NORTH CENTRAL SECTION
INSTITUTE OF TRANSPORTATION ENGINEERS

TRAFFIC SIGNAL COMMITTEE
Meeting Minutes
06-02-2004

This document is available online at http://www.nc-ite.org/signals.html

ATTENDEES

Jerry Kotzenmacher	Mn/DOT	Jeremy Gorden	TKDA
Wayne Sandberg	Washington Co.	Roger Plum	SEH
Bryant Ficek	Bonestroo	Heather Kienitz	SEH
Pete Sorenson	Bolten & Mink	Linda Taylor	Mn/DOT
Joe Gustafson	Scott Co.	Ted Schoenecher	Bloomington
Kristi Sebastian	Dakota Co.	Ray Starr	Mn/DOT

LOCATION

Mn/DOT – Waters Edge 323

HANDOUTS

Mn/DOT Draft Guidelines for Traffic Signal Protected Left Turn Phasing (5/4/04 Update)
ITE Flow Chart to Determine Type of Left Turn Phasing
Advanced Synchro Class Survey Results

WEB LINKS

1. TTI Study on ADAPTIVE LEFT TURN PHASING (Changing from Protected only to Protected/Permissive based on time of day): http://transops.tamu.edu/documents/AdLftPha.pdf
2. How to Use "Inhibit Phases" to Avoid the "Yellow Trap": http://www.naztec.com/tecnotes/tn3013.htm
3. Kittleson's "NCHRP Research Project 3-54 (Evaluation of Traffic Signal Displays for Protected/Permitted Left Turn Control)" Website: http://projects.kittelson.com/pplt/index.html
4. NCHRP Final Report 493, Evaluation of Traffic Signal Displays for Protected/Permissive Left-Turn Control: http://gulliver.trb.org/publications/nchrp/nchrp_rpt_493.pdf

LEFT TURN PHASING

The Draft Mn/DOT Guidelines and a Flow Chart were handed out.

On page 3 of Mn/DOT draft Guidelines, suggested merging the left turn offset and opposing peak hour left turn volume into one bullet. Discussion about 100 vehicles (~3 per cycle) being too high. Group decided to change to read 'regularly blocking sightlines' to give more engineering judgment. Exact numbers are good for sight distances, but not for volumes which are constantly changing.

On page 4, group discussed regarding the definition of opposing through lanes. It was felt the current write-up is too restrictive and needs to be changed to: 'An opposing separate right turn lane should not be typically be counted with opposing through lanes unless the right turn movement has no yield sign, turns into the same lane as the left turn movement, and there is sufficient volume of left turns and opposing right turns to cause frequent conflicts.' As before, the idea is to allow engineering judgment rather than locking into specific thresholds. Further group discussion determined that this statement regarding right turn lanes does add value to the guidelines and should be left in the document.

Group discussed about the railroad preemption suggested out-state does not like to use 8-phase operation. It was stated that these criteria would only be used after the need for a left turn phase has been established. Further discussion led to conclusion that the railroad preemption needs more language for better understanding and that it cannot be fully covered in this document. Therefore, a reference to the Railroad Preemption Guidelines should be added in place of the current text and that manual should be updated to cover all the necessary items.

The reference to the WisDOT manual should be removed in favor of the actual text from that manual so people do not need to go another manual.

The ITE left turn phasing flow chart was handed out and discussed. This chart uses the same basic items and re-enforces the Mn/DOT guidelines, but uses different numbers.

Ray S. will make corrections to the document and update on the website until it is fully incorporated into the signal design manual. A tech memo would be released when it is at that point.

Group discussion then turned to the potential use of 4-section heads (red arrow, yellow arrow, flashing yellow arrow, green arrow) for protective/permissive left turn phasing. Jerry K. checked into using this with current controllers and found that Econolite is unlikely to include in their controller unless demand calls for it (such as the MUTCD adding language). However, it could be done with added equipment and wiring outside the cabinet. Ray S. will attempt to get an experiment for this type of control with the University of Minnesota. Suggesting this type of study does not mean the U of M will select it for research. However, Mn/DOT may also have other options. Benefits from this type of phasing include higher understanding based on existing studies, allowing a switch from protected only to protective/permissive based on time of day or other factors, head placement directly over the left turn lane, and limiting the left turn trap. See the websites for additional information.

