Traffic Signal Timing and Phasing Policy

Prepared for:

Metropolitan Government of Nashville and Davidson County Department of Public Works, Engineering Division

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I. INTRODUCTION

The Metropolitan Government of Nashville and Davidson County Department of Public Works (MPW) – Engineering Division has adopted a set of traffic signal timing and phasing policies for implementation at signalized intersections under their jurisdiction. The purpose of this policy is to establish standard practices and operational procedures for traffic signal timing parameters to be used by MPW staff and consulting engineers performing signal timing services for MPW. This policy is in no way intended to conflict with the Federal Highway Administration's (FHWA) *Manual on Uniform Traffic Control Devices* (*MUTCD*). Should any conflict arise, the current edition of the *MUTCD* shall prevail.

The guidelines referenced in this document – *Traffic Signal Timing and Phasing Policy* – are to be implemented at new traffic signal installations, traffic signal upgrades, and along signalized corridors as they are re-timed. The adoption of this policy does not imply that each and every traffic signal under the jurisdiction of MPW will automatically comply with these guidelines. Rather, traffic signal settings will be updated along signalized corridors throughout Metro Nashville-Davidson County as they are re-timed.

MPW established the policy to provide guidance on various signal timing parameters. However, signal timing should be independently evaluated for all situations based upon standard traffic engineering principles and local intersection characteristics. Necessary adjustments should be made to meet the traffic conditions at each individual signalized intersection. This policy should serve to promote consistent, safe, and efficient control of traffic signals within Metro Nashville-Davidson County.

Prior to developing this document, MPW performed research on federal, state, and professional organization standards/guidelines. In addition, during the original document development, MPW conducted interviews with other selected peer public agencies throughout the United States (primarily located in the southeast). The following groups were either interviewed or researched prior to the development of this document:

- Federal Highway Administration (FHWA)
- Institute of Transportation Engineers (ITE)
- Tennessee Department of Transportation
- North Carolina Department of Transportation
- South Carolina Department of Transportation
- Kentucky Transportation Cabinet (KTC)
- City of Memphis, Tennessee
- City of Knoxville, Tennessee
- City of Chattanooga, Tennessee
- City of Atlanta, Georgia
- City of Birmingham, Alabama
- City of Newport News, Virginia
- Lexington-Fayette Urban County Government, Kentucky
- Louisville-Jefferson County Metropolitan Government, Kentucky
- Miami-Dade County Government, Florida
- City of Fort Worth, Texas
- City of Vacaville, California

This policy was originally developed in 2004 and adopted on October 1, 2004. In 2010 the FHWA published the 2009 *MUTCD*. The 2009 *MUTCD* introduced additional standards, guidance, and options for the operation of traffic signals. This policy was updated in 2010 to be consistent with the 2009 *MUTCD*.

II. VEHICLE CLEARANCE INTERVALS

The Federal Highway Administration's (FHWA) *Manual on Uniform Traffic Control Devices* (*MUTCD*)[1] requires that vehicle clearance intervals consist of a required yellow change interval and an optional red clearance interval.

The Metropolitan Government of Nashville and Davidson County Department of Public Works (MPW) will provide a yellow change interval and has elected to include a red clearance interval at every signalized intersection under their jurisdiction.

The calculation of vehicle clearance/change intervals shall be based upon the criteria set forth in the Institute of Transportation Engineer's (ITE) *Manual on Traffic Signal Design*[2]. The following formula provides a total clearance interval value and will satisfy requirements of the 2009 *MUTCD* Section 4D.26 paragraph 3:

$$VCI = t + \frac{V}{2a + 64.4g} + \frac{W + L}{V}$$

Where:

VCI = total vehicle clearance interval (yellow change + red clearance), seconds
t = perception-reaction time, seconds
V = approach speed, feet/second
a = deceleration rate, feet/second^2
g = percent of grade divided by 100 (+ for upgrade, - for downgrade)
W = width of intersection, feet
L = length of vehicle, feet

Typically, the yellow change interval is calculated using the first two terms of the above equation [*t + V/(2a + 64.4g)*]; the red clearance interval is calculated using the third term of the equation [*(W + L)/V*]. A series of tables summarizing the theoretical minimum *VCI* calculations are provided in the **Appendix** of this document.

It is MPW's policy that the total clearance interval shall be rounded up to the next one-half second.

Some of these variables are site-specific, such as intersection width, percent of grade, and approach speed. However, others are not. Typical values for the non-site-specific variables, as suggested in the ITE informational report, *Determining Vehicle Signal Change and Clearance Intervals*[3], are:

t = 1 second
a = 10 feet/second^2
L = 20 feet

The traffic engineer should use engineering judgment when determining whether the typical values apply for a given signalized intersection. If local circumstances warrant something different than the typical values, then the traffic engineer should use values based upon local circumstances.

Percent of grade, *g*, shall be considered when the intersection approach grade exceeds +/- five percent or the approach speed limit exceeds 55 mph. Approach grades less than +/- five percent at speeds of 55 mph or less typically have an effect of less than 0.5 seconds and are within normal interval rounding.

The intersection width, *W*, for through-movements shall be measured from the approach stop line to the far side of the crosswalk. For left- and right-turn movements, this distance shall be measured along the vehicle turning path from the approach stop line to far side of the crosswalk. **Figure 1** depicts these measurements.

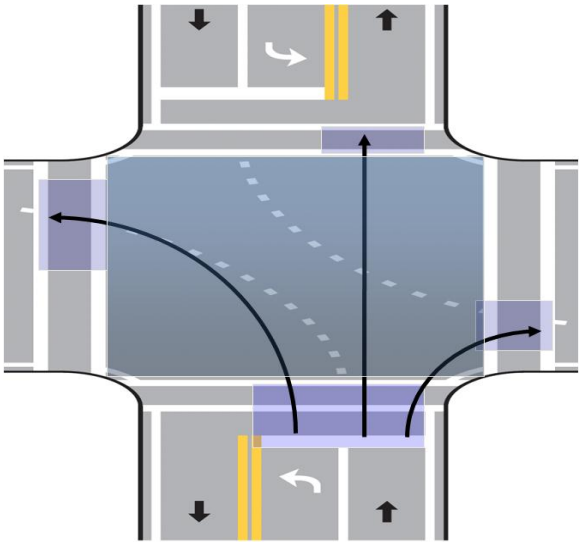


Figure 1: Intersection Widths for Vehicle Clearance Interval Calculations

Once the total vehicle clearance interval, *VCI*, is calculated, MPW has chosen acceptable ranges for both yellow change and red clearance intervals. **Table 1** illustrates these ranges.

Table 1: Typical Ranges for Vehicle Clearance Intervals

Yellow Change Interval (seconds)		Red Clearance Interval (seconds)	
Minimum	Maximum	Minimum	Maximum
3	6	1	6

Although these acceptable ranges will accommodate the majority of signalized intersections under MPW's jurisdiction, there may be instances where the maximum thresholds need to be adjusted. Values greater than those tabulated above should be justified via an engineering study. All total VCI values shall be approved by MPW Traffic Engineering staff prior to implementation.

III. PEDESTRIAN CONTROL FEATURES

There are a number of pedestrian-related items covered in this portion of the policy, including

- Minimum pedestrian walk intervals for pedestrian signal phasing,
- Recommended pedestrian walking speeds,
- Guidelines for pedestrian clearance intervals,
- Recommendations for pedestrian push buttons usage, and
- Walk rest modifier option.

