PROCEDURE

SIGNS

SIGNALS

MARKINGS

SPECIAL OPERATIONAL TOPICS

Section 3.1

SIGNALIZED INTERSECTION FLASHING MODE OPERATION AND FLASHING BEACONS

3.1.1 DEFINITIONS

Flashing Beacon. A Flashing Beacon is a highway traffic signal with one or more signal sections that operates in a flashing mode. It can provide traffic control when used as an intersection control beacon or as a warning beacon in alternative uses.

Flashing Operation of Traffic Control Signals.

(1) **Non-Programmed Flashing Mode Operation.** The automatic transfer from a signalized intersection's normal mode operation (stop and go, steady red-yellow-green displays) to flashing mode operation (stop or caution, flashing red-yellow, or red indications) caused by a malfunction of the signal controller, a conflict in signal displays or manual selection of the flashing mode operation by maintenance or police personnel.

(2) **Programmed Flashing Mode Operation.** The automatic transfer from a signalized intersection's normal mode operation (stop and go, steady red-yellow-green displays) to flashing mode operation (stop or caution, flashing red-yellow or red indications) during set times during the day.

3.1.2 RECOMMENDATIONS FOR SIGNALIZED INTERSECTIONS

3.1.2.1 Programmed Flashing Mode Operation

Flashing operation is both energy and operationally efficient and is encouraged when consistent with the following recommendations:

(1) Flashing yellow/red operation may be used when two-way traffic volumes on the main street are below 200 vehicles per hour.

(2) Flashing yellow/red operation may be used during any hours of the day or night when ***Warrant 1 and Warrant 2 of the MUTCD*** are not met and where the two-way main street volume is greater than 200 vehicles per hour, provided the ratio of main street to side street volume is greater than 4:1.

(3) Signal operation should be changed to regular operation if crash pattern or severity increases or there is an increase in conflicts.

(4) A speedway effect can be avoided and uniform speeds obtained by maintaining sufficient signals cycling through steady red, green and yellow at proper spacing so as to provide signal progression at an appropriate speed.

(5) Traffic signals should be put on flashing operation primarily at simple traffic signal controlled intersections where the side street drivers have an unrestricted view of approaching main street traffic. Intersections with more than four legs, skewed intersections (greater than 15 degrees), or railroad preempted signals should not be considered for flash.

(6) Flashing should be restricted to no more than 3 separate periods in a 24-hour period.

3.1.2.2 Non-Programmed Flashing Mode Operation

All signalized intersections shall automatically transfer to flashing mode immediately (no clearance interval) whenever a malfunction occurs during the normal mode operation of the signalized intersection.

3.1.3 APPLICATION REQUIREMENTS FOR SIGNALIZED INTERSECTION

The signal flashing mode and start-up sequence shall be as follows for:

3.1.3.1 Yellow-Red Flashing Mode

(1) **Main Street.** Flashing yellow during flashing mode, then steady green on start-up sequence.

(2) **Protected Left Turns.** Flashing red during flashing mode, then steady red on start-up sequence. Protected left turn signals should carry all arrow indications.

(3) **Side Street.** Flashing red during flashing mode, then steady red on start-up sequence.

3.1.3.2 Red-Red Flashing Mode

(1) **Main Street.** Flashing red during flashing mode, then steady green on start-up sequence.

(2) **Protected Left Turns.** Flashing red during flashing mode, then steady red on start-up sequence. Protected left turn signals should contain all arrow indications.

(3) **Side Street.** Flashing red during flashing mode, then steady red on start-up sequence.

3.1.4 HEADS TO BE FLASHED

Section 4D.30 of the MUTCD requires all signal faces on an approach to be flashed when the signal is in flashing mode operation. Therefore, a left or right turn signal not illuminated during flashing mode operation is unacceptable. ***Section 4D.30 of the MUTCD*** requires the flashing of red or yellow arrow indications.

Pedestrian signal indications (WALK and DON'T WALK) shall not be illuminated during flashing mode operation at signalized intersections.

3.1.5 FLASHING INDICATION COLORS

(1) The color to be flashed, red or yellow circular indication, or arrow indications shall be determined as follows:

(a) Each approach or separately-controlled turn movement that is controlled during normal stop-and-go operation shall be provided with a flashing display.

(b) All signal faces on an approach shall flash the same color, either yellow or red circular or arrow. However, separate signal faces for separately-controlled turn movements may be flashed as described in ***Section 4D.30 of the MUTCD***. Flashing yellow indications for through traffic do not have to be shielded or positioned to prevent visual conflict for drivers in separately-controlled turn lanes; however, shielding for separate protected turn movements shall be in accordance with ***Section 4D.22***, ***Section 4D.23***, and ***Section 4D.24 of the MUTCD***.

(c) When a signal face consisting entirely of arrow indications is to be put on flashing operation, or when a signal face contains no circular indication of the color that is to be flashed, the appropriate red or yellow arrow indication shall be flashed.

(d) When a signal face includes both circular and arrow indications of the color that is to be flashed, only the circular indication of that color shall be flashed. A 5-section head cluster shall be flashed the same color as the approach through lanes. Only circular red or circular yellow indications shall be flashed in a flashing mode operation.

(e) No steady green indication or flashing yellow indication shall be terminated and immediately followed by a steady red or flashing red indication without the display of the steady yellow change indication; however, transition may be made directly from a steady green indication to a flashing yellow indication. This applies to both the circular and arrow indications. The transition from stop-and-go to flashing operation, when the transition is initiated by a signal conflict monitor or by a manual switch, may be made at any time.

(2) **Main Street, Through Traffic.** From flashing yellow to steady green.

(3) **Main Street, Separate Left Turn.** From flashing red to steady red.

(4) **Side Street, Through Traffic.** From flashing red to steady red.

(5) Green arrow indications which are continuously illuminated during normal operations should be continually illuminated during flashing mode operation.

3.1.6 APPLICATION REQUIREMENTS FOR FLASHING BEACONS

(1) All existing flashing beacons are considered to meet the ***MUTCD*** requirements whether they are single or dual indicated.

(2) However, all new or replacement intersection control beacon installations shall be designed and installed with dual indications. Wherever practical, the dual indications shall both be positioned laterally within each approach width to the intersection. For example, a four-way beacon assembly over each side of a divided four-lane highway does not meet this requirement. In no instance shall intersection control beacon indications on an approach be closer than 8 feet apart measured horizontally.

3.1.7 OPERATION OF FLASHING BEACONS

(1) Intersection Control Beacons. Dual indications for intersection control beacons displaying horizontally aligned red indications shall be flashed simultaneously. Alternate flashing of dual horizontally aligned red indications is reserved for highway approaches to a railroad. Two vertically aligned red signal indications shall be flashed alternately. Refer to ***Section 4L.02 of the MUTCD***.

(2) Warning Beacons. Warning beacons typically are installed at obstructions or to emphasize warning signs. These may be singular or dual indications and may be flashed alternately or simultaneously. Refer to ***Section 4L.03 of the MUTCD***.

Section 3.2

GUIDELINES FOR LEFT TURN TREATMENT

3.2.1 PURPOSE

The purpose of this section is to provide guidelines to determine the selection of the following types of left turn treatments, as defined in ***Section 4D.17 of the MUTCD***:

(1) Permissive Only Mode

(2) Protected/Permissive Mode

(3) Protected Only Mode

(4) Split Phasing (each direction alternatively has both left turn green arrow and circular green)

Option:

(5) A flashing YELLOW ARROW signal indication may be displayed to indicate a permissive left-turn movement in either a protected/permissive mode or a permissive only mode of operation.

(6) It is not necessary that the left-turn mode for an approach always be the same throughout the day. Varying the left-turn mode on an approach among the permissive only and/or the protected/permissive and/or the protected only left-turn modes, during different periods of the day is acceptable.

3.2.2 LEFT TURN SIGNAL PHASING

(1) If the need for left turn phasing on an intersection approach has been firmly established, the following guidelines should be used to select the type of left turn phasing to provide. Sound traffic engineering judgment should be exercised in applying these guidelines.

(2) A protected/permissive mode should be provided for all intersection approaches that require a left turn phase unless there is a compelling reason for using another type of left turn phasing. If the decision between providing protected/permissive or protected only mode is not obvious, the traffic engineer should initially operate the left turn phase as protected/permissive mode on a trial basis. If satisfactory operations result, the protected/permissive mode should be retained. If unsatisfactory operations result, the protected/permissive mode should be converted to protected only mode.

(3) A protected only mode shall be provided for an intersection approach if any of the following conditions exist:

(a) Two or more left turn only lanes are provided.

(b) Geometric conditions and resulting sight distance necessitate protected only mode.

(c) The approach is the lead portion of a lead/lag intersection phasing sequence.

(d) The use of offset left turn lanes to the degree that the cone of vision requirements in ***Section 4D.13 of the MUTCD*** for the shared signal display cannot be met.

(4) A protected only mode may be considered if any of the following conditions exist:

(a) Speed limit of opposing traffic is higher than 45 mph.

(b) Left turn traffic must cross three or more lanes of opposing through traffic.

(c) A protected/permissive mode is currently in use and the number of left turn angle crashes caused by left turn drivers on this approach exceeds six per year.

(d) Unusual intersection geometrics exist that will make permissive left turning particularly confusing or hazardous, such as restricted sight distance.

(5) A permissive/protected mode can be used effectively for some intersection approaches if the traffic engineer feels that the advantage to be gained in better progression, as demonstrated in a traffic signal analysis computer program, is worth the violation of driver expectancy. However, use of this type of left turn phasing should be limited and should be restricted to only the following situations which will not create a left-turn trap:

(a) T-intersections where opposing U-turns are prohibited.

(b) Four-way intersections where the opposing approach has prohibited left turns or protected left turn phasing.

(c) Four-way intersections where the left turn volumes from opposing approaches do not substantially differ throughout the various time periods of a normal day, so that overlap phasing is not beneficial or required.

(6) Split phasing can be used effectively if any of the following conditions apply:

(a) Opposing approaches are offset to an extent that simultaneous left turns from opposing directions would be impossible or hazardous.

(b) Left turn volumes are extremely heavy on opposing approaches and both are nearly equal to the adjacent through movement critical lane volume.

(c) Left turn volume is extremely heavy on an approach that does not include a separate left turn lane.

(d) Drivers are permitted to turn left from more than one lane, but drivers are also permitted to use the right-most left turn lane as a through lane.

3.2.3 LEFT TURN SIGNAL DISPLAYS

The following are the left turn signal displays as referenced in ***Section 4D.17 of the MUTCD*** to be used with the various types of left turn phasing.

(1) **Protected/Permissive Mode.** A 5-section signal display centered over the lane line between the left turn lane and the left-most through lane should be used. The 5-section signal display could serve as one of the two required through traffic signal heads. No supplemental signing should be provided.

(2) **Protected Only Mode with a single left turn lane.** A 3-section vertical signal head from top to bottom -- (or left to right in a horizontally-aligned face) left turn red arrow, left turn yellow arrow, left turn green arrow) should be centered over the left turn lane.

(3) **Protected Only Mode with two or more left turn lanes.** At least two 3-section vertical signal heads (or left to right in a horizontally-aligned face) as described in the paragraph above should be used with one centered over each left turn lane.

(4) **Split phasing.** A 5-section signal display centered over the lane line between the left turn lane and the left-most through lane should be used. The 5-section signal display could serve as one of the two required through traffic signal heads. No supplemental signing should be provided.

3.2.4 SIGNAL DISPLAY FOR EXCLUSIVE LEFT TURN LANE

A 3-section (red, yellow, and green) signal face shall not be placed over, and/or devoted to, an exclusive left turn lane, unless the signal phasing sequence provides a protected left turn movement during the cycle.

3.2.5 LEFT TURN PHASES FOR SEPARATED LEFT AND THRU LANES

(1) Left turn lanes at signalized intersections that are separated from through lanes by raised or painted islands may be operated as protected only mode, as protected/permissive or permissive only mode. If protected/permissive mode is used, the 5-section signal display should be placed overhead on the lane line between the adjacent through lane and the island so as to be obvious that the signal display is shared. In all cases, the cone of vision requirements in ***Section 4D.13 of the MUTCD*** shall be met. Below is an illustrative example using standard lane widths on a 4-lane divided highway. A corresponding table for maximum allowable island width (without shifting the signal head) for the indicated signal head distance from stop line is given.