NCITE SPONSORED CLASSES

Railroad Preemption – Jerry K. has not yet been able to contact Rick Campbell for more information regarding this class. Jerry will continue to try to contact Rick as well as look into other options thru Mn/DOT Railroad personnel and additional contacts at FHWA.

City Planning/Forecasting – Linda T. inquired about interest in this type of training. Group expressed more interest in a TranPlan course if the state continues to use this as a main tool.

Professional Development Group – Wayne S. discussed Marc C. presentation to the NCITE Board of forming this type of group to continually gauge interest in training topics and look for sponsors.

Mn/DOT Beta Classes – Mn/DOT has an Advanced Controller Class scheduled for June 16-17, 2004 and a Master Controller Class schedule for the fall. Having the internal Beta class is part of the process before providing the training to the wider community. The Econolite controller is planned for use at these classes, although Eagle and Traconite controller experts are also expected to be at the class.

Advanced Synchro Training – Roger P. provided a hand-out for these minutes, which is attached. In general, attendees liked the examples and learning about the advanced functions. Additional training ideas of CorSim and transferring data

from Synchro to a signal controller were mentioned. Please contact Roger if you have any questions about the attached survey information.

ROUND ROBIN

Ray S. – Mn/DOT has had problems with the paint on plastic heads. They have tried a few and still are not satisfied with the products yet.
– He is meeting with Dialight today regarding light failure in the field. Mn/DOT is considering removing them from the approved list. Left turn arrow was stated as being cold-weather related, but new ones are still failing quickly in the field. Discussion in group about not waiting for contractors to re-lamp failures and doing it themselves as well as concern about higher prices if dropped from the approved list.
– He believes the law banning use of EVP emitters by non-authorized persons did not pass in the regular session. An older law discussing traffic signal interference may be able to be used for enforcement.

Kristi S. – Dakota Co. is trying to use traffic responsive detection on a corridor. She is having problems with the Eagle controller and is switching to Econolite on this corridor. Eagles are being moved to isolated intersections. Jerry stated Mn/DOT is having some problems with Econolite shorting phases and that they are experimenting with Eagle in Moorhead.

Pete S. – Asked if anyone has seen or heard of any fall-out regarding the new motorcycle law that allows them to proceed on a red light in certain circumstances. Group discussion determined that while this movement has been observed, no comments have been heard or received.

NEXT MEETING

DATE

No Meetings the next two months!!
Wednesday, September 1st, 2004
8:00 – 10:00 am

LOCATION

Mn/DOT – Golden Valley

TOPIC

Battery Backup / Power Fail

Mn/DOT Selection Guidelines for Traffic Signal Protected Left Turn Phasing

Draft ~~2/7/2003~~5/4/2004

Introduction

The correct type of left turn phasing used at signalized intersections is a critical component for safe and efficient operation. In many cases an experienced designer can easily choose the correct phasing when considering volume, speed data, accident history and geometrics. In other cases the left turn selection process can be difficult when there are special concerns or gray areas.

Permissive or protected-permissive left turn operation is usually the most efficient. However, when the driver is placed in difficult decision or risk taking situations, the protected only left turn operation can increase safety. Inversely, drivers lose respect for protected only left turn signals when they can obviously make their own safe decision to turn on a gap. Enhanced signal detection, sequencing, and timing can reduce delay associated with protected only phasing.

Gains in efficiency and safety of left turn operation, as well as reductions in fuel consumption and emissions can be appreciated by implementation of appropriate left turn signal design. Signal optimization programs can indicate which type of left turn phasing is more efficient, however they do not consider safety aspects required to complete this decision making process.