Minimum Pedestrian Walk Intervals for Pedestrian Signal Phasing

Following the *MUTCD* guidance statement, signalized intersections that have pedestrian phasing under the Metropolitan Government of Nashville and Davidson County Department of Public Works (MPW) jurisdiction will have a preferred minimum of seven seconds of walk time. However, if pedestrian volumes and other intersection characteristics, including satisfying *MUTCD* section 4E.06 paragraph 14, do not require a seven-second walk interval, walk intervals as low as five seconds may be used. Engineering judgment shall be used when determining if the absolute minimum of a five-second walk interval should be used.

Pedestrian walk intervals greater than seven seconds may be necessary in areas with heavy pedestrian volumes; a larger percentage of elderly, elementary school-aged, and/or handicapped pedestrians; or other situations deemed necessary by MPW staff.

Recommended Pedestrian Walking Speeds

The typical pedestrian walking speed used to determine pedestrian phasing should be 3.5 feet per second (fps) as supported by the *MUTCD*. However, in areas with significant percentages of elderly pedestrians or elementary-aged children, a walking speed of less than 3.5 fps may be deemed appropriate by MPW staff.

Guidelines for Pedestrian Clearance

Consistent with the *MUTCD* guidance statement, MPW will typically use part of the yellow change interval plus the red clearance interval to equal a minimum of three seconds as the “buffer interval” (steady UPRAISED HAND). The pedestrian change interval (flashing UPRAISED HAND) will begin during the concurrent vehicle green interval, if applicable, and will normally end when the vehicle signal changes to yellow. In some cases, such as presence of heavy right turns, it may be desirable to end the pedestrian change interval and display steady UPRAISED HAND before the vehicle signal changes to yellow.

Recommendations for Pedestrian Push Button Usage

Pedestrian push button actuation is recommended for pedestrian phases that cross the ‘main street’ approaches so that ‘side street’ vehicle phases do not have to accommodate pedestrian timings unless they are actuated via a pedestrian push button.

The need for push button actuation to cross side street approaches shall be determined via engineering judgment by the MPW traffic engineer.

For the purposes of determining main street approaches in reference to pedestrian timings, the main street approaches will be considered the signalized approaches that are coordinated and, therefore, are non-actuated. If a traffic signal is pre-timed or fully-actuated, the differentiation between main street and side street does not apply for this situation.

In cases where pedestrian push buttons are provided without pedestrian signal displays, the timing for the green interval during a pedestrian actuation shall, at a minimum, be equal to the calculated pedestrian crossing times.

Walk Rest Modifier Option

During main street vehicle signal phases that are non-actuated, there are often situations where the vehicle split is significantly larger than the required pedestrian walk and clearance intervals. Rather than increasing the pedestrian clearance interval to accommodate the additional time available, MPW staff will allow the signal controller to extend the length of the pedestrian walk interval. There are, however, situations where this option, known as the walk rest modifier, should not be allowed. Such applications where the walk rest modifier should not be utilized where:

- Right-turn volumes are heavy across the pedestrian crossing area,
- Permissive left-turn volumes are heavy across the pedestrian crossing area, or
- MPW staff has determined that the walk rest modifier option should not be implemented.

IV. MINIMUM VEHICLE GREEN TIMES

Minimum vehicle green times should be short enough so that green time is not wasted; yet not so short that motorists unexpectedly see the yellow change interval while entering the intersection and become confused. This section of the policy establishes the minimum recommended green times. This does not suggest that all signalized intersections will utilize these minimum values. Greater minimum green times may be utilized; however, values lower than those mentioned below are not recommended.

In addition, when determining minimum vehicular green times, the percentage of trucks should also be reviewed on an intersection-by-intersection basis. A high percentage of trucks may necessitate increasing the minimum green time controller setting.

Maximum green times are not established in this policy since they vary significantly by location and are based on signal operation, vehicle demand, and other operational characteristics.

Minimum Green Times for Left-turn Phases

The minimum green time setting for left-turn phases is four (4) seconds.

Minimum Green Times for Side Street Through Phases

The minimum green time setting for side street phases is seven (7) seconds.

Minimum Green Times for Main Street Through Phases

The minimum green time setting for main street through phases is ten (10) seconds.

Main Street and Side Street Definitions

‘Main street’ approaches are those that correspond to coordinated streets or other non-actuated phases. At pretimed or fully-actuated locations, normally the higher classified roadway or the road with the heavier traffic volumes will be considered the ‘main street.’ In cases where the intersecting roadways are approximately equal in importance, they may both be treated as ‘main streets’ or as ‘side streets’ depending on the circumstances. Intersection approaches with two or more through lanes should be treated as main street approaches.

V. LEFT-TURN SIGNAL PHASING GUIDELINES

Left-turn phasing guidelines as discussed in the Federal Highway Administration's (FHWA) *Traffic Signal Timing Manual*[4] are to be used for assistance in assessing the need for left-turn phasing at signalized intersections under Metropolitan Government of Nashville and Davidson County Department of Public Works (MPW) jurisdiction. The Appendix of this document contains a reprinted flowchart from this referenced guideline. These referenced guidelines shall be used as a tool for determining the need for left-turn phasing at signalized intersections along with engineering judgment by the traffic engineer.

The Institute of Transportation Engineers (ITE) *Traffic Engineering Handbook*[5] presents selection criteria for left-turn phasing and indication sequence and may be used for assistance in assessing the need for left-turn phasing at signalized intersections under MPW jurisdiction. These guidelines are included in the appendix of this document.

In addition to the guidelines referenced above, the following is adopted as MPW policy:

> Exclusive (protected only) left-turn signal phasing shall be installed where multiple left-turn lanes exist on a single approach.

Exclusive/Permissive Left-Turn Phase Operation

Phasing for eight-phase signal controllers should prohibit a phase change from main street green to a main street left-turn phase if the left-turn phase operates leading protected/permissive. In the absence of a side street actuation, the signal controller should remain in main street green to allow left-turn movements to occur on the permissive green.

This does not apply if the intersection is intended to operate with a lagging left turn, or if the left-turn phase is exclusive-only. However, the oncoming approach must have the left turn prohibited, or operated as exclusive-only, to avoid a "left turn trap;" if this is not practical, it must be equipped with a standard sign warning of this condition (per section 4D.05 of the 2009 *MUTCD*).

VI. SPLIT-PHASE TIMING OPERATION GUIDELINES

The term split-phase signal operation describes a signal phasing sequence where one approach is given exclusive right-of-way into the intersection followed by the opposing approach being provided exclusive right-of-way into the intersection. This operation eliminates left-turn conflicts; however, it is often described by traffic engineers as an inefficient signal phasing option since a single approach is served while the remaining intersection approaches are given red indications. Nonetheless, there are situations where the use of split-phasing should be considered. For traffic signals under the jurisdiction of Metropolitan Government of Nashville and Davidson County Department of Public Works (MPW), the following situations may necessitate the need for split-phase timing operation:

- Where offset approaches exist that may cause motorist conflicts/confusion if permissive phasing were implemented;
- Where intersection width prevents opposing left-turn movements from operating concurrently (Prior to implementing split-phase operation due to this geometric limitation, the installation of lead-lag phasing should also be considered.);
- When an accident problem exists between left-turn and through-movement conflicts that has not been successfully remedied via other operational improvements;
- Where a sizeable volume imbalance exists on the side street approaches;
- Where a second left-turn lane is needed, but must be shared with a through-movement lane; or
- Where the need to serve the left-turn volume is relatively close to the time needed to serve the concurrent through-movement volume.