Figure 3.2-1. Signal Head/Left-Turn Treatment

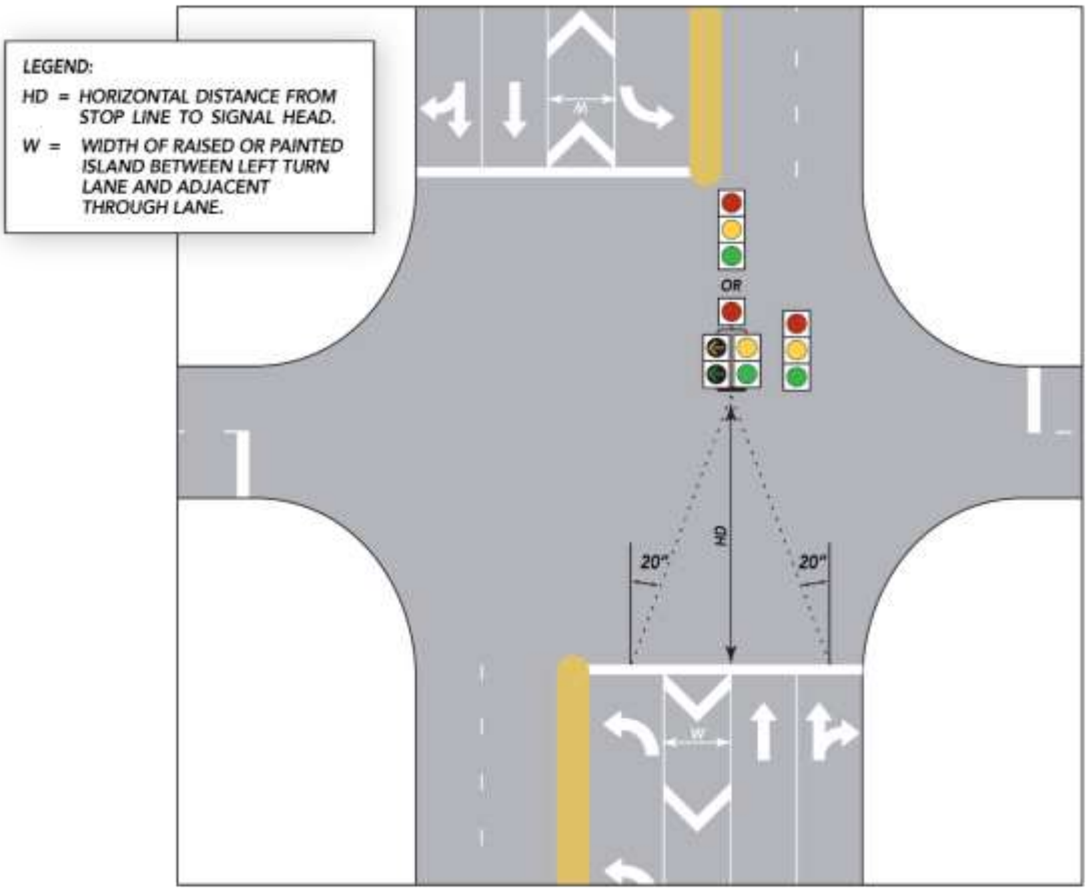


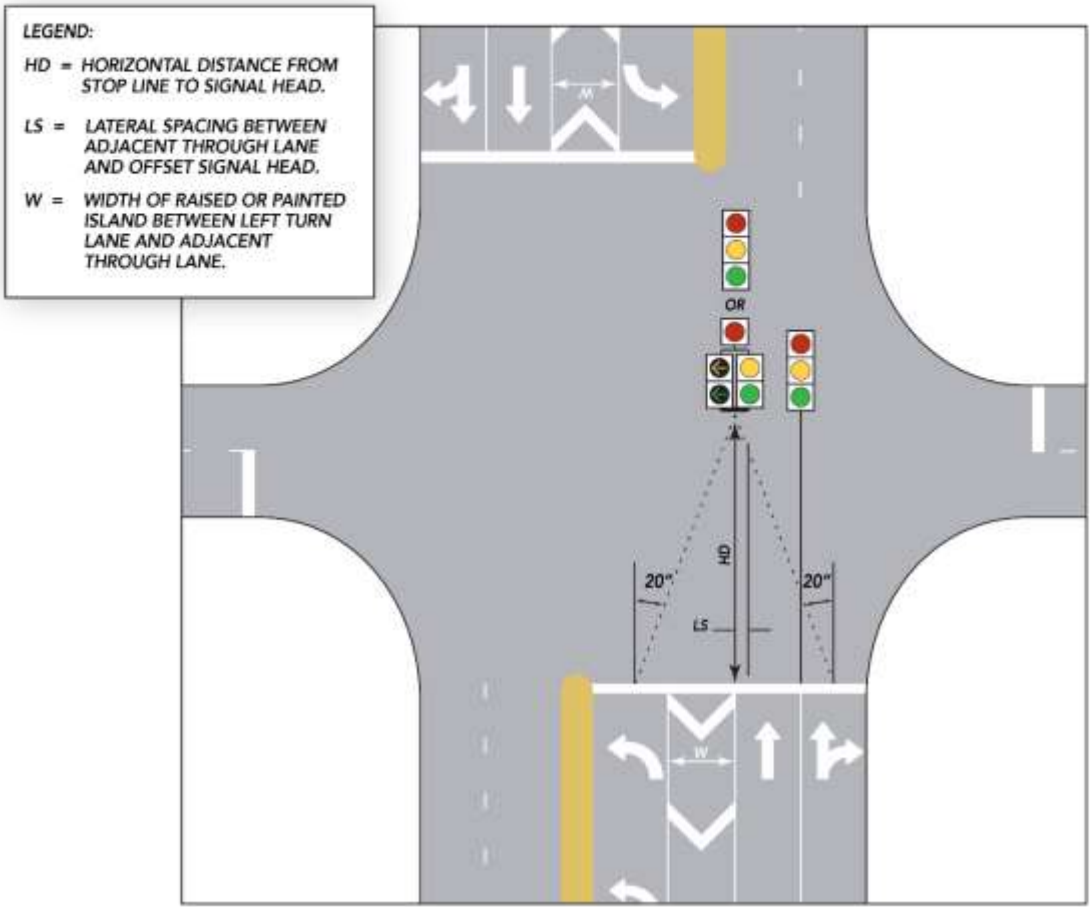
Table 3.2-1. Maximum Width of Hatched-Out Area Without Shifting Signal Head

Horizontal Distance	Width
40	8
50	12
60	15
70	19
80	23
90	26
100	30
110	34
120	37
130	41
140	44
150	48

(2) Signal faces containing circular green signal indication for a permissive only left-turn should not be located above an exclusive left-turn lane or the extension of the lane, nor should they be post-mounted on the far side median in front of the left-turn lane. Permissive only left turn signal displays shall not be provided in an exclusive left turn signal face. If the separation or geometric conditions of the offset left turn lane is such that the cone of vision would not be met with a shared signal head positioned on the lane line adjacent to the nearest through lane, the shared signal face may be offset to the left from the adjacent through lane line such that the required cone of vision is still met for the right most through lane and for the left turn lane. This lateral offset spacing should be used only after other options such as increasing the horizontal distance to the signals heads has been considered and placed so as to be obvious that the signal display is shared. The lateral offset spacing of the shared signal head from the adjacent through lane generally should not be greater than one half the width of the island (½W).

(3) If the lateral shift is too great, the cone of vision may not be adequate for the driver in the right most through lane. Where the cone of vision cannot be met, protected only mode must be used. This may be due to a large parallel offset left turn lane or due to a tapered or curved offset left turn lane.

Figure 3.2-2. Left Turn Lane Signal Head Shift



3.2.6 PERMISSIVE ONLY MODE IN MULTI- LEFT TURN LANE APPROACHES

A permissive green interval for two or more left turn lane approaches shall not be used.

Section 3.3

SCHEDULING INTERSECTION CONTROL EVALUATIONS AND FUNDING ARRANGEMENTS

3.3.1 PURPOSE

The intent of this section is to establish criteria for responding to requests for traffic signal installations, for funding and implementation arrangements for warranted signals, and for conducting related studies such as the Intersection Control Evaluation (ICE) to determine the need and type of improvement.

3.3.2 GENERAL

Since the Department is charged with the responsibility to erect and maintain a uniform system of traffic signals and other traffic control devices for regulation, control, guidance, and protection of traffic on the State Highway System, there is need to provide uniformity in responding to requests for signals and in the scheduling and conducting of traffic studies to determine signal needs. If an intersection is determined to meet signal warrants, the procedure as described in the ***Department's Manual on Intersection Control Evaluation*** must be conducted to determine the appropriate intersection control strategy.

3.3.3 RESPONSE TO SIGNAL REQUESTS AND SCHEDULING TRAFFIC SIGNAL STUDIES

(1) The ***District Traffic Operations Office*** shall objectively review all requests for traffic signal installations received by the Department against existing information and local knowledge of the intersection before agreeing to commit resources for a detailed traffic study. This initial screening may require a brief site visit to view the field conditions. During the initial screening, all data shall be recorded in writing and kept on file. An attempt shall be made to relate all data and analysis to standards set forth in the ***MUTCD***. If the initial screening results in a decision to conduct a signal warrant study, the appropriate ***District Traffic Operations Office*** should contact the local government traffic engineering agency, advise them of the Department's decision, and obtain their views and input. Also, the appropriate ***District Traffic Operations Office*** should advise the local government traffic engineering agency that should signal warrants be met, an ICE analysis will be required to determine the appropriate intersection control strategy.

(2) If the initial screening results in a decision to not consider signalization or further study, the ***District Traffic Operations Office*** shall document the reasons and advise the requestor of the findings with a copy to the local government traffic engineering agency. Although local government concurrence is desirable, it is not a prerequisite for committing Department resources to a full signal warrant study and subsequent ICE analysis if the signal is warranted.

(3) The ***District Traffic Operations Office*** shall normally conduct signal warrant studies for proposed signal installations on the State Highway System. However, a local government traffic engineering agency may conduct such studies and submit them to the ***District Traffic Operations Office*** for review. All studies shall be conducted in accordance with the procedure and standards prescribed in this document and shall be signed and sealed by a professional engineer.

(4) If the signal warrant study shows the installation of a new traffic signal is warranted, the ***District Traffic Operations Office*** or local government traffic engineering agency will conduct an ICE analysis to determine the appropriate intersection form.

(5) Formal legal resolutions from local agencies may form the basis of their concurrence in the need for a traffic signal study. However, such documents should not be required by the Department as a prerequisite to scheduling the study. Additionally, the availability of implementation funds should not be a prerequisite to assessing traffic signalization needs (conducting a study).

(6) The ***District Traffic Operations Office*** shall keep a log of requests for traffic signal studies and their disposition. To the extent practical, a priority system utilizing the request date, traffic volumes, accident experience, and the level of local government interest should be used to schedule traffic signal studies.

3.3.4 TRAFFIC SIGNAL STUDIES AND ENGINEERING

(1) Department of Transportation staff, local agency engineers, or qualified consulting engineers may perform traffic signal studies, ICE analyses, and provide any required engineering services for the preparation of implementation plans and specifications for proposed traffic signals and/or alternative intersections on the State Highway System. However, the Department is responsible for requiring and overseeing such work.

(2) Traffic signal studies shall be made in accordance with ***Department's Manual on Uniform Traffic Studies (MUTS),*** particularly, ***Chapter 2 of the MUTS Manual*****,** referred therein. ICE analyses shall be made in accordance with the ***Department's Manual on Intersection Control Evaluation***. Plans and specifications, if required, shall be prepared in accordance with established Department procedures.

(3) Traffic signal studies, ICE analyses or engineering analyses conducted for new, or proposals to significantly revised, private access points to major traffic generators shall be conducted by qualified traffic engineers at no cost to the Department. Except under unusual circumstances, these studies and/or analyses shall be part of the Driveway Permit Application as per the requirements of ***Rule 14-96***. In accordance with ***Section 2.3(1)(d) in the Department's Manual on Intersection Control Evaluation***, a Driveway Permit Application for Category E, F, and G standard connection categories are required to conduct ICE analysis and have the analysis approved by both the District Design Engineer and the ***District Traffic Operations Engineer (DTOE)***. These studies shall, in addition to evaluating the need for signal control at unsignalized intersections and alternative intersections forms from the ICE analyses, also consider enhanced features at existing upstream and downstream signalized intersections, as appropriate. Such study and report shall be signed and sealed by a Florida registered professional engineer. Likewise, engineering costs associated with the preparation of implementation plans and specifications should also normally be borne by the developer. There may be instances where the Department determines that specific critical design requirements make it essential that the engineering work be performed by Department forces. In such instances, the District Secretary may direct that the engineering work be done by the Department at no cost to the developer.

(4) Studies and engineering at existing private access points which may be required as a result of normal traffic growth are usually made by qualified traffic engineers by the requestor. In extraordinary situations the Department may elect to do so.

3.3.5 FUNDING ARRANGEMENTS FOR WARRANTED NEW SIGNAL INSTALLATIONS

(1) New traffic signal installations and/or alternative intersections from the ICE analysis on the State Highway System may be funded from private, local, state, or federal funds, or any combination of such funds.

(2) The developers shall totally fund the installation of any new traffic signal, any alternative intersection construction, and/or the enhancements of any existing traffic signals when these improvements are requirements specified in a new or revised Driveway Permit or local government Development Order. If proposals to provide signalization or alternative intersection or modify existing signalization is above the minimum required by Permit or Development Order and provides a betterment to the State Highway System substantially beyond mitigation for development impacts, the Department’s District Secretary may determine an appropriate financial participation formula and assign percentages of participation to the developer in consideration of the specific conditions at each site.

(3) Although signal installation and/or alternative intersection construction on the State Highway System is the responsibility of the Department, local governments may contribute, on a voluntary basis, a portion, or all of the cost of signal installation and/or alternative intersection construction depending upon specific cooperative arrangements worked out between the Department’s District Offices and the local agency. Local funds are most often utilized in these cooperative efforts to advance the implementation schedule of a warranted traffic signal and/or alternative intersection. When local funds are accepted by the Department, a formal joint project agreement executed by both parties is necessary.

(4) Most local governments in Florida’s urban areas have qualified traffic engineering organizations with experienced traffic signal field crews and many new signals have been installed on the State Highway System using local agency installation crews with control hardware supplied by the Department. Where the local agency is agreeable to this procedure (most are because of their maintenance and operational involvement in these sites), this technique should be encouraged. No formal agreement is necessary since no money is changing hands; however, a letter from the local agency agreeing to install Department supplied hardware should be obtained.

3.3.6 OTHER CONSIDERATIONS

(1) Prior to purchase, use, or installation, traffic signals must comply with provisions of the ***FDOT Approved Product List Submittal Process***.

(2) Prior to finalizing the agreement of intersection improvement, the study must comply with the ***Department's Manual on Intersection Control Evaluation***.

(3) Prior to installation of traffic signals, compliance with ***Topic No. 750-010-022, Traffic Signal Maintenance Agreements***, is necessary.

Section 3.4

EMERGENCY TRAFFIC CONTROL SIGNALS

3.4.1 PURPOSE

The objective of this section is to provide guidance for warranting, designing, and operating emergency traffic control signals at locations where emergency vehicles, most commonly fire trucks, need special traffic signal assistance to egress onto the street system.

3.4.2 BACKGROUND

The Department's district offices often receive local public agency requests for traffic signal control for the departure of emergency vehicles. This section was developed to give comprehensive guidance to determine if the signals are warranted.