The Signal Designer must also be aware of the effects to special operations such as Emergency Vehicle Preemption and system coordination. Every intersection is unique; situations not defined in the guidelines, such as Emergency Vehicle Preemption (EVP), pedestrian conflicts, geometric constraints, a high proportion of trucks, and existing left turn performance as observed in the field may influence the choice of left turn phasing in favor of safety.

These guidelines do not address split phasing, where the left turn and through phase run simultaneously for one approach, and then for the opposite approach.

The aim of these guidelines is to establish an uncomplicated standard selection process that can be used as a starting point for determining the proper type of left turn phasing. Engineering judgment is still required taking into account the specific conditions at the site.

Left Turn Protected Phasing Selection Guidelines

The Guideline Descriptions section provides more information about the meaning of the criteria and considerations.

These guidelines provide a starting reference point for determining the left turn operation at an intersection. Engineering judgment and site specific considerations of safety and efficiency may cause deviations from the operation indicated by these guidelines. Examples of other considerations include Emergency Vehicle Preemption (EVP), pedestrian conflicts, geometric constraints, intersection delay, older drivers, human factors, a high proportion of trucks, and existing left turn performance as observed in the field.

Need for a Left Turn Phase

Before using the guidelines below to evaluate protected only or protected permissive left turn operation, the signal designer should perform an~~intersection capacity~~ analysis to determine the need for a separate left turn phase. This analysis may utilize the methodology described in the Highway Capacity Manual produced by the Transportation Research Board, based upon geometrics, speeds, volumes, volume cross products, and other factors, which analyzes intersection performance in terms of measures such as volume to capacity ratio and level of service. Simulation software is also useful in evaluating candidate left turn phasing.

Protected Only Guidelines

Protected only left turn phasing is recommended if indicated by the "Minimum Protected Only Guidelines" or the "Combination of Protected Only Guidelines".

Minimum Protected Only Guidelines

Protected only left turn phasing is recommended when any one or more of the following conditions exist:

- Railroad preemption, and the movement is opposite the track clearance movement or turns across the tracks
- Lead-lag left turn sequence is ~~possible~~planned
- Intersection geometrics such that paths of opposing left turns cross
- 3 or more opposing through lanes
- Limited sight distance (see table, chart, and formula)
- Protected permissive operation is in place and there are 5 or more left turn related accidents per year over a 3 year period susceptible to correction by protected only phasing
- Dual exclusive left turn lanes with opposing traffic

Combination of Protected Only Guidelines

Protected only left turn phasing is recommended when any two or more of the following conditions exist:

- Protected permissive operation is in place and there are 3 or more left turn related accidents per year over a 3 year period susceptible to correction by protected only phasing
- Dual left turn lanes of any type with opposing traffic
- Speed 50 MPH or higher or 45 MPH with grade exceeding 3 percent

- Peak hour left turn volume greater than 240 vehicles or peak hour cross product greater than 80,000 (100,000 if 2 opposing lanes)

-□Left turn lane alignment offset ~~greater than 8 feet~~along with other intesection and approach geometrics such that an opposing left turn vehicle would block the left turner's view of oncoming traffic.

- Opposing peak hour left turn volume is greater than 100 vehicles[?]

Guideline Descriptions

Railroad Preemption. Left turn movements that conflict with the railroad tracks should be protected only, so that they can be omitted when a train is present.

Because of the left turn trap scenario, where railroad preemption may cause a lagging left turn arrow on the track clearance movement the left turn movement opposing the track clearance phases should be protected only.

Lead-Lag Turn Sequence. Lead-lag left turn sequence can benefit progression in systems. Because of the left turn trap scenario, protected left turn phasing is required for the left turn opposite the lagging left turn.

Crossing Left Turn Paths. At some locations geometric constraints at the intersection cause the paths of opposing left turn vehicles to cross. An example is an approach that crosses a divided roadway with a wide median. In these locations, it may be necessary to operate the left turns in a lead-lag sequence or a split phase sequence, not allowing simultaneous opposing left turns. This operation will require protected left turns.

Opposing Through Lanes. An opposing separate right turn lane will not be counted with opposing through lanes unless the right turn movement has no yield sign and turns into the same lane as the left turn movement.