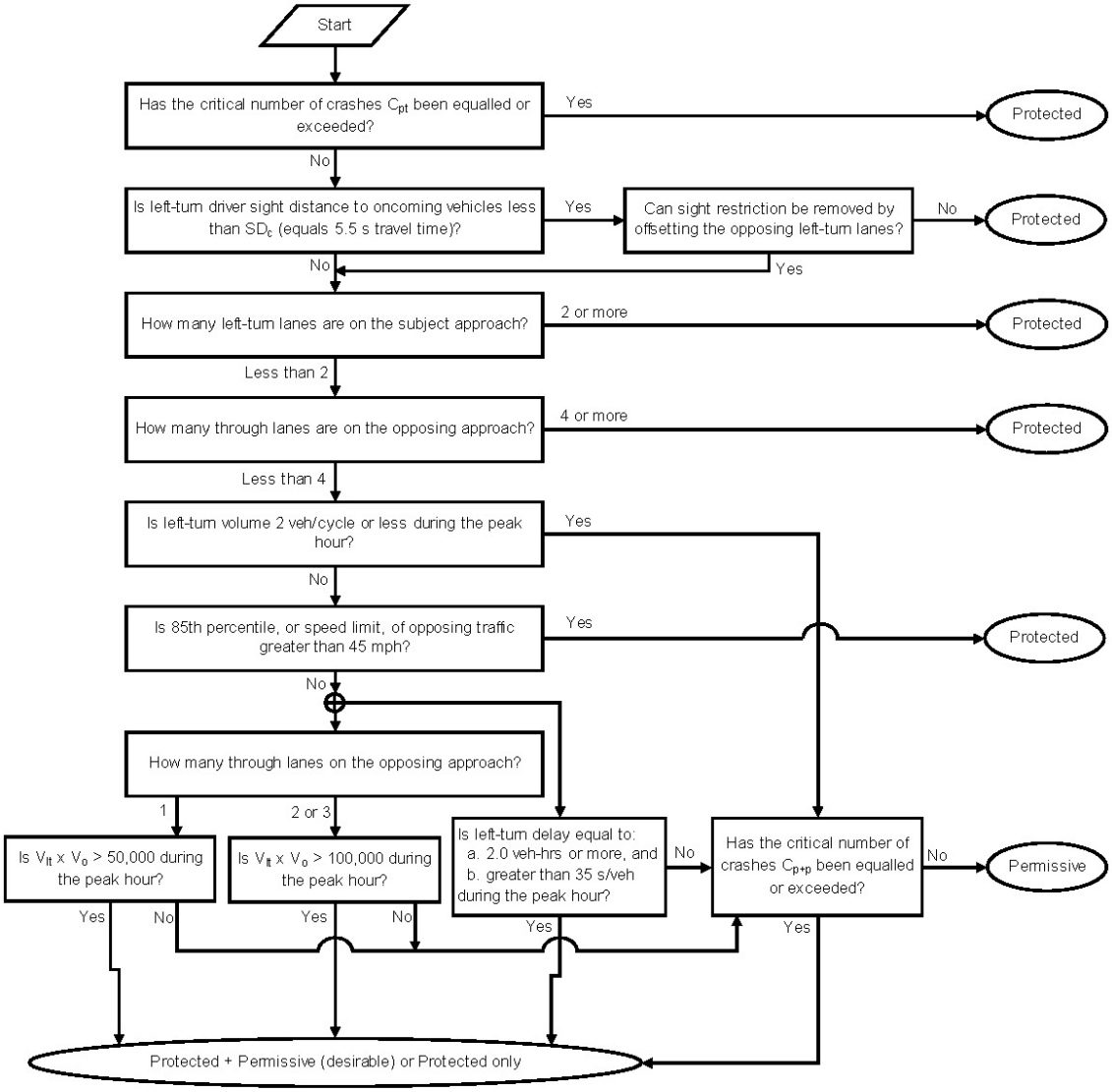
For each case, a capacity analysis should be performed comparing split-phase timing operation versus other signal phasing options prior to implementation.

REFERENCES

1. Federal Highway Administration. *Manual on Uniform Traffic Control Devices.* Washington, DC: U.S. Department of Transportation, 2009.
2. Institute of Transportation Engineers. *Manual on Traffic Signal Design,* 2nd Ed. Washington, DC: James H. Kell and Iris J. Fullerton, ed. Institute of Transportation Engineers, 1998.
3. Institute of Transportation Engineers. *Determining Vehicle Signal Change and Clearance Intervals.* Washington, DC: Institute of Transportation Engineers, 1994.
4. Federal Highway Administration. *Traffic Signal Timing Manual.* Washington, DC: U.S. Department of Transportation, 2008.
5. Institute of Transportation Engineers. *Traffic Engineering Handbook,* 5th Ed. James L. Pline, ed. Institute of Transportation Engineers, 1999.

APPENDIX

Figure A-1: Federal Highway Guidelines for Determining the Potential Need for a Left Turn Phase