3.4.3 PROCEDURE

The need for an Emergency Traffic Control Signal shall be considered if an engineering study finds that one of the following warrants are met:

(1) Minimum Traffic Volumes (Both directions of travel, based on Signal Warrant 2), as shown in ***Table 3.4-1***.

Table 3.4-1. Minimum Traffic Volumes

Roadway	Peak Hour or	24 Hours
2-Lane	750 VPH	7500 ADT
4-Lane	900* VPH	9000* ADT
6-Lane or more	1200* VPH	12000* ADT
*Values shall be increased by 1/3 when arterial has traffic signal system coordination with signals located within 1000 feet in both directions from the emergency signal location.		

(2) When the geometric design of the arterial and emergency vehicle facility is such that the vehicle when returning must *back in*, and to do so must block traffic when performing this maneuver and the traffic volume and speeds are such that the use of emergency vehicle lights and flaggers have been ineffective in controlling traffic.

(3) When the location of the emergency vehicle driveway consistently conflicts with the normal traffic queue from an adjacent signalized intersection. The use of DO NOT BLOCK INTERSECTION (***R10-7***) sign should be considered in conjunction with the emergency signal installation.

(4) On all approaches when vertical or horizontal curvature or other obstructions do not provide adequate stopping sight distance for traffic approaching an emergency vehicle driveway.

3.4.4 CONFIGURATION AND OPERATION OF EMERGENCY TRAFFIC CONTROL SIGNALS

(1) ***Section 4G.03 of the MUTCD*** defines the operational requirements for a *mid- block* location of an emergency signal. The ***MUTCD*** allows either a steady green or flashing yellow operation of signal heads between emergency vehicle actuations. These choices of operation, combined with limited details for signal configuration requirements have resulted in a lack of uniformity of emergency signal design and operation within the State.

(2) Based on requirements contained in ***Section 4G.04 of the MUTCD***, the following criteria for emergency traffic control signals shall be followed for new or reconstructed installations.

(a) Dual indications shall be provided for each roadway approach. A minimum of one signal face shall be installed for the emergency vehicle driveway but two indications are preferable.

(b) If the emergency service is located off the main roadway and emergency vehicles access the main roadway via a public access street, emergency signals may be erected at the intersection of these roadways. If this practice is followed, dual indication shall be used on the public access street, with the signals resting on the flashing red indication.

(c) Mid-block emergency signals shall be operated as flashing yellow between emergency vehicle actuations. Roadway signal head configuration shall consist of three sections and shall be operated as shown in ***Figure 3.4-1***. (The use of special technological signal devices may be selected, i.e., strobe signals, LED, or solar power. These devices may require temporary permitting prior to installation.)

(d) Signal operation at intersections which are pre-empted by emergency vehicles entering the roadway near or at the intersection should be designed on an individual basis.

(3) It is not practical to outline all possible situations which may be encountered in the field. Such factors as emergency vehicle route distance between the intersection and emergency vehicle driveway, intersection geometrics, number of lanes, normal queue length, traffic volumes, etc., should be considered.

3.4.5 EMERGENCY SIGNAL SIGN (R10-13)

(1) As emergency signals are installed at locations along major arterials where emergency vehicles enter the roadway, the EMERGENCY SIGNAL sign (***R10-13***), shall be placed on the span wire or mast arm to identify the purpose of the signal to the driver.

(2) The EMERGENCY SIGNAL sign (***R10-13***) shall always be legible, shall be mounted adjacent to each signal face, and shall be located between the dual signal indications on each roadway approach.

(3) No sign is required for the emergency vehicle driveway approach.

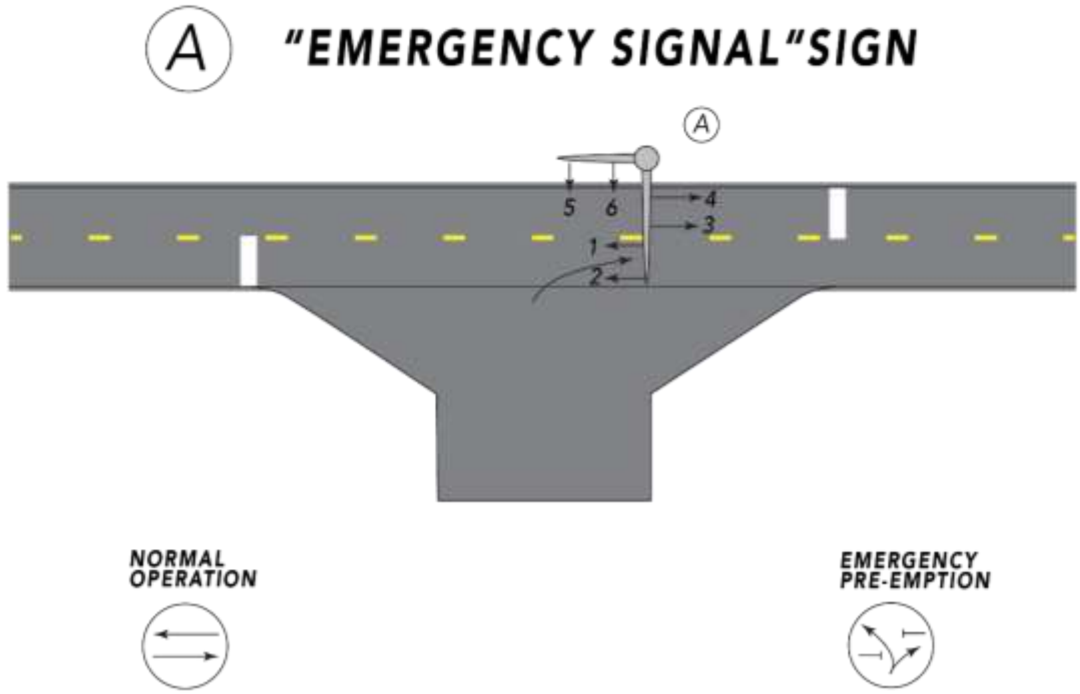
3.4.6 OTHER REQUIREMENTS

(1) A controller timing chart shall be a part of the contract plans.

(2) A Maintenance Agreement shall be required for all emergency signals on the State Highway System.

(3) A signal timing study is required to determine proper clearance intervals.

Figure 3.4-1. Mid-Block Emergency Signal Operation



NORMAL OPERATION	CHANGE TO EMERGENCY PREEMPTION	EMERGENCY PREEMPTION	CHANGE FROM EMERGENCY PREEMPTION	RELEASE
Signal 1, 2, 3, 4 G or FY	Signal 1, 2, 3, 4 Y	Signal 1, 2, 3, 4 R	Signal 1, 2, 3, 4 R	Signal 1, 2, 3, 4 G or FY
Signal 5, 6,	Signal 5, 6,	Signal 5, 6, G	Signal 5, 6,	Signal 5, 6,

Section 3.5

TRAFFIC SIGNAL MAST ARM SUPPORT BOUNDARIES

3.5.1 GENERAL

The ***Department's Plans Preparation Manual, Topic No. 625-000-007, Volume 1 – Chapter 7*** requires that all traffic signals installed on the State Highway System that are within the Mast Arm Structures Boundary shall be supported by mastarms.

3.5.2 IMPLEMENTATION

3.5.2.1 Mast Arm Structures Boundary Maps

The mast arm structures boundary map follows an alignment of state roads that are parallel to an approximate ten miles distance to the coastline. Official mapping of this boundary is maintained on a Map Info-Base by the ***State Traffic Engineering and Operations Office***. Current district maps are provided at this location: ***https://www.fdot.gov/traffic/trafficservices/pdfs/districts***.

Section 3.6

STANDARDIZATION OF YELLOW CHANGE AND RED CLEARANCE INTERVALS FOR SIGNALIZED INTERSECTIONS

3.6.1 PURPOSE

This section provides standardization of yellow and red intervals for signalized intersections. The yellow change and red clearance intervals are used to provide a consistent transition between conflicting traffic signal phases. The function of yellow change interval is to warn traffic of an impending change in the right-of-way assignment and the function of the red clearance interval is to provide additional time following the yellow change interval to clear the intersection before conflicting traffic is released. The ***MUTCD*** states that a yellow change interval should have a minimum duration of 3 seconds and a maximum duration of 6 seconds, and a red clearance interval should have duration not exceeding 6 seconds. The standards for application of yellow and red intervals must comply for all of the following signalized intersection timing changes on the State Highway System (SHS):

(1) New signal installations

(2) All Traffic Infraction Detectors installed

(3) Signal phasing changes

(4) Geometric changes affecting the timing or phasing

(5) Corridor re-timing projects

All other existing signalized intersections on the State Highway System must be in compliance with standards implemented in this section as identified in ***Traffic Engineering and Operations Bulletin 02-13, Standardization of Yellow Change Intervals for Signalized Intersections***.

3.6.2 STANDARD

(1) ***Section 316.075(3)(a), F.S.*** states that no traffic control signal device shall be used which does not exhibit a yellow or "caution" light between the green or "go" signal and the red or "stop" signal. The Statute is silent on the yellow clearance interval duration and does not mention nor mandates the use of a red clearance interval.

(2) The formula in Institute of Transportation Engineers (ITE) publication ***Determining Vehicle Signal Change and Clearance Interval*** (1994) shall be used to calculate yellow change interval. For a given posted speed limit (PSL), if the ITE formula produces a value lower than that in ***Table 3.6-1***, the yellow change intervals in ***Table 3.6-1*** shall be used. The yellow change intervals shall not be less than the standard values presented in ***Table 3.6-1***. Yellow change intervals calculated to be lower than 3.4 seconds shall be set at no less than 3.4 seconds. The yellow interval shall not exceed 6 seconds. Any yellow change intervals that are greater than the standard yellow change intervals presented in ***Table 3.6-1*** of this section, for a given PSL, are allowed, but they shall be based on ***Section 4D.26 of the MUTCD***, engineering practice and the ITE formula.

The ITE's ***Guidelines for Determining Traffic Signal Change and Clearance Intervals*** (2020) includes an extended kinematic model for calculating the minimum yellow change interval and shall not be used in Florida. Refer to ITE's ***Determining Vehicle Signal Change and Clearance Interval*** (1994) for calculating the minimum yellow change interval.

(3) Yellow change and red clearance interval times shall be rounded up to the nearest 0.1 second.

(4) Approach speed used in ***Table 3.6-1*** and ***Formula 3.6-1*** is the PSL for the approach being analyzed.

3.6.2.1 Yellow Change Interval

(1) The Florida yellow change intervals shown in ***Table 3.6-1*** are computed using ***Formula 3.6-1*** (found in ITE's ***Determining Vehicle Signal Change and Clearance Interval*** (1994)) with a PRT of 1.4 seconds and a grade of 0%. These intervals are the required standard minimum values.

(2) A Perception Reaction Time (PRT) of 1.4 seconds shall be used.

Table 3.6-1. Florida Yellow Change Interval (0.0% Grade) Standard*

APPROACH SPEED (mph)	YELLOW INTERVAL (SECONDS)
25	3.4
30	3.7
35	4.0
40	4.4
45	4.8
50	5.1
55	5.5
60	5.9
65	6.0
* For approach grades other than 0%, use ITE Formula.	

Formula 3.6-1

$$Y = t + \frac{1.47v}{2(a + Gg)}$$

Where:

Y = Length of yellow interval, sec.

t = Perception-reaction time (use 1.4 sec.)

v = Speed of approaching vehicles, in mph.

a = Deceleration rate in response to the onset of a yellow indication (use 10 ft/sec^2)

g = Acceleration due to gravity (use 32.2 ft/sec^2)

G = Grade, with uphill positive and downhill negative (percent grade/100)

3.6.2.2 Red Clearance Interval

A red clearance interval must be used. Providing adequate red clearance intervals can significantly impact intersection safety by reducing the probability of occurrence of right angle crashes, even if drivers run the red signal indication. The red clearance interval shall be determined using engineering practices. The values are typically computed using ***Formula 3.6-2***, found in ITE's ***Determining Vehicle Signal Change and Clearance Interval*** (1994).

Formula 3.6-2

$$R = \frac{W + L}{1.47v}$$

Where:

R = Length of red interval, sec.

W = Width of the intersection, in feet, measured from the near-side stop line to the far edge of the conflicting traffic lane along the actual vehicle path.

L = Length of vehicle (Use 20 ft.)

v = Speed of approaching vehicles, in mph.

The minimum red clearance interval shall be 2.0 seconds and the maximum red clearance interval should normally not exceed 6.0 seconds. Red clearance intervals longer than the calculated values in ***Formula 3.6-2*** can be used at the engineer's discretion. This longer red clearance interval can be applied where the width of intersection, sight distance, complex intersections, crash history and any other unique conditions that may warrant longer red times are present. This interval extension shall meet the minimum/maximum guidance for red clearance interval. The determination shall be based on engineering judgment.

The ***National Cooperative Highway Research Program (NCHRP) Report 731 Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections*** recommends using a modified ITE formula that allows for 1.0 second reduction due to reaction time delay from the conflicting movement. Therefore, a 1.0 second reduction may be made in the values computed from ***Formula 3.6-2*** and applying engineering judgment. However, the red clearance interval shall be no less than 2.0 seconds.

Section 3.7

ACCESSIBLE PEDESTRIAN SIGNALS

3.7.1 PURPOSE

The purpose of this section is to establish criteria for the installation and operation of accessible pedestrian signals on the State Highway System that provide information in non-visual formats, such as audible tones, speech messages, and/or vibrating surfaces.

3.7.2 GENERAL

Sections 4E.09 to 4E.13 of the MUTCD establish the standards for accessible pedestrian signals installed on public roadways. ***Section 4E.06 of the MUTCD*** also contains guidance for accessible pedestrian signal installations. The ***MUTCD*** must be reviewed and considered with accessible signal installation requests.

