E-W Flow	
(1) Approach Volumes	1350	550	650	750
(2) Divide by Number of Lanes (2)	675	275	325	375
(3) Opposing Lefts	100	50	75	25
(4) Totals (2 + 3)	775	325	400	400
(5) Critical Movements (Larger value on line 4)	775		400	
(6) Intersection Total (sum of 5)	1175			
Level of Service	1175 < 1200; approximately "C"			

Another complication occurs when there are heavy left turns on multi-lane approaches without turn lanes. If one left is heavy enough to be considered a lane by itself, while the opposing left is light, the sum of critical movements is computed as described under the general rules except the approach with the heavy left is considered on a lane basis rather than dividing the total approach volume by the number of lanes. For example:

	East (2 lanes)	West (2 lanes)
L—	230	35
T—	365	235
R—	20	40
Total	615	310

Even though the left turn volume on the east approach is less than the through plus right, it is assumed that only lefts use the left lane because of the heavy through from the opposite direction. Thus, we compare

$(365 + 20) + (35) = 420$ with $\frac{310}{2} + 230 = 385$, and

select 420 as the sum of critical movements as shown.

However, if both left turns are heavy, the best method is to divide by the number of lanes and select the most critical combination:

	East (3 lanes)	West (2 lanes)
L—	200	230
R—	180	190
T—	430	360
Total	810	780

Since $\frac{810}{3} + 230 = 500$ is less than $\frac{780}{2} + 200 = 590$,

the latter is the critical movement total (see Figure 4).

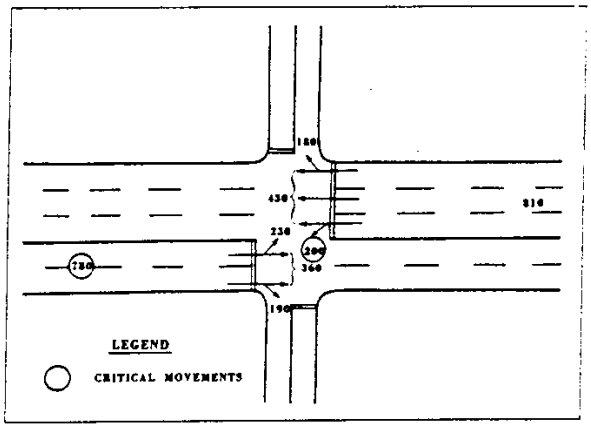
For situations where a double turn lane is needed, the 80 percent efficiency factor in the **Highway Capacity Manual** is applied. A turn volume of 360 vehicles in two lanes is divided by 1.8 and the heaviest lane volume of 200 is used in the critical movement analysis.

rules of procedure: one lane approaches

One lane approaches are the hardest to evaluate because the intersection operation becomes a function of whether or not through and right turn vehicles can "squeeze" by the left turner. On roads without curbs, the shoulder, whether paved or not, often becomes a lane. When curbs are present and only center line markings are used, streets less than 36 feet in width will usually not allow more than a single lane to pass. For planning purposes, it is rare that a single lane approach would be recommended for anything but a minor street, but there are occasions when such approaches must be evaluated and the following rules apply: For streets where the left can be bypassed, evaluate (through plus right) + (opposing left) and select the pair of flows which give the highest total as the critical movement.

FIGURE 4

EXAMPLE OF HEAVY OPPOSING LEFT TURN FLOWS



For streets where lefts cannot be bypassed, evaluate (through plus right plus left) + (opposing through plus right). Critical movements are the two flows with the highest total.

In addition, this technique can be applied to multi-legged intersections. In the case of a 3-legged intersection, right and left turns can often be phased together for more efficient utilization of the intersection and therefore a lower critical movement total. For more than 3 legs, a third set of critical movements is added to the total.

The critical movement method can be a useful tool in the traffic engineer's planning kit—one which provides results reasonably consistent with those that could be obtained through conventional capacity analysis if it were possible to measure the traffic that will be using an intersection at some future date.

A brief technical supplement describing the details of the field work used to develop the standards of comparison is available from the authors.

The authors acknowledge with appreciation the guidance provided by their AMV staff associates, particularly Dan Hoyt, a pioneer user of the critical movement technique for capacity analysis, and Steven Provost, for his review of several early drafts.

References:

[1]Journal of Highway Research, published by the U.S. Bureau of Public Roads.

[2]FREEWAY DESIGN AND OPERATIONS, HRB Bulletin 291 "Capacity Study of Signalized Diamond Interchanges," Capelle, D.G. and Pinnell, C. Highway Research Board, Washington, D.C. 1961 Pp. 1-25.

[3]FREEWAY OPERATIONS, HRB Bulletin 324, "Operational Study of Signalized Diamond Interchanges," Capelle, D.G., and Pinnell, C. Highway Research Board, Washington, D.C. 1963. Pp. 38-72.

[4]Traffic Engineering, McGraw-Hill, 1966. Pp. 336, 342.

Lane Use Factors for Traffic Impact Studies in Anne Arundel County

Number of lanes	Multiply total volumes in these lanes by:
1	1.0
2	0.55
3	0.4
4	0.3

NOTE:Exclusive turn lanes should be analyzed separately.