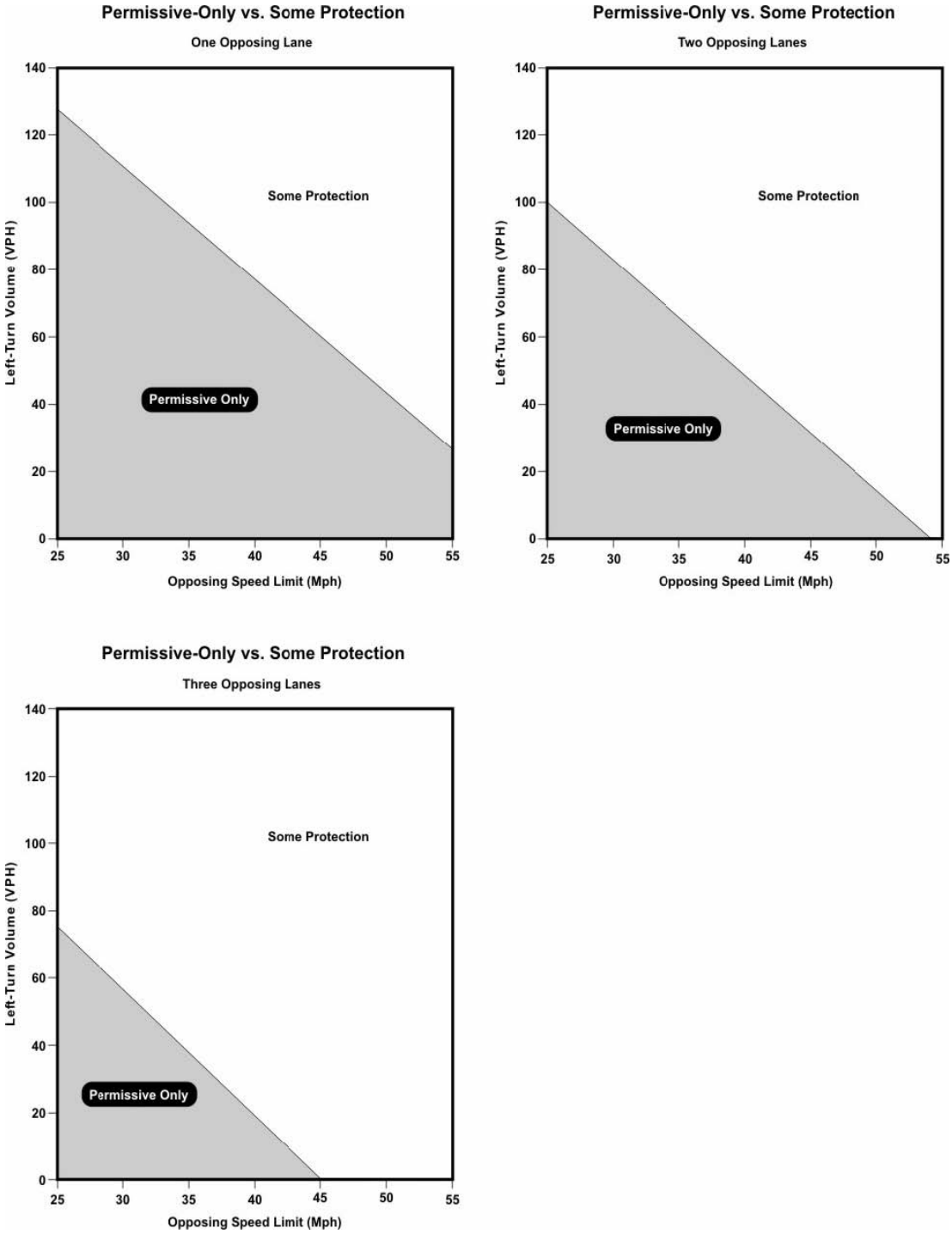
Number of Left-turn Movements on Subject Road	Period During Which Crashes are Considered (years)	Critical Left-Turn-Related Crash Count When Considering Protected-only, C_{pt} (crashes/period)	When Considering Prot.+Perm, C_{p+p} (crashes/period)
One	1	6	4
One	2	11	6
One	3	14	7
Both	1	11	6
Both	2	18	9
Both	3	26	13

Oncoming Traffic Speed Limit (mph)	Minimum Sight Distance to Oncoming Vehicles, SD_c (ft)
25	200
30	240
35	280
40	320
45	360
50	400
55	440
60	480

Variables
V_{lt} = left-turn volume on the subject approach, veh/h
V_o = through plus right-turn volume on the approach opposing the subject left-turn movement, veh/h

Source: Adapted from (Kell and Fullerton, 1998; Orcutt, 1993; Traffic Engineering Manual, 1999).

Figure A-2: Selection Criteria for Left Turn Phasing



From Asante, S. A., S. A. Ardekani, and J. C. Williams. Selection Criteria for Left-Turn Phasing and Indication Sequence. In *Transportation Research Record* 1421, Transportation Research Board, National Research Council, Washington, D.C., 1993, Figure 4, p. 17. Reproduced with permission.

Tables A-1 to A10: Theoretical Minimum Clearance Intervals

Table A - 1
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 30

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	1.7	4.9	3.1	1.7	4.8	3.0	1.7	4.7	2.9	1.7	4.6	2.8	1.7	4.5	2.5	1.7	4.2	2.2	1.7	3.9	2.2	1.7	3.9	2.2	1.7	3.9	2.1	1.7	3.8	2.1	1.7	3.8
	25	3.7	1.4	5.1	3.6	1.4	4.9	3.5	1.4	4.8	3.4	1.4	4.7	3.3	1.4	4.6	2.8	1.4	4.2	2.5	1.4	3.9	2.5	1.4	3.9	2.5	1.4	3.8	2.4	1.4	3.8	2.4	1.4	3.8
	30	4.2	1.1	5.4	4.1	1.1	5.2	4.0	1.1	5.1	3.8	1.1	5.0	3.7	1.1	4.9	3.2	1.1	4.3	2.8	1.1	4.0	2.8	1.1	3.9	2.7	1.1	3.9	2.7	1.1	3.8	2.7	1.1	3.8
	35	4.8	1.0	5.8	4.6	1.0	5.6	4.5	1.0	5.4	4.3	1.0	5.3	4.2	1.0	5.2	3.6	1.0	4.5	3.2	1.0	4.1	3.1	1.0	4.1	3.0	1.0	4.0	3.0	1.0	4.0	2.9	1.0	3.9
	40	5.3	0.9	6.2	5.1	0.9	6.0	5.0	0.9	5.8	4.8	0.9	5.6	4.6	0.9	5.5	3.9	0.9	4.8	3.5	0.9	4.3	3.4	0.9	4.2	3.3	0.9	4.2	3.3	0.9	4.1	3.2	0.9	4.1
	45	5.9	0.8	6.6	5.6	0.8	6.4	5.4	0.8	6.2	5.3	0.8	6.0	5.1	0.8	5.8	4.3	0.8	5.1	3.8	0.8	4.5	3.7	0.8	4.5	3.6	0.8	4.4	3.6	0.8	4.3	3.5	0.8	4.3
	50	6.4	0.7	7.1	6.2	0.7	6.8	5.9	0.7	6.6	5.7	0.7	6.4	5.5	0.7	6.2	4.7	0.7	5.3	4.1	0.7	4.8	4.0	0.7	4.7	3.9	0.7	4.6	3.8	0.7	4.5	3.8	0.7	4.5
	55	6.9	0.6	7.6	6.7	0.6	7.3	6.4	0.6	7.1	6.2	0.6	6.8	6.0	0.6	6.6	5.0	0.6	5.7	4.4	0.6	5.0	4.3	0.6	4.9	4.2	0.6	4.8	4.1	0.6	4.7	4.1	0.6	4.7
	60	7.5	0.6	8.1	7.2	0.6	7.8	6.9	0.6	7.5	6.7	0.6	7.2	6.5	0.6	7.0	5.4	0.6	6.0	4.7	0.6	5.3	4.6	0.6	5.2	4.5	0.6	5.1	4.4	0.6	5.0	4.3	0.6	4.9