3.7.3 PROCEDURE

(1) Accessible pedestrian signals installed on the State Highway System shall be reviewed and approved by the ***DTOE*** prior to installation.

(2) Requests for accessible pedestrian signal installations received from the public, maintaining agencies, public agencies, or support groups for people with visual impairments will be reviewed by the ***DTOE***. The ***DTOE*** may request input from public agencies and organizations that support people with visual impairments to determine if accessible pedestrian signals would be effective and safe for users.

(3) An engineering study shall be conducted if the initial ***DTOE's*** review supports the installation of the accessible pedestrian signal. The engineering study should consider the needs of all pedestrians and not just those with visual impairments.

(4) The following features should be considered when reviewing requests for accessible pedestrian signals:

(a) potential demand for accessible pedestrian signals

(b) right on red movements

(c) free-flow right turn movements

(d) complexity of signal phasing

(e) complexity of intersection geometry

(f) traffic volumes during times when pedestrians might be present

(g) audible tones or sounds that may cause confusion

(h) verbal messages instead of tones or sounds

(i) vibrotactile pedestrian devices

(j) pushbutton or passive pedestrian detectors

(k) sufficient automatic volume adjustment in response to ambient traffic sound level, 100dBA (decibels) maximum

(l) locations with more than four lanes and/or greater than 35 MPH posted speed limit shall be given additional considerations for geometrics, operations, and pedestrian safety

3.7.4 APPROVAL/DENIAL PROCESS

(1) The ***DTOE*** shall review all requests for accessible pedestrian signals received by the Department from an engineering study and/or local request before agreeing to approve the installation. The review should consider the needs of all pedestrians and not just those with visual impairments.

(2) The initial review may require site visits to view the field conditions. During the initial screening, all data shall be recorded and maintained. An attempt shall be made to relate all data and analysis to standards set forth in ***Sections 4E.09 to 4E.13 of the MUTCD***.

(3) If the initial review results in a decision not to install accessible pedestrian signals, the ***DTOE*** shall document the reasons and advise the requestor of the findings with a copy provided to the local government. Although local government concurrence is desirable, it is not a prerequisite for committing Department resources for an accessible pedestrian signal installation.

Section 3.8

RAILROAD TRAFFIC SIGNAL PREEMPTION TIME CALCULATION

3.8.1 PURPOSE

The intent of this section is to provide guidance for determining the required preemption time for traffic signals adjacent to highway at grade rail crossings equipped with an active warning system.

3.8.2 BACKGROUND

This section is developed to give comprehensive guidance in determining traffic signal preemption time calculation as established in ***Rule 14-57.013(5), F.A.C.***

3.8.3 GENERAL

(1) When new and existing signalized intersections are within 200 feet of an existing or new grade crossing, a preemption phase shall be provided to the traffic control system. This must be designed in coordination with the active grade crossing traffic control device.

(2) For new and existing traffic signal intersections between 200 and 500 feet of an existing or new grade crossing, an engineering study is required to determine if preemption is needed.

(3) Preemption should be considered for new and existing traffic signal intersections greater than 500 feet of an existing or new grade crossing, when traffic is observed to queue past the grade crossing or there is potential for traffic to queue past the grade crossing.

(4) Consulting and coordinating with the corresponding railroad agency, District Rail Office and the ***DTOE*** is required prior to implementation.

3.8.4 DEFINITIONS

Advance Preemption (AP). Notification of an approaching train is forwarded to the highway traffic signal controller unit or assembly by the railroad equipment in advance of the activation of the railroad warning devices. Advance preemption time (APT) is the duration for advance preemption.

Clear Storage Distance (CSD). The distance available for vehicle storage measured between 6 feet from the rail nearest the intersection to the intersection stop line or the normal stopping point on the highway.

Controller’s Equipment Response Time to Preempt (CERTP). The time that elapses while the controller unit electronically registers the preempt call.

Design Vehicle (DV). The longest vehicle permitted by statute of the road authority (State or other) on that roadway.

Design Vehicle Clearance Distance (DVCD). The length, in feet, which the design vehicle must travel in order to enter and completely pass through the railroad crossing’s Minimum Track Clearance Distance (MTCD). It is the sum of the minimum track clearance distance and the total design vehicle’s length. Design vehicle length can be found on ***FDOT Design Manual (FDM) 201***.

Design Vehicle Clearance Time (DVCT). Time required for design vehicle to accelerate from a stop and travel through and clear of Minimum Track Clearance Distance (MTCD).

Desired Minimum Separation Time (DMST). A Time buffer between the departure of the last vehicle (the design vehicle) from the railroad crossing and the arrival of the train.

Maximum Highway Traffic Signal Preemption Time (MHTSPT). The maximum amount of time needed following initiation of the preemption sequence for the highway traffic signals to complete the timing of the right-of-way transfer time, queue clearance time, and separation time.

Minimum Green Time during Right-of-way Transfer (MGTRT). The minimum number of seconds that any existing phase will display a green indication before the controller unit terminates the phase through its yellow change and red clearance intervals and transition to the track clearance green interval. A MGTRT of 5 seconds is recommended for the transition to the track clearance green interval as rapid as possible.

Minimum Track Clearance Distance (MTCD). The length along the highway at one or more railroad tracks, measured from the portion of the railroad crossing automatic gate arm farthest from the near rail to 6 feet (2 m) beyond the tracks measured perpendicular to the far rail.

Minimum Walk Time during Right-of-way Transfer (MWTRT). The minimum pedestrian walk indication time. A MWTRT of 5 seconds is recommended for the transition to the track clearance green interval as rapid as possible.

Other Green Time during Right-of-way Transfer (OGTRT). Any additional green time preserved beyond the preempt minimum green time for the worst-case vehicle phase.

Pedestrian clearance time during right-of-way transfer (PCTRT). The pedestrian clearance (i.e., flashing don’t walk indication) time for the worst-case pedestrian phase. A zero value is allowed for the most rapid transition to the track clearance green interval.

Preempt Delay Time (PDT). The amount of time, in seconds, that the traffic signal controller is programmed to wait from the initial receipt of a preempt call until the call is "verified" and considered a viable request for transfer into preemption mode.

Preempt Trap. A potential hazard condition that vehicles can continue to cross the tracks and possibly stop on the tracks when the gates do not block access to the crossing before the expiration of the track clearance green. For preempt trap, the track clearance green interval has already expired so there will be no further opportunity to clear.

Preempt Verification and Response Time (PVRT). The number of seconds between the receipt at the controller unit of a preempt call issued by the railroad's grade crossing warning equipment and the time the controller software actually begins to respond to the preempt call.

Queue Clearance Time (QCT). The time required for the design vehicle of maximum length stopped just inside the minimum track clearance distance to start up and move through and clear the entire minimum track clearance distance.

Queue Start-up Time (QST). Time elapsed after beginning of track clearance green until design vehicle can start moving.

Red Clearance Time (RCT). The required red clearance interval time during right-of-way transfer prior to transition to track clearance.

Required Preemption Time (RPT). The time provided to the railroad signal designer.

Right-of-way Transfer Time (RTT). The maximum amount of time needed for the worst-case condition, prior to display of the track clearance green interval.

Separation Time (ST). The component of maximum highway traffic signal preemption time during which the minimum track clearance distance is clear of vehicular traffic prior to the arrival of rail traffic.

Track Clearance Distance (TCD). The length along a highway at one or more railroad tracks, measured from the highway stop line, warning device, or 12 feet perpendicular to the track center line, to 6 feet beyond the track(s) measured perpendicular to the far rail, along the center line or edge line of the highway, as appropriate, to obtain the longer distance.

Track Clearance Time (TCT). Time required to travel through the track clearance distance plus a four second separation time.

Vehicle-gate Interaction. When the automatic gate descends on a stationary or slow-moving vehicle as it moves through the minimum track clearance distance.

Yellow Change Time (YCT). The required yellow change interval time during right-of-way transfer prior to the track clearance.

3.8.5 PROCEDURE

The maximum preemption time for highway-rail grade crossings could be calculated with the following procedures.

(1) Calculate the Right-of-way Transfer Time (RTT).

The components of RTT include the preempt verification and response time, and the worst-case conflicting vehicle or pedestrian time. This will be done in the following steps:

Step 1: Calculate preempt verification and response time.

Collect the preempt delay time (seconds) and the controller response time to preempt (seconds). The preempt verification and response time (seconds) could be calculated by adding the preempt delay time and the controller response time together.

Step 2: Calculate the worst-case conflicting vehicle time.

Collect the minimum green time during right-of-way transfer (seconds), other green time during right-of-way transfer (seconds), yellow change time (seconds) and red clearance time (second). The worst-case conflicting vehicle time (seconds) is calculated by summing them up.

Step 3: Calculate the worst-case conflicting pedestrian time.

Collect the minimum walk time during right-of-way transfer, pedestrian clearance time during right-of-way transfer, vehicle yellow change time and vehicle red clearance time. The worst-case conflicting pedestrian time (seconds) is calculated by summing them up.

Step 4: Determine the worst-case conflicting vehicle or pedestrian time.

The worst-case conflicting vehicle or pedestrian time is the maximum of worst-case conflicting vehicle time from **Step 2** and worst-case conflicting pedestrian time from **Step 3**.

Step 5: Calculate the right-of-way transfer time.

The right-of-way transfer time is the sum of preempt verification and response time from **Step 1**, and the worst-case conflicting vehicle or pedestrian time from **Step 4**.

(2) Calculate the queue clearance time.

The queue clearance time includes the time that is required for the design vehicle to start moving, and the time for design vehicle to accelerate through the design vehicle clearance distance. This is calculated by the following six steps.

Step 1: Determine the queue start-up distance.

Measure the clear storage distance (CSD) and minimum track clearance distance (MTCD) for the highway-rail grade crossing. The queue start-up distance, L (feet), is calculated by adding the CSD with MTCD.

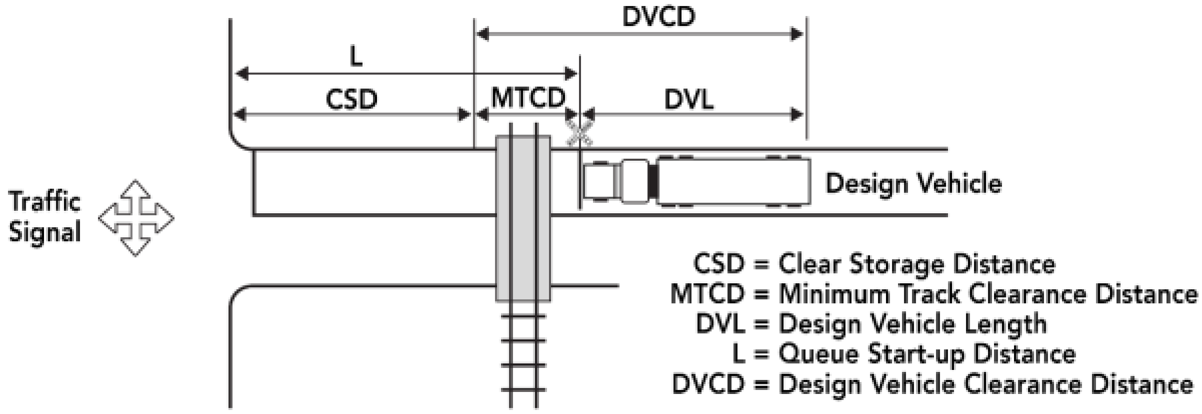
Step 2: Calculate the time required for design vehicle to start moving.

The time required for design vehicle to start moving, can be calculated, in seconds, as 2 plus the queue start-up distance, L divided by the speed of 20 feet per second.

Step 3: Determine the design vehicle clearance distance.

The design vehicle clearance distance is the sum of the minimum track clearance distance and the total design vehicle's length as shown in ***Figure 3.8-1***.

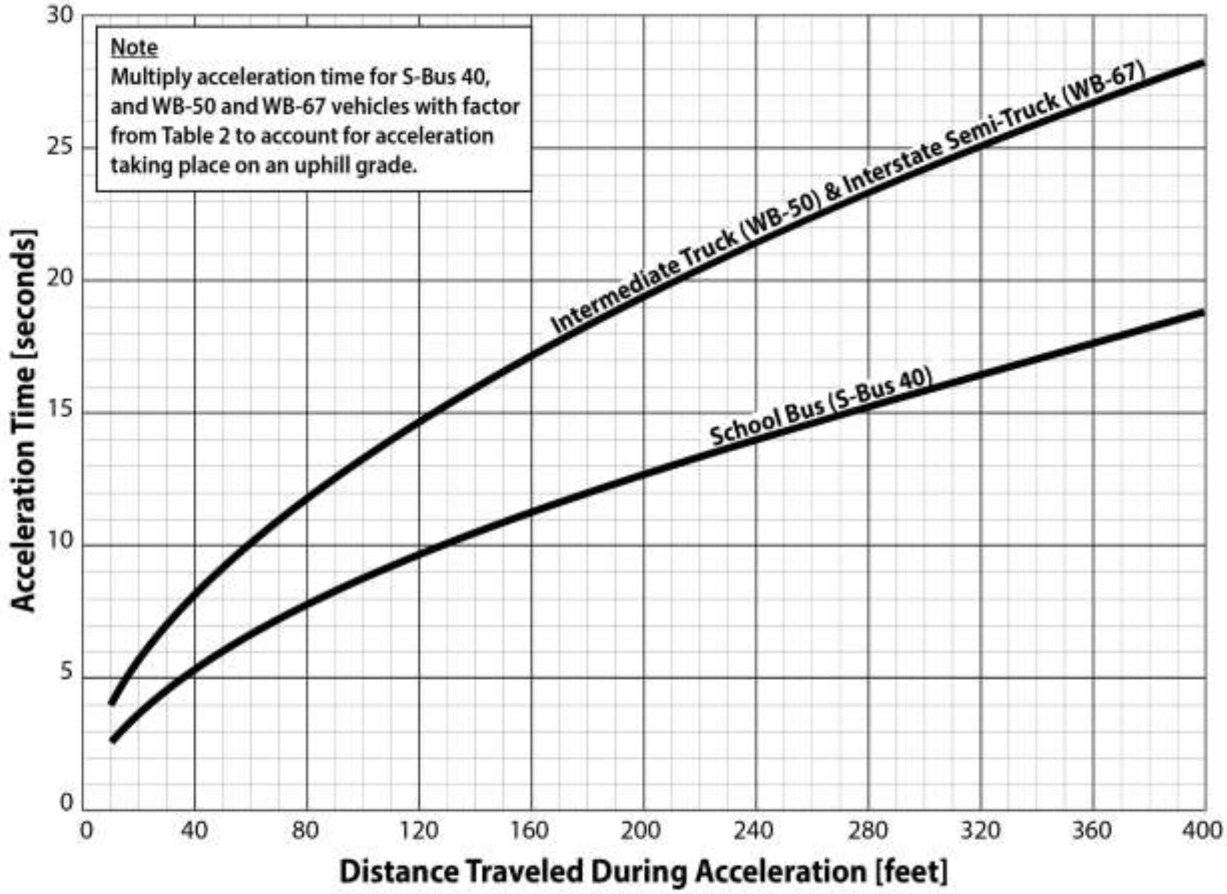
Figure 3.8-1. Geometric Data at the Highway-Rail Grade Crossing



Step 4: Calculate the time for design vehicle to accelerate through the design vehicle clearance distance (DVCD) on level terrain.