Limited Sight Distance. The minimum sight distance values from the left turn stop line for related posted speeds are defined in the table below. This is the sight distance when there is no obstruction by opposing left turning vehicles. This table makes the following assumptions:

- Path of travel for left turning vehicle to clear intersection including length of vehicle is 100 feet (y in the attached diagram)
- Longitudinal width of intersection is 100 feet (z in the attached diagram)
- Acceleration rate of 2.5 feet/sec/sec (truck rate)
- No reaction time delay

30MPH = 500 feet	45MPH = 700 feet	60MPH = 900 feet
35MPH = 550 feet	50MPH = 750 feet	65MPH = 950 feet
40MPH = 625 feet	55MPH = 825 feet	

The attached diagram, chart, and formula allow determination of required sight distance if the above assumptions do not apply.

Left Turn Related Accidents. These are accidents that could be corrected by protected only phasing, such as those between left turning vehicles and opposing through vehicles. The number of accidents is consistent with the traffic signal accident warrant requirements. At higher speeds the accidents are likely to be more severe, and so a lower number of accidents is indicated for high speed approaches. Because of the variations in accident numbers, an average number of accidents per year over a 3 year period should be used if the data is available.

At locations meeting the accident numbers for protected only phasing, but where there is no existing signal or where there is an existing signal with permissive only left turns, an agency may desire to install protected permissive phasing prior to installing protected only phasing. A follow-up study can then determine whether the accident numbers still meet the recommendations for protected only phasing.

Dual Left Turn Lanes. Multiple left turn lanes may consist of only exclusive left turn lanes or a combination of exclusive left turn lanes and lanes that are shared by through and left turning traffic. Left turn lanes where there is no opposing traffic, such as left turns off of a one way street, do not require protected only phasing based upon this criteria.

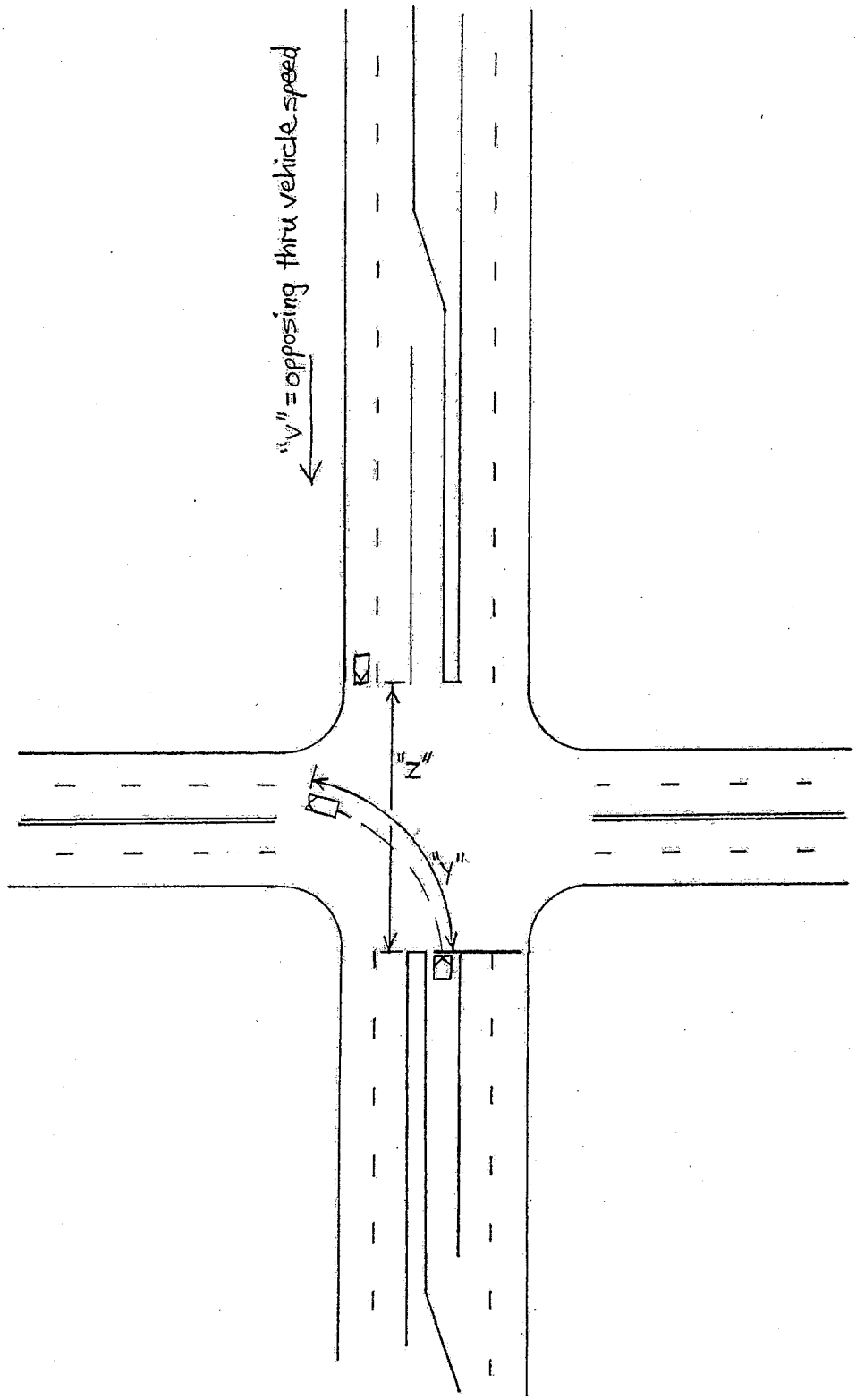
Speed. Because it can be difficult for a driver to accurately judge available gaps in traffic approaching at high speeds, the engineer must exercise extreme discretion when considering permissive or protected permissive left turn phasing with opposing speeds of 45 MPH or above.