Table A - 2
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 40

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	2.0	5.2	3.1	2.0	5.1	3.0	2.0	5.0	2.9	2.0	4.9	2.8	2.0	4.9	2.5	2.0	4.5	2.2	2.0	4.3	2.2	2.0	4.2	2.2	2.0	4.2	2.1	2.0	4.2	2.1	2.0	4.2
	25	3.7	1.6	5.3	3.6	1.6	5.2	3.5	1.6	5.1	3.4	1.6	5.0	3.3	1.6	4.9	2.8	1.6	4.5	2.5	1.6	4.2	2.5	1.6	4.1	2.5	1.6	4.1	2.4	1.6	4.1	2.4	1.6	4.0
	30	4.2	1.4	5.6	4.1	1.4	5.5	4.0	1.4	5.3	3.8	1.4	5.2	3.7	1.4	5.1	3.2	1.4	4.6	2.8	1.4	4.2	2.8	1.4	4.2	2.7	1.4	4.1	2.7	1.4	4.1	2.7	1.4	4.0
	35	4.8	1.2	6.0	4.6	1.2	5.8	4.5	1.2	5.6	4.3	1.2	5.5	4.2	1.2	5.4	3.6	1.2	4.7	3.2	1.2	4.3	3.1	1.2	4.3	3.0	1.2	4.2	3.0	1.2	4.2	2.9	1.2	4.1
	40	5.3	1.0	6.3	5.1	1.0	6.2	5.0	1.0	6.0	4.8	1.0	5.8	4.6	1.0	5.7	3.9	1.0	5.0	3.5	1.0	4.5	3.4	1.0	4.4	3.3	1.0	4.4	3.3	1.0	4.3	3.2	1.0	4.2
	45	5.9	0.9	6.8	5.6	0.9	6.6	5.4	0.9	6.4	5.3	0.9	6.2	5.1	0.9	6.0	4.3	0.9	5.2	3.8	0.9	4.7	3.7	0.9	4.6	3.6	0.9	4.5	3.6	0.9	4.5	3.5	0.9	4.4
	50	6.4	0.8	7.2	6.2	0.8	7.0	5.9	0.8	6.8	5.7	0.8	6.6	5.5	0.8	6.4	4.7	0.8	5.5	4.1	0.8	4.9	4.0	0.8	4.8	3.9	0.8	4.7	3.8	0.8	4.7	3.8	0.8	4.6
	55	6.9	0.7	7.7	6.7	0.7	7.4	6.4	0.7	7.2	6.2	0.7	7.0	6.0	0.7	6.7	5.0	0.7	5.8	4.4	0.7	5.1	4.3	0.7	5.0	4.2	0.7	5.0	4.1	0.7	4.9	4.1	0.7	4.8
	60	7.5	0.7	8.2	7.2	0.7	7.9	6.9	0.7	7.6	6.7	0.7	7.4	6.5	0.7	7.1	5.4	0.7	6.1	4.7	0.7	5.4	4.6	0.7	5.3	4.5	0.7	5.2	4.4	0.7	5.1	4.3	0.7	5.0

Table A - 3
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 50

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	2.4	5.5	3.1	2.4	5.5	3.0	2.4	5.4	2.9	2.4	5.3	2.8	2.4	5.2	2.5	2.4	4.9	2.2	2.4	4.6	2.2	2.4	4.6	2.2	2.4	4.6	2.1	2.4	4.5	2.1	2.4	4.5
	25	3.7	1.9	5.6	3.6	1.9	5.5	3.5	1.9	5.4	3.4	1.9	5.3	3.3	1.9	5.2	2.8	1.9	4.7	2.5	1.9	4.4	2.5	1.9	4.4	2.5	1.9	4.4	2.4	1.9	4.3	2.4	1.9	4.3
	30	4.2	1.6	5.8	4.1	1.6	5.7	4.0	1.6	5.6	3.8	1.6	5.4	3.7	1.6	5.3	3.2	1.6	4.8	2.8	1.6	4.4	2.8	1.6	4.4	2.7	1.6	4.3	2.7	1.6	4.3	2.7	1.6	4.3
	35	4.8	1.4	6.1	4.6	1.4	6.0	4.5	1.4	5.8	4.3	1.4	5.7	4.2	1.4	5.5	3.6	1.4	4.9	3.2	1.4	4.5	3.1	1.4	4.5	3.0	1.4	4.4	3.0	1.4	4.4	2.9	1.4	4.3
	40	5.3	1.2	6.5	5.1	1.2	6.3	5.0	1.2	6.1	4.8	1.2	6.0	4.6	1.2	5.8	3.9	1.2	5.1	3.5	1.2	4.7	3.4	1.2	4.6	3.3	1.2	4.5	3.3	1.2	4.5	3.2	1.2	4.4
	45	5.9	1.1	6.9	5.6	1.1	6.7	5.4	1.1	6.5	5.3	1.1	6.3	5.1	1.1	6.2	4.3	1.1	5.4	3.8	1.1	4.8	3.7	1.1	4.8	3.6	1.1	4.7	3.6	1.1	4.6	3.5	1.1	4.6
	50	6.4	1.0	7.4	6.2	1.0	7.1	5.9	1.0	6.9	5.7	1.0	6.7	5.5	1.0	6.5	4.7	1.0	5.6	4.1	1.0	5.0	4.0	1.0	4.9	3.9	1.0	4.9	3.8	1.0	4.8	3.8	1.0	4.7
	55	6.9	0.9	7.8	6.7	0.9	7.5	6.4	0.9	7.3	6.2	0.9	7.1	6.0	0.9	6.9	5.0	0.9	5.9	4.4	0.9	5.2	4.3	0.9	5.2	4.2	0.9	5.1	4.1	0.9	5.0	4.1	0.9	4.9
	60	7.5	0.8	8.3	7.2	0.8	8.0	6.9	0.8	7.7	6.7	0.8	7.5	6.5	0.8	7.2	5.4	0.8	6.2	4.7	0.8	5.5	4.6	0.8	5.4	4.5	0.8	5.3	4.4	0.8	5.2	4.3	0.8	5.1

Table A - 4
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 60

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	2.7	5.9	3.1	2.7	5.8	3.0	2.7	5.7	2.9	2.7	5.6	2.8	2.7	5.5	2.5	2.7	5.2	2.2	2.7	5.0	2.2	2.7	4.9	2.2	2.7	4.9	2.1	2.7	4.9	2.1	2.7	4.8
	25	3.7	2.2	5.9	3.6	2.2	5.8	3.5	2.2	5.7	3.4	2.2	5.5	3.3	2.2	5.5	2.8	2.2	5.0	2.5	2.2	4.7	2.5	2.2	4.7	2.5	2.2	4.6	2.4	2.2	4.6	2.4	2.2	4.6
	30	4.2	1.8	6.1	4.1	1.8	5.9	4.0	1.8	5.8	3.8	1.8	5.7	3.7	1.8	5.5	3.2	1.8	5.0	2.8	1.8	4.7	2.8	1.8	4.6	2.7	1.8	4.6	2.7	1.8	4.5	2.7	1.8	4.5
	35	4.8	1.6	6.3	4.6	1.6	6.2	4.5	1.6	6.0	4.3	1.6	5.9	4.2	1.6	5.7	3.6	1.6	5.1	3.2	1.6	4.7	3.1	1.6	4.7	3.0	1.6	4.6	3.0	1.6	4.5	2.9	1.6	4.5
	40	5.3	1.4	6.7	5.1	1.4	6.5	5.0	1.4	6.3	4.8	1.4	6.2	4.6	1.4	6.0	3.9	1.4	5.3	3.5	1.4	4.8	3.4	1.4	4.8	3.3	1.4	4.7	3.3	1.4	4.6	3.2	1.4	4.6
	45	5.9	1.2	7.1	5.6	1.2	6.9	5.4	1.2	6.7	5.3	1.2	6.5	5.1	1.2	6.3	4.3	1.2	5.5	3.8	1.2	5.0	3.7	1.2	4.9	3.6	1.2	4.8	3.6	1.2	4.8	3.5	1.2	4.7
	50	6.4	1.1	7.5	6.2	1.1	7.3	5.9	1.1	7.0	5.7	1.1	6.8	5.5	1.1	6.6	4.7	1.1	5.8	4.1	1.1	5.2	4.0	1.1	5.1	3.9	1.1	5.0	3.8	1.1	4.9	3.8	1.1	4.9
	55	6.9	1.0	7.9	6.7	1.0	7.7	6.4	1.0	7.4	6.2	1.0	7.2	6.0	1.0	7.0	5.0	1.0	6.0	4.4	1.0	5.4	4.3	1.0	5.3	4.2	1.0	5.2	4.1	1.0	5.1	4.1	1.0	5.0
	60	7.5	0.9	8.4	7.2	0.9	8.1	6.9	0.9	7.8	6.7	0.9	7.6	6.5	0.9	7.4	5.4	0.9	6.3	4.7	0.9	5.6	4.6	0.9	5.5	4.5	0.9	5.4	4.4	0.9	5.3	4.3	0.9	5.2