Select the design vehicle for the analysis. Use ***Figure 3.8-2*** to determine the time for design vehicle to accelerate through the DVCD on level terrain.

Figure 3.8-2. Acceleration Time Over a Fixed Distance on a Level Surface



Step 5: Calculate the time for design vehicle to accelerate through the DVCD on uphill grade.

If the approach over which the design vehicle has to accelerate over DVCD is an uphill grade, calculate the approach grade factor to account for slower acceleration on uphill grade. The approach grade factor, as illustrated in ***Table 3.8-1***, can be determined based on DVCD, design vehicle and the slope grade.

The time for design vehicle to accelerate through the DVCD on uphill grade can be calculated by multiplying the time for design vehicle to accelerate through the design vehicle clearance distance (DVCD) on level terrain with the approach grade factor.

Table 3.8-1. Factors to Account for Slower Acceleration on Uphill Grades

Acceleration Distance (ft)	Design Vehicle and Percentage Uphill Grade									
	School Bus (S-BUS 40)					Intermediate Truck (WB-50) and Interstate Semi-Truck (WB-67)				
	0-1%	2%	4%	6%	8%	0%	2%	4%	6%	8%
25	1.00	1.01	1.10	1.19	1.28	1.00	1.09	1.27	1.42	1.55
50	1.00	1.01	1.12	1.21	1.30	1.00	1.10	1.28	1.44	1.58
75	1.00	1.02	1.13	1.23	1.33	1.00	1.11	1.30	1.47	1.61
100	1.00	1.02	1.14	1.25	1.35	1.00	1.11	1.31	1.48	1.64
125	1.00	1.03	1.15	1.26	1.37	1.00	1.12	1.32	1.50	1.66
150	1.00	1.03	1.16	1.28	1.40	1.00	1.12	1.33	1.52	1.68
175	1.00	1.03	1.17	1.29	1.42	1.00	1.12	1.34	1.53	1.70
200	1.00	1.04	1.17	1.30	1.43	1.00	1.13	1.35	1.54	1.72
225	1.00	1.04	1.18	1.32	1.45	1.00	1.13	1.35	1.56	1.74
250	1.00	1.04	1.19	1.33	1.47	1.00	1.13	1.36	1.57	1.76
275	1.00	1.05	1.20	1.34	1.49	1.00	1.14	1.37	1.58	1.77
300	1.00	1.05	1.20	1.35	1.50	1.00	1.14	1.37	1.59	1.79
325	1.00	1.05	1.21	1.36	1.52	1.00	1.14	1.38	1.60	1.81
350	1.00	1.05	1.22	1.37	1.54	1.00	1.15	1.39	1.61	1.82
375	1.00	1.06	1.22	1.38	1.55	1.00	1.15	1.39	1.62	1.84
400	1.00	1.06	1.23	1.40	1.57	1.00	1.15	1.40	1.63	1.85

Step 6: Calculate the queue clearance time.

The queue clearance time is the sum of the time for the design vehicle to start moving and the time for design vehicle to accelerate through the design vehicle clearance distance.

(3) Select the desired minimum separation time (seconds).

The separation time is added for safety reasons and to avoid driver discomfort. The Institute of Transportation Engineers (ITE) recommends that the desired minimum separation time be four (4) seconds. This value may be reduced to as low as 0 seconds if the necessary warning time is not available.

(4) Calculate the maximum preemption time.

Sum the right-of-way transfer time, queue start-up time and desired minimum separation time for the required preemption time. If using Advance Preemption, check using worse-case scenario that the preemption phase does not end before the activation of the grade crossing warning devices. Variability in train arrival times should be considered. Submit the calculated maximum preemption time to the ***DTOE*** and District Rail Office for approval.

(5) Coordinate with the corresponding railroad agency and the railroad signal designer.

After approval by the ***DTOE*** and District Rail Office, provide the required preemption time to the railroad signal designer for them to determine the required rail warning system and timings.

3.8.6 PREEMPT TRAP CHECK

Variability in the actual warning time or insufficient track clearance green interval may result in the preempt trap when track clearance phase ends before the active railroad grade crossing warning lights start to flash or the gates start to descend. The preempt trap introduces the possibility that vehicles may cross or stop in the crossing after the end of the track clearance phase, without the opportunity to clear before the arrival of the train. The preempt trap can be checked with the following procedures.

(1) Collect advance preemption time (APT).

Use the actual APT value provided by the railroad. If no APT is provided, a value of zero can be used.

(2) Determine multiplier for maximum APT due to train handling.

The multiplier for maximum APT can be determined from field measurements as the largest APT observed divided by the APT.

If no field observations are available, the multiplier for maximum APT can be estimated as 1.60 if warning time variability is high (or 1.25 if warning time variability is low). High warning time variability can typically be expected in the vicinity of switching yards, branch lines, or anywhere low-speed switching maneuvers take place.

(3) Calculate maximum APT.

The maximum APT can be calculated by multiple APT with the multiplier for maximum APT.

(4) Calculate the minimum duration for the track clearance green interval.

The minimum duration for the track clearance green interval is calculated by subtracting the minimum time for flashing-light signal before the arrival of any train with the minimum time between the gate arm reaches its horizontal position and the arrival of the train.

(5) Calculate the time for gates down after start of preemption.

Calculate the time by adding the maximum APT time to the minimum duration for the track clearance green interval.

(6) Calculate the minimum right-of-way transfer time.

The minimum right-of-way transfer time is calculated by adding preempt verification and response time with best-case conflicting vehicle or pedestrian time. The best-case conflicting vehicle or pedestrian time is usually zero.

(7) Calculate the minimum track clearance green interval.

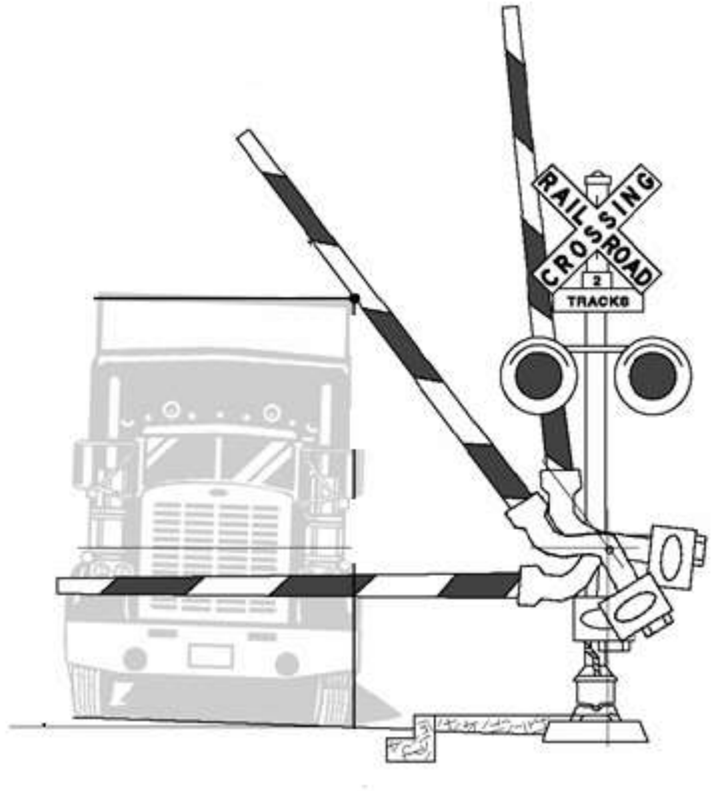
The minimum track clearance green interval is calculated by subtracting the minimum right-of-way transfer time from the time for gates down after start of preemption. This is the minimum time that the track clearance green interval has to be active to avoid the preempt trap.

If the actual track clearance green interval is shorter than the minimum track clearance green interval, the preempt trap will occur.

3.8.7 VEHICLE-GATE INTERACTION CHECK

Even if sufficient warning time is provided and the preempt trap has been addressed, it’s still possible that the automatic gates will descend on slow-moving or stationary vehicles (or vehicle-gate intersection), resulting in panic, confusion, or other unsafe actions. Long, high vehicles with low accelerations (such as tractor-trailers) are most exposed, especially to the gates “clipping” the rear of the trailer as the vehicle crosses the track during the clear track phase. ***Figure 3.8-3*** shows the relationship between descending gate and passing vehicle. The vehicle-gate interaction can be checked with the following procedures:

Figure 3.8-3. Relationship between Descending Gate and Passing Vehicle



(1) Calculate the time required for design vehicle to clear descending gate.

Collect the right-of-way transfer time and time required for design vehicle to start moving from previous steps. Calculate the time required for design vehicle to accelerate through DVL with ***Figure 3.8-2*** and ***Table 3.8-1***.

The time required for design vehicle to clear descending gate is calculated by summing the right-of-way transfer time, time required for design vehicle to start moving, and the time required for design vehicle to accelerate through DVL up.

(2) Collect duration of flashing lights before gate descent start.

This value typically ranges from 3 to 5 seconds and must be obtained from the railroad. The value obtained from the railroad may be verified using field observation.

(3) Calculate non-interaction gate descent time.

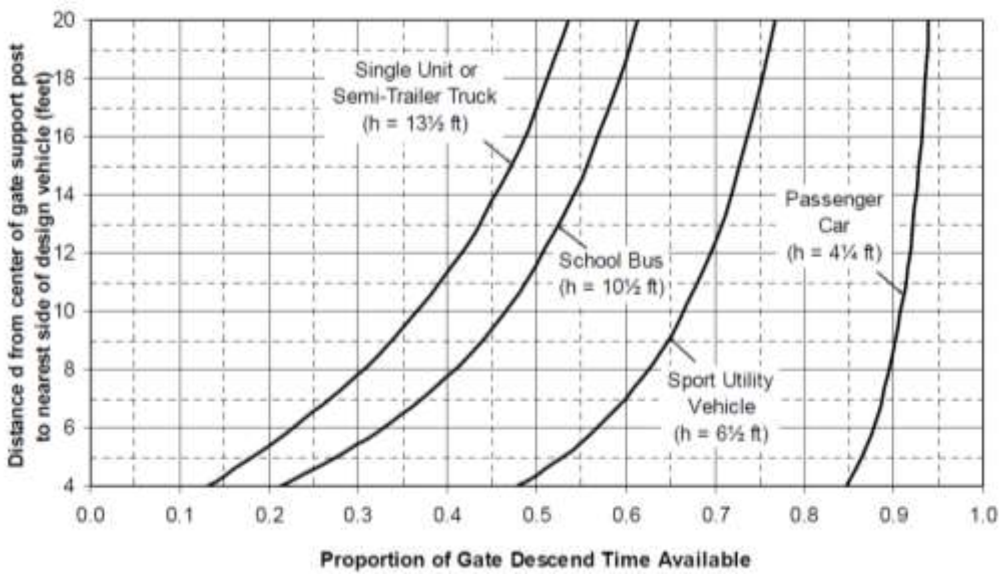
Step 1: Collect the full gate descent time from railroad.

This value must be obtained from the railroad and may be verified using field observation. In the case where multiple gates descend at different speeds, use the descent time of the gate that reaches the horizontal position first.

Step 2: Determine the proportion of non-interaction gate descent time.

Determine the proportion of non-interaction gate descent time with ***Figure 3.8-4***. Select the distance from the center of the gate mechanism to the nearest side of the design vehicle, d, on the vertical axis of ***Figure 3.8-4***, draw a horizontal line until you reach the curve that represents the design vehicle (h is the vehicle height), and then draw a vertical line down to the horizontal axis and read off the value of the proportion of non-interaction gate descent time.

Figure 3.8-4 Proportion of Gate Descent Time Available



Step 3: Calculate the non-interaction gate descent time.

The non-interaction gate descent time is calculated by multiplying the full gate descent time with the proportion of non-interaction gate descent time.

(4) Calculate time available for design vehicle to clear descending gate.

The time available for design vehicle to clear descending gate is calculated by adding duration of flashing lights before gate descent start with non-interaction gate descent time.

(5) Vehicle-gate interaction check.

The vehicle-gate interaction can be checked by comparing the time required for design vehicle to clear descending gate with the time available for design vehicle to clear descending gate.