Use of posted speed limit is recommended. Non-arterial approaches may have lower speeds than the posted speed limit because they are often in a stop condition upon the arrival of traffic. Grades effect the acceleration rate of the left turner and the stopping distance and speed of the opposing through traffic and are therefore considered in conjunction with speeds.

Cross Product. The cross product volume is the left turn volume multiplied by the opposing through volume. The cross product values used in the Combination of Protected Only Guidelines are taken from the Wisconson Department of Transportation (WisDOT) Traffic Signal Design Manual discussion on left turn conflicts analysis, Chapter 2, Section 3, Subject 4.

Left Turn Lane Alignment. Left turn lanes that are aligned directly across from each other (head on) work best for permissive left turns since the driver can more easily see around the opposing left turning vehicle and look for a safe gap in traffic. Directly aligned opposing left turn lanes (double yellow across from a white left turn lane line) would be considered to have a zero foot offset. For medians, the measurement would be made laterally from the ~~edge of pavement at the left turn stop line to the edge of the conflicting through~~center of the left turn lane to the center of the opposing left turn lane. The left turn lane alignment guideline is not applicable where there are no opposing left turns, such as with a 1 way cross street or at a "T" intersection.

Sight Distance Diagram:



Site Distance Criteria
Protected-Only vs. Protected/Permissive Left Turn Phasing
Reaction Time = 0, Acceleration = 2.5 ft/sec/sec, Intersection longitudinal width same as Y