Table A - 5
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 70

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	3.1	6.2	3.1	3.1	6.1	3.0	3.1	6.0	2.9	3.1	6.0	2.8	3.1	5.9	2.5	3.1	5.5	2.2	3.1	5.3	2.2	3.1	5.3	2.2	3.1	5.2	2.1	3.1	5.2	2.1	3.1	5.2
	25	3.7	2.5	6.2	3.6	2.5	6.0	3.5	2.5	5.9	3.4	2.5	5.8	3.3	2.5	5.7	2.8	2.5	5.3	2.5	2.5	5.0	2.5	2.5	5.0	2.5	2.5	4.9	2.4	2.5	4.9	2.4	2.5	4.8
	30	4.2	2.0	6.3	4.1	2.0	6.1	4.0	2.0	6.0	3.8	2.0	5.9	3.7	2.0	5.8	3.2	2.0	5.2	2.8	2.0	4.9	2.8	2.0	4.8	2.7	2.0	4.8	2.7	2.0	4.8	2.7	2.0	4.7
	35	4.8	1.8	6.5	4.6	1.8	6.4	4.5	1.8	6.2	4.3	1.8	6.1	4.2	1.8	5.9	3.6	1.8	5.3	3.2	1.8	4.9	3.1	1.8	4.8	3.0	1.8	4.8	3.0	1.8	4.7	2.9	1.8	4.7
	40	5.3	1.5	6.9	5.1	1.5	6.7	5.0	1.5	6.5	4.8	1.5	6.3	4.6	1.5	6.2	3.9	1.5	5.5	3.5	1.5	5.0	3.4	1.5	4.9	3.3	1.5	4.9	3.3	1.5	4.8	3.2	1.5	4.8
	45	5.9	1.4	7.2	5.6	1.4	7.0	5.4	1.4	6.8	5.3	1.4	6.6	5.1	1.4	6.5	4.3	1.4	5.7	3.8	1.4	5.1	3.7	1.4	5.1	3.6	1.4	5.0	3.6	1.4	4.9	3.5	1.4	4.9
	50	6.4	1.2	7.6	6.2	1.2	7.4	5.9	1.2	7.2	5.7	1.2	7.0	5.5	1.2	6.8	4.7	1.2	5.9	4.1	1.2	5.3	4.0	1.2	5.2	3.9	1.2	5.1	3.8	1.2	5.1	3.8	1.2	5.0
	55	6.9	1.1	8.1	6.7	1.1	7.8	6.4	1.1	7.5	6.2	1.1	7.3	6.0	1.1	7.1	5.0	1.1	6.1	4.4	1.1	5.5	4.3	1.1	5.4	4.2	1.1	5.3	4.1	1.1	5.2	4.1	1.1	5.2
	60	7.5	1.0	8.5	7.2	1.0	8.2	6.9	1.0	7.9	6.7	1.0	7.7	6.5	1.0	7.5	5.4	1.0	6.4	4.7	1.0	5.7	4.6	1.0	5.6	4.5	1.0	5.5	4.4	1.0	5.4	4.3	1.0	5.4

Table A - 6
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 80

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	3.4	6.6	3.1	3.4	6.5	3.0	3.4	6.4	2.9	3.4	6.3	2.8	3.4	6.2	2.5	3.4	5.9	2.2	3.4	5.6	2.2	3.4	5.6	2.2	3.4	5.6	2.1	3.4	5.5	2.1	3.4	5.5
	25	3.7	2.7	6.4	3.6	2.7	6.3	3.5	2.7	6.2	3.4	2.7	6.1	3.3	2.7	6.0	2.8	2.7	5.6	2.5	2.7	5.3	2.5	2.7	5.2	2.5	2.7	5.2	2.4	2.7	5.1	2.4	2.7	5.1
	30	4.2	2.3	6.5	4.1	2.3	6.4	4.0	2.3	6.2	3.8	2.3	6.1	3.7	2.3	6.0	3.2	2.3	5.5	2.8	2.3	5.1	2.8	2.3	5.1	2.7	2.3	5.0	2.7	2.3	5.0	2.7	2.3	4.9
	35	4.8	1.9	6.7	4.6	1.9	6.6	4.5	1.9	6.4	4.3	1.9	6.3	4.2	1.9	6.1	3.6	1.9	5.5	3.2	1.9	5.1	3.1	1.9	5.0	3.0	1.9	5.0	3.0	1.9	4.9	2.9	1.9	4.9
	40	5.3	1.7	7.0	5.1	1.7	6.8	5.0	1.7	6.7	4.8	1.7	6.5	4.6	1.7	6.3	3.9	1.7	5.6	3.5	1.7	5.2	3.4	1.7	5.1	3.3	1.7	5.0	3.3	1.7	5.0	3.2	1.7	4.9
	45	5.9	1.5	7.4	5.6	1.5	7.2	5.4	1.5	7.0	5.3	1.5	6.8	5.1	1.5	6.6	4.3	1.5	5.8	3.8	1.5	5.3	3.7	1.5	5.2	3.6	1.5	5.1	3.6	1.5	5.1	3.5	1.5	5.0
	50	6.4	1.4	7.8	6.2	1.4	7.5	5.9	1.4	7.3	5.7	1.4	7.1	5.5	1.4	6.9	4.7	1.4	6.0	4.1	1.4	5.4	4.0	1.4	5.4	3.9	1.4	5.3	3.8	1.4	5.2	3.8	1.4	5.1
	55	6.9	1.2	8.2	6.7	1.2	7.9	6.4	1.2	7.7	6.2	1.2	7.4	6.0	1.2	7.2	5.0	1.2	6.3	4.4	1.2	5.6	4.3	1.2	5.5	4.2	1.2	5.4	4.1	1.2	5.4	4.1	1.2	5.3
	60	7.5	1.1	8.6	7.2	1.1	8.3	6.9	1.1	8.1	6.7	1.1	7.8	6.5	1.1	7.6	5.4	1.1	6.5	4.7	1.1	5.8	4.6	1.1	5.7	4.5	1.1	5.6	4.4	1.1	5.5	4.3	1.1	5.5