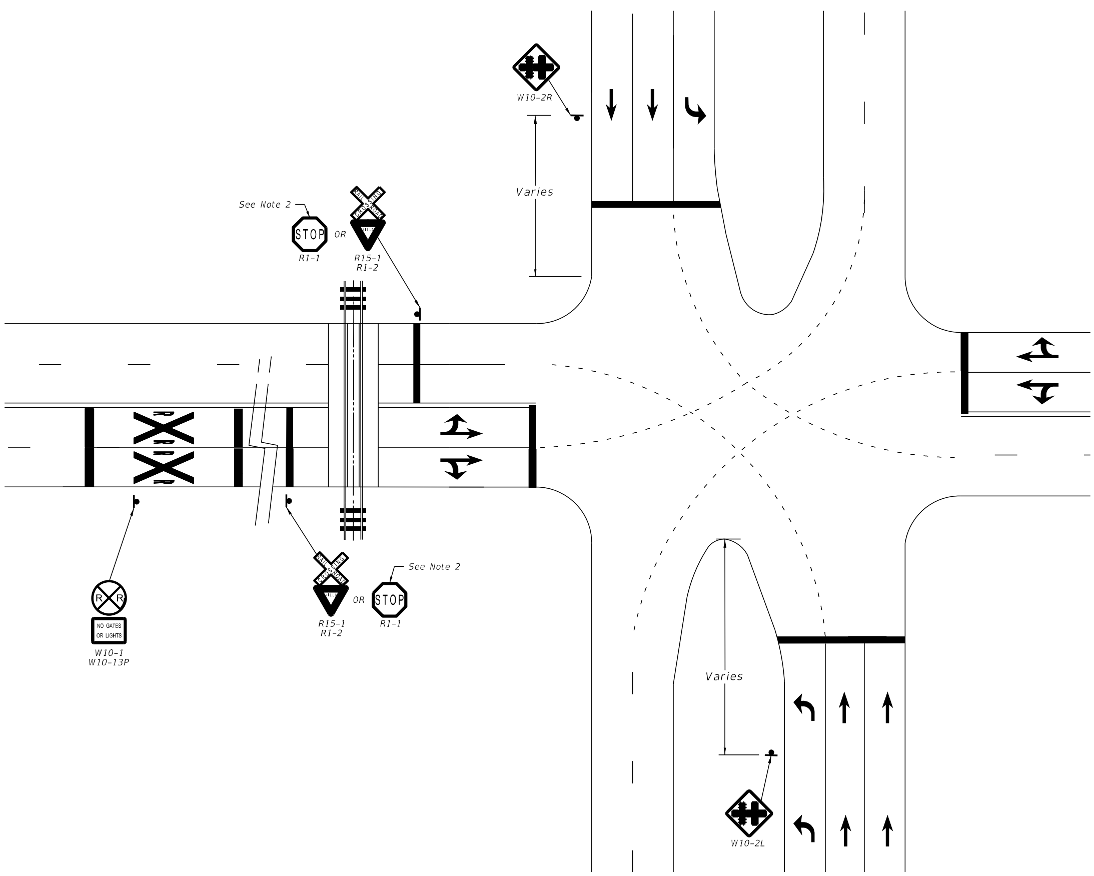
If the time available for design vehicle to clear descending gate is greater than or equal to the time required for design vehicle to clear descending gate, no vehicle-gate intersection will occur.

If the time available for design vehicle to clear descending gate is less than the time required for design vehicle to clear descending gate, APT time shall be provided to avoid design vehicle-gate interaction.

3.8.8 Example

The highway-rail grade crossing in ***Figure 3.8-5*** is within 200 feet of an existing signalized intersection. A preemption phase is required for the traffic control system. This example was developed to illustrate the step-by-step procedure for calculating the preemption time for highway-rail grade crossing.

Figure 3.8-5 Intersection for Preemption Time Calculation



(1) Calculate the Right-of-way Transfer Time (RTT).

Step 1: Calculate the preempt verification and response time.

The preempt delay time is 0 seconds. The controller response time to preempt provided by the controller manufacturer is 0 seconds. The preempt verification and response time is 0 seconds by adding the preempt delay time and controller response time together.

Step 2: Calculate the worst-case conflicting vehicle time.

The worst-case conflicting vehicle phase number is 8 for this intersection. The minimum green time during right-of-way transfer is 5 seconds. The other green time during right-of-way transfer is 1 seconds. The yellow change time for Phase 8 is 4 seconds, and red clearance time for Phase 8 is 1 seconds. The worst-case conflicting vehicle time is 11 seconds.

Step 3: Calculate the worst-case conflicting pedestrian time.

The worst-case conflicting pedestrian phase number is 8. The minimum walk time during right-of-way transfer is 5 seconds. The pedestrian clearance time during right-of-way transfer is 0 seconds. The vehicle yellow change time is 4 seconds, and vehicle red clearance time is 1 second. The worst-case conflicting pedestrian time is 10 seconds.

Step 4: Determine the worst-case conflicting vehicle or pedestrian time.

The worst-case conflicting vehicle or pedestrian time is 11 seconds based on results from step 2 and step 3 above.

Step 5: Calculate the right-of-way transfer time.

The right-of-way transfer time is 11 seconds based on results from **Step 1** and **Step 4** above.

(2) Calculate the queue clearance time.

Step 1: Determine the queue start-up distance.

The measured clearance storage distance (CSD) is 54 feet. The measured minimum track clearance distance (MTCD) is 55 feet. The queue start-up distance is 109 feet.

Step 2: Calculate the time required for design vehicle to start moving.

The time required for design vehicle to start moving is calculated as below:

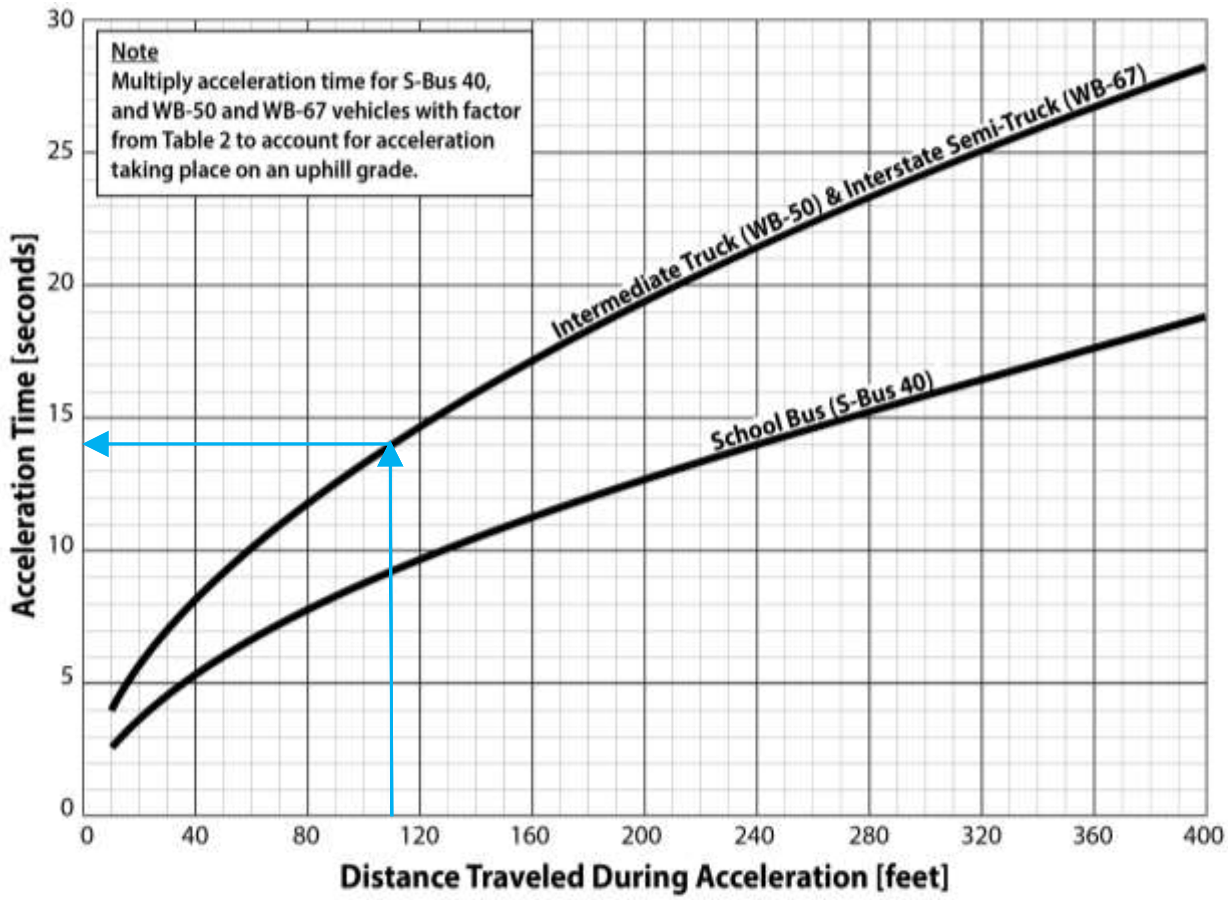
$$2+109\div20=8 \text{ seconds}$$

Step 3: Determine the design vehicle clearance distance (DVCD).

The minimum track clearance distance (MTCD) is 55 feet and the design vehicle length (DVL) is 48 feet. The design vehicle clearance distance is 103 feet based on MTCD and DVL.

Step 4: Calculate the time for design vehicle to accelerate through the DVCD on level terrain.

Figure 3-8.6 Calculation of Time for Design Vehicle to Accelerate through the DVCD on Level Terrain



The design vehicle is WB 50 & WB-67. The time for design vehicle to accelerate through the DVCD on level terrain is 14 seconds based on ***Figure 3.8-6***, as shown above.

Step 5: Calculate the time for design vehicle to accelerate through the DVCD on uphill grade.

The terrain for the selected intersection is level. Therefore, the calculation of time for design vehicle to accelerate through the DVCD on uphill grade is not needed.

Step 6: Calculate the queue clearance time.

The time required for design vehicle to start moving (**Step 2**) is 8 seconds, and the time for design vehicle to accelerate through the DVCD on level terrain (**Step 4**) is 14 seconds. The queue clearance time is 22 seconds based on results in **Step 2** and **Step 4** above.

(3) Select the desired minimum separation time.

The minimum separation time is 4 seconds based on the minimum recommended value found in the ITE Journal.

(4) Calculate the maximum preemption time.

The right-of-way transfer time is 11 seconds. The queue clearance time is 22 seconds. The desired minimum separation time is 4 seconds. The maximum preemption time is 37 seconds.

The final calculated maximum preemption time is 37 seconds for this intersection.

Section 3.9

INSTALLING RETROREFLECTIVE SIGNAL BACKPLATES ON EXISTING STRUCTURES

3.9.1 PURPOSE

The purpose of this section is to provide guidance on retrofitting existing signal structures with retroreflective signal backplates on the State Highway System.

3.9.2 BACKGROUND

(1) The use of retroreflective signal backplates improves the contrast between the traffic signal indications and their surroundings for enhanced conspicuity during both day and night conditions and during power outages. The ***FHWA Crash Modification Factor (CMF) Clearinghouse*** reports a CMF for installing retroreflective signal backplates.

(2) Rigid retroreflective backplates (RRBs) shall be installed on all new or reconstructed traffic signal structures for all approaches. However, retrofitting RRBs to existing signal head indications has been a challenge for many years due to the unknown structural capacity limits of existing signal support structures. Research and structural analysis evaluations using flexible retroreflective backplates have shown negligible wind loading impacts to mast arm and span wire support structures. The purpose of this section is to establish guidelines for installing flexible retroreflective backplates (FRBs) on existing mast arm and span wire structures at signalized intersections where backplates have not been utilized.

3.9.3 DEFINITIONS

Flexible Retroreflective Backplate (FRB). A signal backplate that allows portions of the panels to fold back when subjected to high winds and return to their original position when the wind subsides.

Mast Arm. A structure that is rigidly attached to a vertical pole and is used to provide overhead support of highway traffic signal faces or grade crossing signal units.

Rigid Retroreflective Backplate (RRB). A traditional signal backplate that remains fixed in one position when subjected to wind loading.

Signal Face. An assembly of one or more signal sections that is provided for controlling one or more traffic movements on a single approach.

Signal Head. An assembly of one or more signal faces that is provided for controlling traffic movements on one or more approaches.

3.9.4 PROCEDURE

(1) For existing mast arm and span wire structures, the use of FRBs that are listed on the ***Department's Approved Product List (APL)*** are exempt from the structural capacity analysis requirements of ***FDM 261***. This exemption is only applicable when the elements to be added to an existing signal structure are the FRBs. For all FRB installations, the ***Districts Traffic Operations Offices*** shall track and document locations and date of implementation by updating their respective ***Traffic Signal Maintenance and Compensation Agreement (Exhibit A)*** listings through the ***Department's Transportation Data Portal (GIS@FDOT)***.

(2) All other signal hardware, features, and attachments that are proposed for retrofitting on existing traffic signal structures are required to undergo structural analysis in accordance with ***FDM 261*** to determine if adequate structural capacity is available. Examples of signal hardware, features and attachments requiring structural analysis include, but are not limited to:

(a) Rigid Backplates

(b) Signal Heads

(c) Overhead Street Name Signs

(d) Static Signs

(e) Blank out Signs

(3) Structural analysis of existing traffic signal structures when required shall be performed in accordance with ***FDM 261***. Refer to the ***Section 18.3, Volume 3 of the Structures Manual*** for additional information regarding the analysis of existing structures. FRBs can be used to alleviate loading capacity per the ***Structures Manual*** guidance.

Section 3.10

FLASHING YELLOW ARROW SIGNAL APPLICATION

3.10.1 PURPOSE

The objective of this section is to provide criteria, guidelines, and best practices for the installation and operation of flashing yellow arrow (FYA) signals consistent with ***Section 4D.20 of the MUTCD***.

3.10.2 BACKGROUND

For many years, some engineers have had concerns that drivers turning left on a permissive circular green signal indication might inadvertently mistake that indication as implying the left turn has the right of way over opposing traffic, especially under some geometric conditions. Furthermore, FYA and Flashing Red Arrow (FRA) have been used to mitigate the yellow trap condition. Based on the intuitive understanding of FYA for permissive turning movements, the Department encourages the use of FYA over FRA to ensure uniformity across the state.