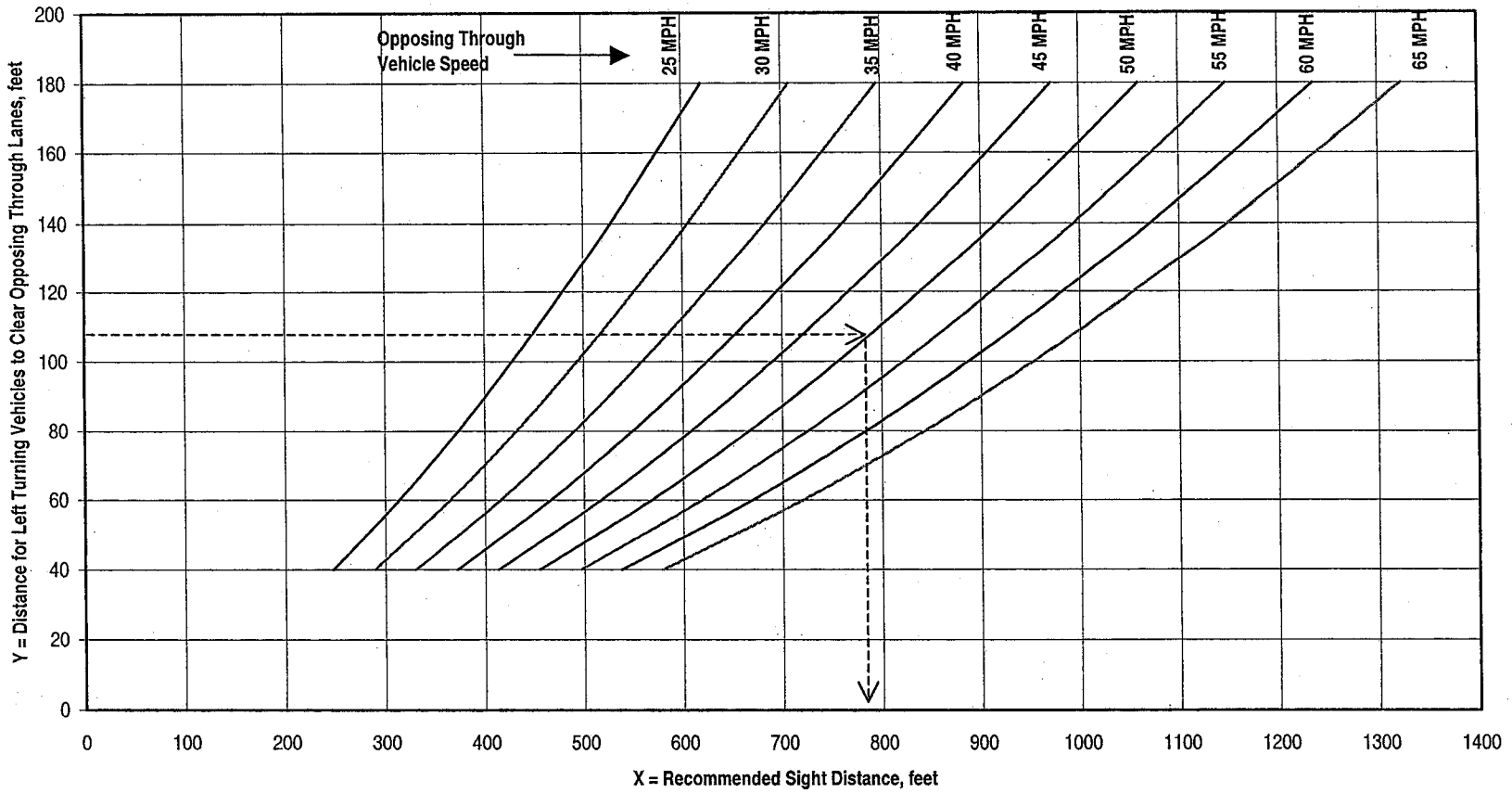


Chart 1

Distance to clear opposing through lanes (= y)

Required Sight Distance

	Speed in MPH								
	25	30	35	40	45	50	55	60	65 MPH
40	247	289	330	372	413	455	496	538	579
60	314	365	416	466	517	568	619	670	720
80	373	432	491	549	608	667	725	784	843
100	428	494	559	625	690	756	821	887	953
120	479	551	623	695	767	838	910	982	1054
140	528	606	683	761	838	916	994	1071	1149
160	575	658	741	824	907	990	1073	1156	1238
180	620	708	796	884	972	1060	1148	1236	1324
Feet									

Assumptions used to generate graphs:

1) Longitudinal intersection width is the same distance as the path of the left turner to clear the through lane (including vehicle length). i.e., assume z = y

2) Acceleration rate of left turning vehicle is 2.5 ft/sec/sec (reflects truck acceleration).