Table A - 7
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 90

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	3.8	6.9	3.1	3.8	6.8	3.0	3.8	6.7	2.9	3.8	6.6	2.8	3.8	6.6	2.5	3.8	6.2	2.2	3.8	6.0	2.2	3.8	5.9	2.2	3.8	5.9	2.1	3.8	5.9	2.1	3.8	5.9
	25	3.7	3.0	6.7	3.6	3.0	6.6	3.5	3.0	6.5	3.4	3.0	6.4	3.3	3.0	6.3	2.8	3.0	5.8	2.5	3.0	5.5	2.5	3.0	5.5	2.5	3.0	5.5	2.4	3.0	5.4	2.4	3.0	5.4
	30	4.2	2.5	6.7	4.1	2.5	6.6	4.0	2.5	6.5	3.8	2.5	6.3	3.7	2.5	6.2	3.2	2.5	5.7	2.8	2.5	5.3	2.8	2.5	5.3	2.7	2.5	5.2	2.7	2.5	5.2	2.7	2.5	5.2
	35	4.8	2.1	6.9	4.6	2.1	6.8	4.5	2.1	6.6	4.3	2.1	6.5	4.2	2.1	6.3	3.6	2.1	5.7	3.2	2.1	5.3	3.1	2.1	5.2	3.0	2.1	5.2	3.0	2.1	5.1	2.9	2.1	5.1
	40	5.3	1.9	7.2	5.1	1.9	7.0	5.0	1.9	6.8	4.8	1.9	6.7	4.6	1.9	6.5	3.9	1.9	5.8	3.5	1.9	5.3	3.4	1.9	5.3	3.3	1.9	5.2	3.3	1.9	5.1	3.2	1.9	5.1
	45	5.9	1.7	7.5	5.6	1.7	7.3	5.4	1.7	7.1	5.3	1.7	6.9	5.1	1.7	6.8	4.3	1.7	6.0	3.8	1.7	5.4	3.7	1.7	5.4	3.6	1.7	5.3	3.6	1.7	5.2	3.5	1.7	5.2
	50	6.4	1.5	7.9	6.2	1.5	7.7	5.9	1.5	7.4	5.7	1.5	7.2	5.5	1.5	7.0	4.7	1.5	6.2	4.1	1.5	5.6	4.0	1.5	5.5	3.9	1.5	5.4	3.8	1.5	5.3	3.8	1.5	5.3
	55	6.9	1.4	8.3	6.7	1.4	8.0	6.4	1.4	7.8	6.2	1.4	7.6	6.0	1.4	7.4	5.0	1.4	6.4	4.4	1.4	5.7	4.3	1.4	5.7	4.2	1.4	5.6	4.1	1.4	5.5	4.1	1.4	5.4
	60	7.5	1.3	8.7	7.2	1.3	8.4	6.9	1.3	8.2	6.7	1.3	7.9	6.5	1.3	7.7	5.4	1.3	6.7	4.7	1.3	5.9	4.6	1.3	5.8	4.5	1.3	5.7	4.4	1.3	5.7	4.3	1.3	5.6

Table A - 8
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 100

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	4.1	7.3	3.1	4.1	7.2	3.0	4.1	7.1	2.9	4.1	7.0	2.8	4.1	6.9	2.5	4.1	6.6	2.2	4.1	6.3	2.2	4.1	6.3	2.2	4.1	6.3	2.1	4.1	6.2	2.1	4.1	6.2
	25	3.7	3.3	7.0	3.6	3.3	6.9	3.5	3.3	6.7	3.4	3.3	6.6	3.3	3.3	6.5	2.8	3.3	6.1	2.5	3.3	5.8	2.5	3.3	5.8	2.5	3.3	5.7	2.4	3.3	5.7	2.4	3.3	5.7
	30	4.2	2.7	7.0	4.1	2.7	6.8	4.0	2.7	6.7	3.8	2.7	6.6	3.7	2.7	6.5	3.2	2.7	5.9	2.8	2.7	5.6	2.8	2.7	5.5	2.7	2.7	5.5	2.7	2.7	5.4	2.7	2.7	5.4
	35	4.8	2.3	7.1	4.6	2.3	7.0	4.5	2.3	6.8	4.3	2.3	6.7	4.2	2.3	6.5	3.6	2.3	5.9	3.2	2.3	5.5	3.1	2.3	5.4	3.0	2.3	5.4	3.0	2.3	5.3	2.9	2.3	5.3
	40	5.3	2.0	7.4	5.1	2.0	7.2	5.0	2.0	7.0	4.8	2.0	6.8	4.6	2.0	6.7	3.9	2.0	6.0	3.5	2.0	5.5	3.4	2.0	5.4	3.3	2.0	5.4	3.3	2.0	5.3	3.2	2.0	5.3
	45	5.9	1.8	7.7	5.6	1.8	7.5	5.4	1.8	7.3	5.3	1.8	7.1	5.1	1.8	6.9	4.3	1.8	6.1	3.8	1.8	5.6	3.7	1.8	5.5	3.6	1.8	5.4	3.6	1.8	5.4	3.5	1.8	5.3
	50	6.4	1.6	8.0	6.2	1.6	7.8	5.9	1.6	7.6	5.7	1.6	7.4	5.5	1.6	7.2	4.7	1.6	6.3	4.1	1.6	5.7	4.0	1.6	5.6	3.9	1.6	5.6	3.8	1.6	5.5	3.8	1.6	5.4
	55	6.9	1.5	8.4	6.7	1.5	8.2	6.4	1.5	7.9	6.2	1.5	7.7	6.0	1.5	7.5	5.0	1.5	6.5	4.4	1.5	5.9	4.3	1.5	5.8	4.2	1.5	5.7	4.1	1.5	5.6	4.1	1.5	5.5
	60	7.5	1.4	8.9	7.2	1.4	8.6	6.9	1.4	8.3	6.7	1.4	8.0	6.5	1.4	7.8	5.4	1.4	6.8	4.7	1.4	6.1	4.6	1.4	6.0	4.5	1.4	5.9	4.4	1.4	5.8	4.3	1.4	5.7

Table A - 9
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 110

Approach Speed (mph)	Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
	Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
	20	3.2	4.4	7.6	3.1	4.4	7.5	3.0	4.4	7.4	2.9	4.4	7.3	2.8	4.4	7.2	2.5	4.4	6.9	2.2	4.4	6.7	2.2	4.4	6.6	2.2	4.4	6.6	2.1	4.4	6.6	2.1	4.4	6.5
	25	3.7	3.5	7.2	3.6	3.5	7.1	3.5	3.5	7.0	3.4	3.5	6.9	3.3	3.5	6.8	2.8	3.5	6.4	2.5	3.5	6.1	2.5	3.5	6.0	2.5	3.5	6.0	2.4	3.5	6.0	2.4	3.5	5.9
	30	4.2	3.0	7.2	4.1	3.0	7.1	4.0	3.0	6.9	3.8	3.0	6.8	3.7	3.0	6.7	3.2	3.0	6.2	2.8	3.0	5.8	2.8	3.0	5.7	2.7	3.0	5.7	2.7	3.0	5.7	2.7	3.0	5.6
	35	4.8	2.5	7.3	4.6	2.5	7.1	4.5	2.5	7.0	4.3	2.5	6.8	4.2	2.5	6.7	3.6	2.5	6.1	3.2	2.5	5.7	3.1	2.5	5.6	3.0	2.5	5.6	3.0	2.5	5.5	2.9	2.5	5.5
	40	5.3	2.2	7.5	5.1	2.2	7.3	5.0	2.2	7.2	4.8	2.2	7.0	4.6	2.2	6.9	3.9	2.2	6.1	3.5	2.2	5.7	3.4	2.2	5.6	3.3	2.2	5.5	3.3	2.2	5.5	3.2	2.2	5.4
	45	5.9	2.0	7.8	5.6	2.0	7.6	5.4	2.0	7.4	5.3	2.0	7.2	5.1	2.0	7.1	4.3	2.0	6.3	3.8	2.0	5.7	3.7	2.0	5.7	3.6	2.0	5.6	3.6	2.0	5.5	3.5	2.0	5.5
	50	6.4	1.8	8.2	6.2	1.8	7.9	5.9	1.8	7.7	5.7	1.8	7.5	5.5	1.8	7.3	4.7	1.8	6.4	4.1	1.8	5.8	4.0	1.8	5.8	3.9	1.8	5.7	3.8	1.8	5.6	3.8	1.8	5.5
	55	6.9	1.6	8.6	6.7	1.6	8.3	6.4	1.6	8.0	6.2	1.6	7.8	6.0	1.6	7.6	5.0	1.6	6.6	4.4	1.6	6.0	4.3	1.6	5.9	4.2	1.6	5.8	4.1	1.6	5.7	4.1	1.6	5.7
	60	7.5	1.5	9.0	7.2	1.5	8.7	6.9	1.5	8.4	6.7	1.5	8.2	6.5	1.5	7.9	5.4	1.5	6.9	4.7	1.5	6.2	4.6	1.5	6.1	4.5	1.5	6.0	4.4	1.5	5.9	4.3	1.5	5.8

