# A Summary of the Use of Warrants for the Installation of Left-Turn Phasing at Signalized Intersections

by Nazir Lalani, Daniel Cronin, David Hattan, and Terence Searls

Members of the Colorado/Wyoming Section of the Institute of Transportation Engineers believed that a need existed to document current techniques being used by state and local agencies to determine when a left-turn phase should be installed at signalized intersections. A technical committee (composed of the authors) was formed to investigate this subject. No financial resources were available to undertake extensive new independent research. The committee wanted to assemble information on the subject from Institute members and publicize the information collected. The committee did not assume that at the end of its deliberations a particular technique would be recommended. The committee believed that the information collected would prove useful to traffic engineers evaluating their own agency's methods or establishing a new method for their particular agency. The committee also hoped the information collected could be used for future research by a national ITE committee or by the Federal Highway Administration to establish nationally recommended techniques.

## Objectives

The objectives of the study, as identified by the committee, were to

1. Conduct a questionnaire-type survey of Institute members working for state and local agencies to determine techniques in current use by the agencies.
2. Summarize the responses from each agency as briefly and clearly as possible, and assemble comprehensive bibliographic information on this subject.
3. Draw reasonable conclusions from agency responses and other information made available to the committee.

## Survey Methodology

The committee sent 1200 questionnaires to members of the Institute of Transportation Engineers identified as working for state and local agencies. Members in the United States, Canada, Australia, Europe, Africa, the Middle East, and Asia were included. Approximately 300 questionnaires were returned. The committee did not expect 100% return as they anticipated that many questionnaire recipients worked for the same agencies. Full details of each technique and comprehensive bibliography are available in the committee's full report.[1] This study was done in conjunction with a study on the use of techniques for establishing left-turn phase change intervals.[2]

## Results of the Study

*Analysis of Agencies Currently Using Warrants/Techniques*

To determine how many agencies were currently using a warrant or technique for left-turn phasing, the questionnaire asked, "Does your agency use warrants or techniques for installation of left-turn phase?"

One-hundred and sixty four respondents said yes, 50 said no, and 4 had no response.

The committee also analyzed all the responses (regardless of whether they contained useful information) to obtain a geographical breakdown (Tables 1 & 2).

**Table 1. Number of Responses by State**

| State | Responses (No.) | State | Responses (No.) | State | Responses (No.) |
|---|---|---|---|---|---|
| Alabama | 5 | Louisiana | 8 | New York | 8 |
| Arizona | 7 | Massachusetts | 2 | Ohio | 10 |
| California | 59 | Maryland | 3 | Oklahoma | 3 |
| Colorado | 7 | Maine | 2 | Oregon | 9 |
| D.C. | 1 | Michigan | 10 | Pennsylvania | 5 |
| Florida | 19 | Minnesota | 2 | South Carolina | 3 |
| Georgia | 6 | Missouri | 4 | South Dakota | 2 |
| Iowa | 3 | Mississippi | 2 | Tennessee | 9 |
| Idaho | 3 | North Carolina | 4 | Texas | 11 |
| Illinois | 7 | North Dakota | 2 | Utah | 3 |
| Indiana | 1 | Nebraska | 3 | Virginia | 5 |
| Kansas | 1 | New Jersey | 10 | Vermont | 1 |
| Kentucky | 2 | Nevada | 3 | Washington | 18 |
| | | | | Wyoming | 2 |

*Summary of Current Warrants*

To determine details of warrants or techniques in current use by agencies that determine when installation of left-turn phasing was justified at a signalized intersection, the question was asked, "If you use left-turn phase warrants, are they based on delay, accidents, turning movement volume, or other?"

The responses to these questions are summarized in Table 3. Engineers interested in the detailed responses should refer to the full report.[1]

*Opinions on a National Technique*

One of the questions on the survey form asked, "Do you feel that a nationally accepted warrant for left-turn phases should be provided by ITE or the *Manual on Uniform Traffic Control Devices*?"

One-hundred and thirty-seven respondents were in favor of establishing a national warrant; 38 were against the establishment of a national warrant. Forty-three respondents were in favor of guidelines with provisions for variations in local conditions, engineering judgment, coordination systems, rural conditions, buses, and trucks.

**Table 2. Foreign Responses**

| *Country* | *Responses* |
|---|---|
| Canada | 14 |
| China | 1 |
| South Africa | 2 |

## Recommendations

The committee recommended that the findings summarized in the report be used by the Institute of Transportation Engineers and the National Committee on Uniform Traffic Control Devices for establishing nationally recommended techniques to determine when left-turn phasing is needed at signalized intersections.

Members interested in the Colorado/Wyoming Section's full reports[1,2] should contact City of Lakewood, Traffic Engineering, 445 S. Allison Parkway, Lakewood, Colorado 80226-3105. A $5.00 charge covers the cost of printing and mailing each Colorado/Wyoming Technical Committee Report. Checks should be made payable to ITE-Colorado/Wyoming Section.