3) The value "y" should include the distance of the vehicle travel path through the intersection, as well as the length of the design vehicle.

4) Reaction time is zero.

Sight Distance Formula:

$$x = z + 1.467(v)(t_r) + 2.074(v)\sqrt{(y/a)}$$

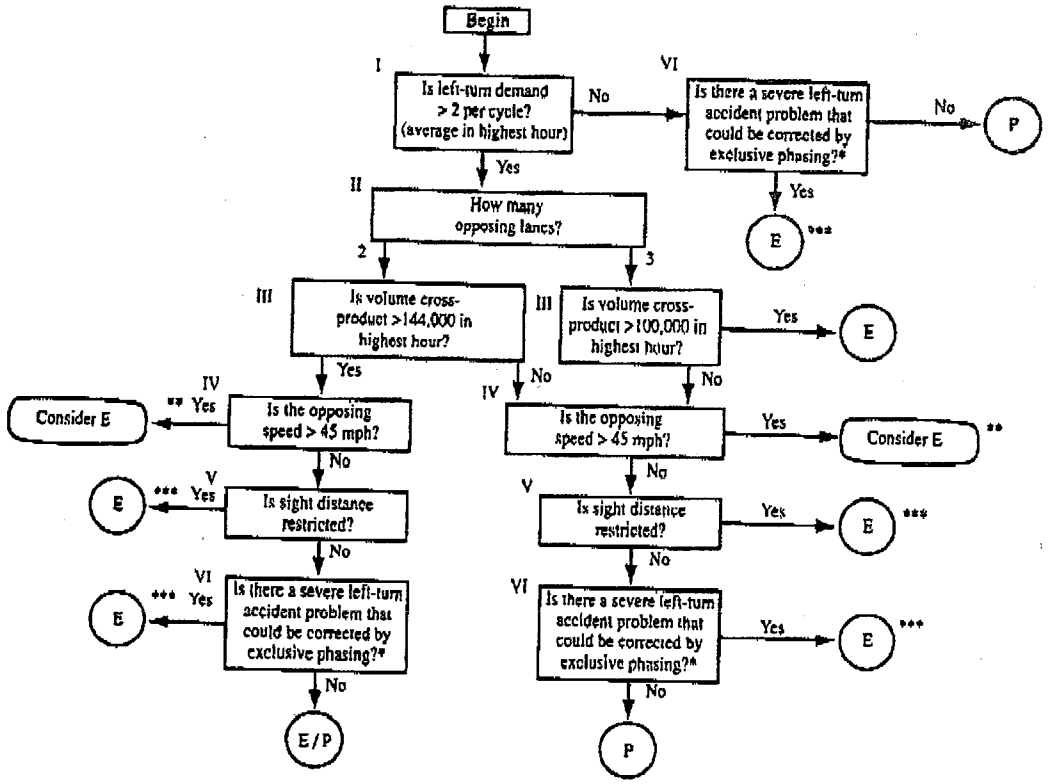
Where:
x = recommended sight distance from the left turn stop bar, feet
y = distance for left turning vehicle to clear opposing thru lanes, measured along vehicle path, including the length of the vehicle, feet

z = longitudinal width of the intersection, feet

v = opposing thru vehicle speed, miles per hour

a = acceleration of left turning vehicle, feet/sec/sec

t_r = reaction time of left turner upon finding a gap before accelerating



P – Permissive

E/P – Exclusive/Permissive

E – Exclusive

Note: This procedure applies to locations with a separate left-turn lane.

Restrictive Sight Distance is:

< 250 ft when speeds are 35 mph or less;

< 400 ft when speeds are 40 mph or more.

* See text for definition of severe left-turn accident problem.

** An opposing speed > 45 mph indicates a potential left-turn accident problem. Consider exclusive phasing, realizing that non-left-turn accidents may increase.