Table A - 10
Theoretical Minimum Clearance Intervals
Intersection Width (ft) = 120

Grade (%)	-10			-9			-8			-7			-6			-5 to +5			+6			+7			+8			+9			+10		
Interval	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T	Y	R	T
Approach Speed (mph) 20	3.2	4.8	7.9	3.1	4.8	7.8	3.0	4.8	7.7	2.9	4.8	7.7	2.8	4.8	7.6	2.5	4.8	7.2	2.2	4.8	7.0	2.2	4.8	7.0	2.2	4.8	6.9	2.1	4.8	6.9	2.1	4.8	6.9
25	3.7	3.8	7.5	3.6	3.8	7.4	3.5	3.8	7.3	3.4	3.8	7.2	3.3	3.8	7.1	2.8	3.8	6.7	2.5	3.8	6.4	2.5	3.8	6.3	2.5	3.8	6.3	2.4	3.8	6.2	2.4	3.8	6.2
30	4.2	3.2	7.4	4.1	3.2	7.3	4.0	3.2	7.1	3.8	3.2	7.0	3.7	3.2	6.9	3.2	3.2	6.4	2.8	3.2	6.0	2.8	3.2	6.0	2.7	3.2	5.9	2.7	3.2	5.9	2.7	3.2	5.8
35	4.8	2.7	7.5	4.6	2.7	7.3	4.5	2.7	7.2	4.3	2.7	7.0	4.2	2.7	6.9	3.6	2.7	6.3	3.2	2.7	5.9	3.1	2.7	5.8	3.0	2.7	5.8	3.0	2.7	5.7	2.9	2.7	5.7
40	5.3	2.4	7.7	5.1	2.4	7.5	5.0	2.4	7.3	4.8	2.4	7.2	4.6	2.4	7.0	3.9	2.4	6.3	3.5	2.4	5.8	3.4	2.4	5.8	3.3	2.4	5.7	3.3	2.4	5.7	3.2	2.4	5.6
45	5.9	2.1	8.0	5.6	2.1	7.8	5.4	2.1	7.6	5.3	2.1	7.4	5.1	2.1	7.2	4.3	2.1	6.4	3.8	2.1	5.9	3.7	2.1	5.8	3.6	2.1	5.7	3.6	2.1	5.7	3.5	2.1	5.6
50	6.4	1.9	8.3	6.2	1.9	8.1	5.9	1.9	7.8	5.7	1.9	7.6	5.5	1.9	7.5	4.7	1.9	6.6	4.1	1.9	6.0	4.0	1.9	5.9	3.9	1.9	5.8	3.8	1.9	5.8	3.8	1.9	5.7
55	6.9	1.7	8.7	6.7	1.7	8.4	6.4	1.7	8.2	6.2	1.7	7.9	6.0	1.7	7.7	5.0	1.7	6.8	4.4	1.7	6.1	4.3	1.7	6.0	4.2	1.7	5.9	4.1	1.7	5.9	4.1	1.7	5.8
60	7.5	1.6	9.1	7.2	1.6	8.8	6.9	1.6	8.5	6.7	1.6	8.3	6.5	1.6	8.0	5.4	1.6	7.0	4.7	1.6	6.3	4.6	1.6	6.2	4.5	1.6	6.1	4.4	1.6	6.0	4.3	1.6	5.9

Table A-11: Conversion from Miles per Hour To Feet per Second

Y = Yellow Change Interval = $t + \frac{V}{2a+64.4g}$

R = Red Clearance Interval = $\frac{W+L}{V}$

T = Total Clearance Interval = $(Y + R)$

Where,

t = perception-reaction time, seconds (1 second for tables above)
V = approach speed, feet/second
a = deceleration rate, feet/second^2 (10 feet/second^2 for tables above)
g = percent of grade divided by 100 (+ for upgrade, - for downgrade)
W = width of intersection, feet
L = length of vehicle, feet (20 feet for tables above)

Table A - 11
Conversion from Miles per Hour (MPH) to Feet per Second (FPS)

MPH	FPS
15	22.00
20	29.33
25	36.67
30	44.00
35	51.33
40	58.67
45	66.00
50	73.33
55	80.67
60	88.00
65	95.33
70	102.67

To convert MPH to FPS multiply by 1.4667

Metropolitan Government of Nashville
and Davidson County Department of Public Works,
Engineering Division

ENGINEERING POLICY FORM

Section: Engineering / Traffic	**Policy No.**
Subject: Traffic Signal Timing and Phasing	**Effective:** September 1, 2010 **Page:** 1 of 1
Applies To : Engineers and Technicians	___ **New Issue** _X_ **Partial Revision** ___ **Complete Revision**

Purpose:
This policy is intended to govern traffic signal timing and phasing within Metro Nashville. All signal timing and phasing practices must be compliant with the current edition of the Manual on Uniform Traffic Control Devices (MUTCD). Should a conflict arise the MUTCD shall prevail. This policy has been updated to be consistent with changes in the 2009 edition of the MUTCD.

Policy:
The attached document establishes standard practices and operational procedures for traffic signal timing parameters to be used by MPW staff and consulting engineers performing signal timing services for MPW. The guidelines referenced in the document titled "Traffic Signal Timing and Phasing Policy" are to be implemented at new traffic signal installations, traffic signal upgrades, and along signalized corridors as they are re-timed. The adoption of this policy does not imply that each and every traffic signal under the jurisdiction of the Metro Nashville Department of Public Works will automatically comply with these new guidelines. Rather, traffic signal settings will be updated along signalized corridors throughout Metro as they are re-timed. This policy should serve to provide consistent, safe, and efficient control of traffic signals within Metro Nashville. This policy has been updated to be consistent with changes in the 2009 edition of the MUTCD.

Exceptions:
This policy has been established to provide guidance on various signal timing parameters. However, signal timing should be evaluated for all situations independently based upon standard traffic engineering principles and local intersection characteristics. Necessary adjustments using proper engineering judgment and documented with an engineering study should be made to meet the traffic conditions at each individual signalized intersection.

Revision No.: 1 **Revision Date:** August 1, 2010	**Issued by:** Mark Macy, P.E.