To date, research studies and guidelines have only been conducted for left turning FYA treatments. However, the use of right turn FYA treatments is permissible in accordance with the ***MUTCD*** and this section. Further guidance for right turn FYA treatments will be included upon research findings, implementation, and case studies.

In 2003, ***National Cooperative Highway Research Program*** (***NCHRP***) completed research for the "***Evaluation of Traffic Signal Displays for Protected/Permissive Left-Turn Control***" and published the ***NCHRP Report 493***. The key findings of the research are as follows:

- The FYA was found to be a good overall alternative to the circular green as the permissive signal display for a left-turn movement.
- The FYA was found to have a high level of understanding and correct response by left-turn drivers, and a lower fail-critical rate than the circular green.
- The FYA display in a separate signal face for the left-turn movement offers more versatility in field application. It is capable of being operated in any of the various modes of left-turn operation by time of day and is easily programmed to avoid the "yellow trap" associated with some permissive turns at the end of the circular green display.

The ***FHWA Crash Modification Factor (CMF) Clearinghouse*** reports a CMF for installation of left turn FYA signals and supplemental traffic signs.

3.10.3 OPERATIONAL REQUIREMENTS

In accordance with ***Section 4D.20 of the MUTCD***, the following design and operational requirements shall apply when a separate left-turn signal phase is being operated in a protected/permissive left-turn (PPLT) mode and a flashing left-turn yellow arrow signal indication is provided.

Mode(s) of Left-Turn Operation:

The flashing YELLOW ARROW signal indication may be displayed to indicate a permissive left-turn movement in either a protected/permissive mode or a permissive only mode of operation.

Varying the left-turn mode of operation (i.e., the permissive only, the protected only, and the protected/permissive left-turns) during different periods of the day is permitted when the following conditions apply:

- The Critical Gap is calculated to be 7 seconds at minimum during non-peak hours. The ***Department's Manual on Uniform Traffic Studies (MUTS)*** provides additional guidance on conducting vehicular critical gap studies.
- The Left-turn volume routinely is less than 240 vehicles per hour on average or the product of opposing through and left-turn hourly volumes is less than 50,000 (one opposing through lane), or 100,000 (two opposing through lanes).
- There are no fatalities and two or less left turn crashes per year that are attributed to permissive left turning movements.

Signal Head Arrangement: At least one separate four-section signal head, in addition to the minimum of two signal heads for other traffic on the approach, shall be provided for the left-turn movement. The separate left-turn signal face shall be capable of displaying, from top to bottom (or left to right in a horizontally aligned face), the following set of signal indications: Steady left-turn RED ARROW, steady left-turn YELLOW ARROW, flashing left-turn YELLOW ARROW, and steady left-turn GREEN ARROW.

Signal Head Location: Within an exclusive left-turn lane that has a left-turn signal head mounted over the roadway, that left-turn signal head should be centered over the left-turn lane or the extension thereof. If centering of the overhead left-turn signal head is not practical, it shall not be positioned any further to the right than the lane line (or the extension of the lane line) between the left-turn lane and the adjacent through lane, nor shall it be positioned any further to the left than the left edge of the left-turn lane (or extension thereof).

Signal Displays: Signal head displays shall meet the following requirements:

- Shall be capable of displaying the following signal indications: steady left-turn RED ARROW, steady left-turn YELLOW ARROW, flashing left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time.
- During the protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed.
- A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication.
- During the permissive left-turn movement, a flashing left-turn YELLOW ARROW signal indication shall be displayed.
- A steady left-turn YELLOW ARROW signal indication shall be displayed following the flashing left-turn YELLOW ARROW signal indication if the permissive left-turn movement is being terminated and the separate left-turn signal head will subsequently display a steady left-turn RED ARROW indication. At locations where permissive left turn phases have shown to have a history of non-compliant driver yielding behavior to pedestrians and documented by the engineer, the following countermeasures may be implemented:
    - Omit FYA when the pedestrian phase is called.
    - Implement LPI in accordance with ***TEM 3.11***.
- A flashing left-turn YELLOW ARROW signal indication shall be permitted to display for a permissive left-turn movement while the signal heads for the adjacent through movement display steady CIRCULAR RED signal indications and the opposing left-turn signal heads display left-turn GREEN ARROW signal indications for a protected left-turn movement.
- Before the FYA begins, provide a start-up delay (2 seconds) for all opposing through movements to establish position in the intersection.
- When changing phase from permissive left-turn movement to a protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed immediately upon the termination of the flashing left-turn YELLOW ARROW signal indication. A steady left-turn YELLOW ARROW signal indication shall not be displayed between the display of the flashing left-turn YELLOW signal indication and the display of the steady left-turn GREEN ARROW signal indication. See ***TEM 3.10.4*** for further guidance.
- The display shall be a four-section signal head except that a three-section signal head containing a dual-arrow signal section shall be permitted where signal head height limitations (or lateral positioning limitations for a horizontally mounted signal head) will not permit the use of a four-section signal head. The dual-arrow signal section, where used, shall display a GREEN ARROW for the protected left-turn movement and a flashing YELLOW ARROW for the permissive left-turn movement. Prior to the use of three section signal head, where space limits a four- section signal head, concurrence and approval from the DTOE will be required.

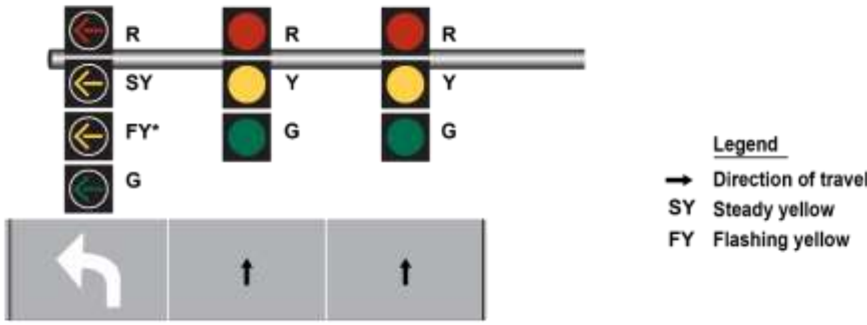
- During steady mode (stop-and-go) operation, the signal section that displays the steady left-turn YELLOW ARROW signal indication during change intervals shall not be used to display the flashing left-turn YELLOW ARROW signal indication for permissive left turns.
- During flashing mode operation (see ***Section 4D.30 of the MUTCD***), the display of a flashing left-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady left-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

Yellow Trap: FYA can be used to reduce the risk of a left turn yellow trap condition. Signal timing sequence may allow the permissive left-turn phase (FYA) to continue until the opposing traffic's through phase terminates, even if the adjacent through phase has already terminated. When implementing FYA engineers should review all potential sequencing combinations, including when phases are skipped due to lack of demand and special patterns such as preemption, to determine if a yellow trap situation could occur. If there is a possibility of a yellow trap, modifications to sequencing and controller programming parameters should be incorporated into design as necessary to eliminate the yellow trap. Primary responsibility lies with the design engineer to include adequate information in design plans for others who may be establishing sequences and controller programming.

The Four-Section Signal PPLT Mode (***Figure 3.10-1***), is illustrated in ***Figure 4D- 12 of the MUTCD***.

Figure 3.10-1. Four-Section Signal Protected-Permissive Left Turn Mode

A – Typical Position



B – Typical Arrangements

Installation Guide:

The FYA is an option for permissive/protected left turn phasing. However, as with protected/permissive operation in general, careful consideration is needed when deciding where to install the FYA.

Prior to implementing FYA at signalized intersections, it is recommended that the districts obtain concurrence from the Local Agencies and provide them with information on where the FYA(s) are being proposed.

The following guidelines are provided to ensure statewide consistency during the installation of the FYA:

- Four-section FYA signal displays for new signal installations and candidate retrofit locations that meet the criteria below should be considered and prioritized based on the following:
    - Corridors where changing to lead/lag rather than lead/lead left-turn phasing would improve progression.
    - Locations where left-turn demand is low during off-peak periods and variable modes of left-turn phasing will improve safety and operations.

- For new and retrofit FYA installation, the signal display for the left-turn movement should be centered over the corresponding exclusive left-turn lane.
- For locations with a high 65 years and older population or intersections located in a ***Safe Mobility for Life Coalition Priority County***, conduct intersection operations and crash history evaluation prior to implementation.
- It is optional use of the supplemental LEFT TURN YIELD ON FLASHING YELLOW ARROW (***FTP-85-13***) sign during the initial implementation of FYA across the state to educate motorists on FYA operations.
- The ability to install the supplemental LEFT TURN YIELD ON FLASHING YELLOW ARROW (***FTP-85-13***) sign depends on whether the structural loading capacity meets the minimum requirements to withstand the wind loading under the Department's established design criteria. Please see ***TEM 3.10.4*** for further guidance on loading.
- FYA use for permissive-only, protected/permissive, permissive/prohibited phasing should consider time-of-day applications.
- Phasing out the existing 5-section head by adding a separate 4-section FYA indication for the left-turn lane and 3-section indication for the inside through-lane. The Department will follow the ***Traffic Engineering and Operations Bulletin 20-02, Adding Backplates to Existing Traffic Signals*** to address reduced wind load requirements to facilitate the installation of the FYA signals in the most expedient manner.
- Avoid FYA installation when the following conditions exist:
  - Locations where crash patterns involve left-turning vehicles and could be attributed to driver misunderstanding of shared signal indications.
  - Locations with frequent railroad or emergency vehicle preemption activations which result in higher risk of a left-turn trap condition.
  - Locations undergoing signal upgrades.

3.10.4 INSTALLATION CRITERIA

Signalized intersections that have the following characteristics may be considered for installation of PPLT operation FYA:

- Existing intersection geometry and traffic operations characteristics facilitate the installation of the FYA including:
  - Opposing left-turn paths do not conflict.
  - Adequate left-turn crossing distance.
  - Available sight distance must be greater than required site distance based on approach speeds and left-turn lane offset conditions.
  - Use when the approach has only one left-turn bay.
  - Use when there are two opposing through lanes. Three opposing through lanes may be considered on a case-by-case basis.

- There is already an existing protective/permissive operation in place and less than three left turn related collisions per year recorded over a three- year period susceptible to correction by protected only phasing.
- Use the FYA when the left-turn volume is less than 240 vehicles per hour on average or the product of opposing through and left-turn hourly volumes is less than 50,000 (one opposing through lane), or 100,000 (two opposing through lanes).
- Signal coordination plans indicate operational improvement with the installation of FYA permissive-protected operation based on volume criteria and crash pattern during peak periods.

While it is desirable to be consistent in the application of left turn treatment along a corridor for driver expectation, it may not be practical to install FYA left turn protected/permissive mode in a consistent manner along a corridor. For example, FYA left turn operation requires a separate left turn signal head. Signalized intersections along a corridor equipped with shared signal heads that would require installation of new signal poles with longer mast-arms may be cost prohibitive to convert to FYA left turn operation.

There are existing implementations of FYA that have resulted in a mix of FYA and 5-section green ball protected/permissive operation. However, it would be appropriate to install the FYA at a new signalized intersection meeting the criteria for PPLT mode operation on the corridor without immediately modifying the other existing intersections along the corridor. Preferably, the intersection should not be within view of other intersections with the 5-section green ball.

Consider using a FYA protected/permissive mode at a location that previously operated in protected mode only after an engineering study of the intersection. Do not remove protected-only left turn phasing if opposing sight distance is inadequate for permissive left turns, operating speed is too great, roadway geometry is complicated or there are too many opposing through lanes. For more information on sight distance refer to the ***FDM 212***.

3.10.5 VARIABLE MODE OF OPERATION

Variable mode operation, changing between protected only to protected/permissive mode, or between protected/permissive to permissive only operation by time of day is possible with the 4-section FYA signal head where an engineering study shows this type of operation will improve safety and operations. However, it is important to ensure that the traffic signal controller is capable of switching between modes in a manner such that the flashing yellow arrow indication and the opposing through movement indication terminate together.

When switching between protected/permissive to permissive only, ensure that the controller is capable of reassigning the left turn detectors to call the associated through phases by time of day.

3.10.6 PUBLIC NOTIFICATION

Installation of a FYA left turn operation should be coordinated with the District Public Information Office. Consider providing press releases with specific details on when the public can expect to see the new indications. Press releases should be prepared and sent out (approximately two weeks or more in advance of conversion).

3.10.7 EDUCATION

The Department's Safe Mobility for Life Program/Coalition developed a FYA tip card (***Figure 3.10-2***) to inform and educate the public about this new traffic control device. The tip card was developed using human factors studies to help the public simply understand what to do when encountering a FYA on the roadway system. This FYA tip card is part of the Roadway Safety Series and can be used by district staff for public outreach where these traffic control devices are installed. To obtain digital and/or print versions of the FYA educational materials, visit ***SafeMobilityFL.com***.

Location-specific education using Portable Changeable Message Signs (PCMS) should also be conducted. The following alternating messages should be displayed both prior to (minimum one week) and after implementation (maximum six weeks):

- Phase 1: NEW SIGNAL DISPLAY
- Phase 2: YIELD ON FLASHING ARROW

Figure 3.10-2. Flashing Yellow Arrow Tip Card

3.10.8 SIGNAL RETROFIT CHECKLIST

Before FYA signal is set up in the field, the following checklist can be used to examine the existing hardware conditions at the intersections. Full awareness of the existing hardware conditions can facilitate a smooth implementation of FYA

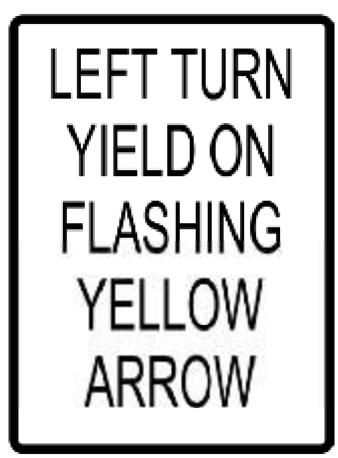
Signal Retrofit Checklist:

- Check replacement head size/mounting. Sometimes, installation of four-section vertical signal head (to replace five-section doghouse) may need to raise wire spans.
- Check if the number of available cables is sufficient to enable FYA signals. A common installation of PPLT phasing using a green ball for the permissive interval makes use of the green through phase to illuminate the green ball. Due to the flashing indication, additional cabling may be necessary in order for the flashing display to be controlled by its own circuit.
- Check if the mast arm is long enough to center the FYA signal head over the exclusive left-turn lane.