*** Use exclusive phasing with the understanding that non-left-turn accidents may increase.

Figure 13–7 Recommended Procedure for Determining Type of Left-Turn Phasing

Source: J.E. Upchurch, "Guidelines for Selecting Type of Left-Turn Phasing," *Traffic Control Devices and Rail-Highway Crossings*, Transportation Research Record 1069, Washington, D.C.: Transportation Research Board, National Research Council, 1986, p. 30.

The University of Texas at Arlington has developed guidelines for left-turn phasing based on research, actual field data, easy-to-use quantitative measures, and statistical analysis of most suitable left-turn options. The process favors the least restrictive option—permitted left-turn—unless traffic and geometrics warrant a more restrictive control.[16] The decisions to be made are classified into three levels summarized as follows and shown in Figure 13–8.

Level 1: Permissive-Only Versus Some Protection

The permissive option should be used only if all of the following conditions exist:

[16] S.A. Asante, S.A. Ardekani, and J.C. Williams, "Selection Criteria for Left-Turn Phasing and Indication Sequence," *Traffic Control Devices, Visibility, and Traffic Signal Systems*, Transportation Research Record 1421 (Washington, D.C.: Transportation Research Board, National Research Council, 1993), p. 11.

Panel c displays a circular red for through-traffic and a green arrow for the protected left turn. This protected movement is terminated by a yellow-arrow change interval (Panel d), leading to the singular display of a circular red (Panel e), while the right-of-way is transferred to the cross roadway.

To supplement the protected/permissive types of operations depicted, an informational sign (e.g., LEFT TURN PROTECTED ON GREEN ARROW ONLY) may be used, but is not required. Regulatory left-turn signal signs (e.g., LEFT ON GREEN ARROW ONLY) may not be used.

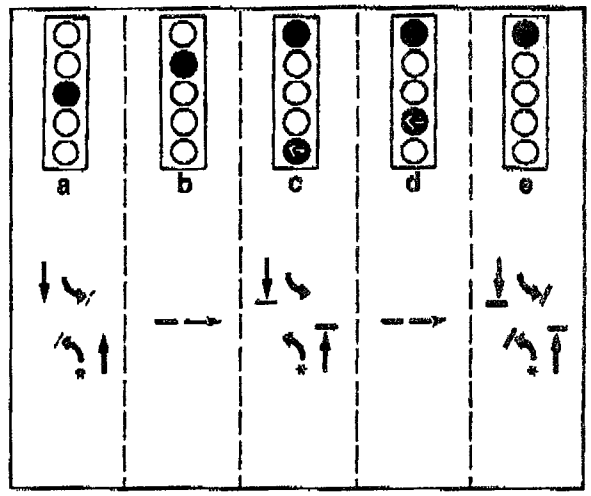


Figure 13–6 Simultaneous Lag-Left Turns

Source: *Traffic Control Devices Handbook*, p. 4-76.

Criteria for Determining Need and Mode

A wide selection of signal phasing can accommodate the left-turn movement. The objective is to delay heavier through-traffic volumes as little as possible while accommodating left-turn maneuvers promptly and in relative safety. The special phasing of left-turn movements will always require engineering judgment because the provision for left-turn signal green time will detract from through-traffic green time, requiring some balance between signal phases for the total intersection.

A sample of the data needed to determine the best option for left-turn phasing has been suggested by Upchurch:[15]

- left-turn volumes (hourly during peak hour),
- cycle length,
- opposing traffic during peak hour of highest left-turn demand,
- number of opposing traffic lanes,
- speed of opposing traffic,
- available sight distance, and
- accident history, including left-turn accidents.

Additionally, a time-space diagram showing traffic signal progression for adjacent signal installations should also be reviewed. Upchurch provides a left-turn phasing decision tree to determine a recommended option, based on existing practice (Figure 13–7).

[15] J.E. Upchurch, "Guidelines for Selecting Type of Left-Turn Phasing," *Traffic Control Devices and Rail-Highway Crossings*, Transportation Research Record 1069, (Washington, D.C.: Transportation Research Board, National Research Council, 1986), p. 30.