*References*


1. Lalani, Nazir; Cronin, Daniel; Hattan, David; et al. *A Study of the Use of Warrants for the Installation of Left-Turn Phasing at Signalized Intersections.* Colorado/Wyoming Section Technical Report, March, 1985.
2. Lalani, Nazir; Cronin, Daniel; Hattan, David; et al. *A Study of the Use of Techniques for Establishing Left-Turn Phase Change Intervals.* Colorado/Wyoming Section Technical Committee Report, March 1985.
3. Transportation Research Board. *Interim Materials on Highway Capacity.* Circular 212. Washington, D.C.: Transportation Research Board, January 1980.
4. *Traffic Manual.* State of California, Department of Transportation, pp. 9–15.
5. *The Canadian Manual on Uniform Traffic Control Devices.*
6. *Manual of Uniform Traffic Control Devices.* Province of Ontario, Ministry of Transportation and Communications of Ontario, February 1982, pp. B4-2, B4-5.
7. *Technical Notes.* 82-1 to 82-5. New York State, Department of Transportation, October 1982.
8. Leisch, Jack E. "Capacity Analysis Techniques for Design of Signal Intersections." Public Roads, Vol. 34, No. 9, 10. August 1967, October 1967.
9. Institute of Transportation Engineers. *Left-Turn Signal Warrants.* Technical Report 76-1. Wash-

**Table 3. The Most Widely Used Techniques for Warranting Left-Turn Phasing at Signalized Intersections**

| *Type of Warrant* | *Criteria* | *Agencies Using Warrant* |
|---|---|---|
| Warrants Based on Accidents | | |
| Accidents | 3–5 Left-turn accidents/year | 85 |
| Warrants Based on Volumes | | |
| Cross product of left turn × opposing | 2 lane exceeds 30,000–50,000 | |
| | 4 lane exceeds 50,000–100,000 | 43 |
| Minimum left-turn hourly volumes | Exceeds 50–100 vehicles/hour | 32 |
| Minimum left-turn volume per cycle | Exceeds 2/cycle | 26 |
| Average daily or peak hour left-turn volume | Exceeds 10% of through volume | 4 |
| Level of service/capacity analysis | Soap, webster, critical lane | 26 |
| Left-turn check in TRB 212[3] | $V_L$ exceeds 1200 G/C–$V_O$ | 12 |
| Warrants Based on Delay/Queues | | |
| Left-turn vehicle delay | Exceeds 2 vehicles/hour | 13 |
| Left-turn vehicle delay | Exceeds 35 seconds/cycle | 5 |
| Vehicle queue | More than 10% left at end of through phase | 6 |
| Vehicle delay | Exceeds 2–3 cycles | 3 |
| Left-turn storage | Exceeded by left-turn demand | 2 |
| Other Warrants | | |
| Caltrans[4] | Combination of accidents, delay volume, and speed criteria | 20 |
| Geometric design | Sight distance inadequate | 16 |
| Signal system | Progressive movement/adjacent intersection phasing | 10 |
| Number of opposing lanes | Exceeds 2 | 5 |
| Gap analysis | — | 2 |
| Traffic conflicts | Exceeds 10–14/hour | 4 |
| Blanket policy | At all intersections with separate left-turn lanes | 2 |
| Street classifications | At all arterial/arterial, arterial/collector, and collector/collector intersections | 3 |
| Approach speed | Of opposing traffic exceeds 45 mph | 11 |
| Number of left-turn lanes | At all double left-turn lanes | 3 |
| Canadian MUTCD[5] | (See reference for full details) | 1 |
| MUTCD of Province of Ontario[6] | (See reference for full details) | 4 |
| New York State DOT policy[7] | (See reference for full details) | 1 |
| Jack Leisch[8] | Chart 17 (See reference for full details) | 3 |
| ITE Technical Committee Report 76-1[9] | (See reference for full details) | 1 |
| Tanner's curve[10] | (See reference for full details) | 2 |
| Political | — | 6 |
| Public demand | — | 4 |

ington, DC: Institute of Transporation Engineers, January 1978.
10. Tanner, J. C. "A Problem of Interface Between Two Queues." *Biometrika* Vol. 40, 1953. ▮

**Nazir Lalani,** P.E., is traffic engineer for the City of Santa Rosa, California. He received a B.S. in engineering from the University of Exeter and an M.S.C.E. from Arizona State University. Lalani has held municipal and county traffic engineering positions in England, Arizona, and Colorado and has also served as a private consultant. He is a member of ITE and is currently serving as District 6 technical chairman.

**Dan Cronin,** P.E., is chief transportation engineer for CRS Sirrine. He received a B.S. in civil engineering and an M.S. in transportation engineering from the University of Colorado. Cronin is an associate member of ITE and is currently president of the Colorado/Wyoming ITE section.

**David Hattan,** P.E., is director of transportation engineering for Centennial Engineering. His work includes all aspects of traffic and safety engineering and transportation planning. He received a B.S.C.E. from the University of Colorado, Boulder, and an M.S.C.E. from the University of California, Berkeley. Hattan is a member of ITE.

**Terence Searls,** P.E., is in charge of traffic signal engineering in transportation engineering with the City and County of Denver. He is responsible for studies, planning, design, and operation of the city signal system. Searls received a B.S. in civil engineering from the University of Colorado. He is a registered traffic engineer in California. Searls is a member of ITE.