- Check status of signal equipment. Before implementing FYA signals, the equipment to be used should be checked, e.g., a malfunctioned load switch or a bad load switch socket may lead to problems during the implementation of FYA.
- Confirm with signal equipment manufacturers about the applicability and programming method of the controller and management malfunction unit (MMU). Most leading signal equipment manufacturers have developed new models of controllers and MMUs that support FYA signal operations. Controllers must have the correct firmware to enable FYA operations.
- Check if cabinet modification is required. Controller manufacturers have not standardized on FYA operation. Cabinet modification will depend on controller make and model. An MMU capable of FYA operation is required. Install a new MMU recommended by the controller manufacturer. A modification to the cabinet flash programming is required. Contact the manufacturer representative.
- The ***MUTCD*** does not include a standard explanatory sign for FYA installation since FYA display is intuitively obvious in meaning to drivers and an explanatory sign is unnecessary. However, the Department has designed a 36-inch x 30-inch white background and black lettering LEFT TURN YIELD ON FLASHING YELLOW ARROW (FTP-85-13) sign as shown in Figure 3.10-3. The specific sign detail is shown in the Standard Plans, Index 700-102 and can be installed adjacent to the new FYA signal head for additional clarification. If the FYA signal module is to be installed at an existing location with a 5-section head, verify the sign can be installed and ensure any conflicting signs such as the LEFT TURN YIELD ON GREEN (R10-12) sign is removed if in place.

Other FYA signs may NOT be used as an alternative to FTP-85-13, including sign variations that replace the text with symbols.

Figure 3.10-3. Flashing Yellow Arrow Sign (FTP-85-13)



Section 3.11

SIGNAL TIMING APPLICATIONS FOR PEDESTRIAN MOVEMENT

3.11.1 PURPOSE

This section defines signal timing applications that are used to improve safety and enhance mobility for pedestrian movements. This section covers considerations for implementing Leading Pedestrian Interval (LPI), Flashing Yellow Arrow (FYA) Omit by Ped, and Delayed Turn applications, for signalized intersections.

3.11.2 BACKGROUND

Signal timing features are used to improve traffic conspicuity and pedestrian safety. The ***NCHRP Report 812*** ***Signal Timing Manual*** and ***NCHRP Report 969*** ***Traffic Signal Control Strategies for Pedestrians and Bicyclists*** highlight signal timing applications for pedestrian movements. Signal timing and signal timing adjustments are evaluated, determined, and documented by a Traffic Engineer.

3.11.3 DEFINITIONS

Automatic Pedestrian Recall. A recall mode where a call is automatically placed for continuous pedestrian service, resulting in the pedestrian walk and clearance intervals timing every cycle. Automatic pedestrian recall eliminates the need for a pedestrian to push a pedestrian push button or passive detection of pedestrians and ensures that the pedestrian phase is presented each cycle.

Concurrent Yet Protected. A variation on the *Delayed Turn* timing treatment, where left and right-turning movements are not permitted during the conflicting *Walk* and *Flashing Don't Walk* intervals. This treatment requires exclusive turn lanes, signal heads, and *No Turn On Red* signage.

Flashing Don't Walk. A warning to pedestrians that the *Walk* indication has ended and the *Don't Walk* indication is underway.

Flashing Yellow Arrow Omit by Ped (FYA Omit by Ped). A signal controller option omitting a permissive left-turn movement during the conflicting *Walk* and *Flashing Don't Walk* intervals.

Delayed Turn. A signal controller option that releases through vehicles and pedestrians concurrently while holding turning movements with a red indication and *No Turn On Red* signage. This treatment requires exclusive turn lanes, signal heads, and *No Turn On Red* signage.

Lagging Pedestrian Interval. A pedestrian interval option where the pedestrian walk interval starts several seconds after the adjacent through movement phase. This option allows a waiting right turn queue to clear before the *Walk* indication is presented and reduces conflicts with right-turning vehicles. It is applicable to intersections where there is either an exclusive right-turn lane (or lanes) or the two intersecting roads have one-way traffic.

Leading Pedestrian Interval (LPI). A pedestrian interval option, also known as "pedestrian head start" or "delayed vehicle green", which gives pedestrians an advance *Walk* indication before a concurrent green signal is provided to vehicles. This allows pedestrians to establish a presence in the crosswalk, thereby reducing conflicts with turning vehicles. LPI is a proven safety countermeasure to reduce vehicle-pedestrian crashes at signalized intersections.

Pedestrian Detector Call. An input into the associated phase of the controller unit for service of a pedestrian demand, upon detection of a pedestrian.

Pedestrian Omit. A command that ignores pedestrian calls for service and prevents the service of a pedestrian phase. Activation of this input does not affect a pedestrian movement in the process of timing. This feature is a consideration at intersections with rail preemption.

Pedestrian Recycle. A signal controller option that allows a pedestrian phase to be served multiple times within the same vehicle phase when pedestrian demand exists and the split time remaining is greater than or equal to the time needed to serve the pedestrian phase.

- In the actuated mode, if a serviceable pedestrian call exists on the subject and the *Hold* input is active, the pedestrian movement is recycled when the *Pedestrian Recycle* input is active, regardless of whether a serviceable conflicting call exists.
- In the non-actuated mode, if the subject phase has reached the *Green Dwell/Select* state, the *Pedestrian Omit* is not active on the phase and a serviceable conflicting call does not exist, the pedestrian movement is recycled when the *Pedestrian Recycle* input is active.

Pedestrian Scramble/Barnes' Dance. A type of exclusive pedestrian phase, that is configured such that no vehicular movements are served concurrently with pedestrian traffic, where pedestrians may cross all intersection legs and may include diagonal crossing. (Note: The walking time is extended for the diagonal movement, ped heads, Audible Pedestrian Signal (APS) and pavement markings are installed to indicate diagonal crossing.)

Pedestrian Walk Interval. An indication providing initial right-of-way to pedestrians during a pedestrian phase and prior to the pedestrian clearance interval.

Rest in Walk. The pedestrian phase is set to rest in the walk interval to maximize the walk display during a vehicle green. This pertains whether the walk signal initially comes on through activation of the pedestrian push button, passive pedestrian detection, or through automatic pedestrian recall. The *Flashing Don't Walk* interval times prior to the yield point.

Walk Rest Modifier. When activated, modifies non-actuated operation only. Upon activation, the non-actuated phase(s) remain in the timed-out *WALK* state (*REST IN WALK*) in the absence of a serviceable conflicting call without regard to the Hold input status. With the input nonactive, non-actuated phase(s) do not remain in the timed-out *WALK* state unless the Hold input is active. The controller unit recycles the pedestrian movement when reaching the *Green Dwell/Select* state in the absence of a serviceable conflicting call.

3.11.4 GENERAL CONSIDERATIONS

This section provides general considerations of signal timing applications for pedestrian movement.

Avoid lengthy traffic signal cycles; consider reviewing the ***INRIX Smart Signal Dashboard*** to determine efficiencies in cycle lengths. Cycle length reductions can help reduce pedestrian wait times and increase pedestrian compliance behavior with pedestrian signals.

Consider automatic pedestrian recall where vehicles need at least the same amount of time as the sum of the *Walk* and *Flashing Don't Walk* intervals.

3.11.5 LPI CONSIDERATIONS

Comply with ***Section 4E.06 of the MUTCD*** when considering LPI signal applications.

Review all new signalized intersections, and existing intersections as timing changes are made, for LPI implementation. Considerations for where LPIs may be appropriate are provided in ***TEM 3.11.5.1***. LPI implementation is at the discretion of the ***DTOE***. The decision process for LPI implementation should be documented in the project file in the format of either email or technical memorandum.

3.11.5.1 LPI LOCATION SCREENING CONSIDERATIONS

LPIs are generally used for pedestrian phases which have a concurrently timed conflicting right turn and research has demonstrated that LPIs can be beneficial at intersections of any pedestrian volume.

Here are some general considerations for where to implement an LPI. Do not use these considerations to exclude locations:

- Field observations, citizen complaints, crash history, near misses, or risk analysis indicating conflicts between turning vehicles on green and pedestrians.
- At marked school crossings.
- Determination of a visibility issue blocking drivers' view of pedestrians due to obstructions or poor sight distance. At a minimum, consider the following:
    - Intersection geometry that tends to obscure pedestrians from motorists or vice versa.
    - Lighting problems that cannot be adequately addressed through standard lighting requirements.
    - Sun angle that blocks drivers' visibility at certain times of day or times of the year.
- Approaches where the time needed to serve vehicular demand is less than the associated *Walk* and *Flashing Don't Walk* intervals.

Consider the following points at low to medium pedestrian volume intersections:

- Increased conspicuity of pedestrians in areas where pedestrian volume is low and may not be expected by drivers may be achieved through the use of LPIs.
- Where the pedestrian phase is actuated, LPIs can benefit pedestrians when they are present without timing every cycle.
- Combining LPI with automatic pedestrian recall for low pedestrian volume phases may increase vehicular impacts of the LPI with limited added benefit for pedestrians.
- With medium pedestrian volume (particularly on corridors with more signals), actuated LPIs lead to increased vehicular delay as progression is lost. Implementing automatic pedestrian recall in these cases can generally recover the vehicle delay as it is often not caused by capacity constraints but by lack of progression.

Consider the following points at high pedestrian volume intersections:

- Vehicular impacts of LPIs may be lower where a high volume of crossing pedestrians may inhibit right turn movements.
- LPIs may not provide the desired level of protection at very high pedestrian crossing locations. A pedestrian scramble may be more appropriate where either of the following conditions exist:
    - There is a very high volume of pedestrian crossings.

- There is a high volume of right turns.
- There is high demand for diagonal pedestrian crossings.

3.11.5.2 LPI IMPLEMENTATION CONSIDERATIONS

Most modern controllers support LPI natively. At locations where the controller does not support LPI programming, consider replacing the controller. For information on how to program an LPI, refer to the ***FDOT Leading Pedestrian Interval Programming Primer***.

LPI timing should allow pedestrians to clear at least the width of one lane in the direction of moving traffic, including the width of a parking and bicycle lane, to increase the visibility of pedestrians to turning traffic. A minimum of 3-second LPI duration is required by the ***MUTCD***.

A maximum LPI duration is established to limit driver's tendency to disobey the signal.

- With an actuated pedestrian phase, the maximum time of the LPI should be 10 seconds. If greater time is needed for the LPI, either based on ***Formula 3.11.5.2-1*** or due to sight distance concerns, consider geometry updates such as curb bulb-outs to shorten the distance a pedestrian needs to cross to get through one through lane. Alternatively, consider using an exclusive pedestrian phase or concurrent yet protected signal timing if site conditions allow.
- With a pedestrian phase on automatic recall, the maximum LPI time is 7 seconds.

Consider a 3-second LPI duration when an intersection operates close to capacity.

Use ***Formula 3.11.5.2-1*** to calculate LPI duration for each crosswalk:

Formula 3.11.5.2-1

$$\mathrm{LPI} = \frac{\mathrm{ML} + \mathrm{B}}{\mathrm{W}} + \mathrm{PS}$$

Where:

LPI = Number of seconds (rounded up to the nearest interval allowed by controller) between onset of "Walk" signal for pedestrians and green indication for vehicles.

ML = Distance on crosswalk to clear width of one through lane from the edge of curb, in feet. Consider large corner radii as per ***Section 4E.06.22 of the MUTCD***.

B = Distance from pedestrian detector location to the edge of curb, in feet. Use 6 feet if no pedestrian detector is present. This accounts the distance a pedestrian travels to arrive at the curb.

W = Walking speed (3.5 ft/s for pedestrian clearance interval calculation suggested by the ***MUTCD***). The ***Department's Manual on Uniform Traffic Studies (MUTS)*** provides additional guidance on conducting individual pedestrian walking speed studies.

PS = Pedestrian start-up lost time (recommend using 1.6 seconds). This term can be omitted if an Accessible Pedestrian Signal (APS) is provided.

Consider the use of an Accessible Pedestrian Signal (APS) (***Sections 4E.09 to 4E.13 of the MUTCD***) with LPI applications, as vision-impaired pedestrians use the sound of moving traffic to start crossing. APSs alert pedestrians that the walk signal has initiated. Refer to ***TEM 3.7*** for APS applicability and implementation.

When an LPI is used, consider concurrent turning movements across the crosswalk.

Right turn

Use either of the following options:

- Prohibited turns on red using a static or dynamic "NO TURN ON RED" sign (R10-11)
- A shared lane with through vehicles totaling more than two-thirds of the traffic within the lane.

If a dynamic sign is used, display the message during the LPI interval and the preceding yellow and red intervals.

Protected left turn

Do not time LPIs concurrent with the opposing protected left-turn interval. Protected left turns may be leading or lagging; however, lagging the opposing left turn movement is preferred to reduce pedestrian conflicts with late turning vehicles.

For opposing leading left-turn movement, time the LPIs after the opposing protected left-turn movement and prior to the green interval for through vehicle movements. For opposing lagging left-turn movement, time the LPIs prior to the green interval for through vehicle movements.

Protected-permissive left turn

Do not time LPIs concurrent with the opposing protected left turn interval. Protected-permissive left turns may be leading or lagging. Lagging the opposing left turn movement is preferred to reduce pedestrian conflicts with late turning vehicles.

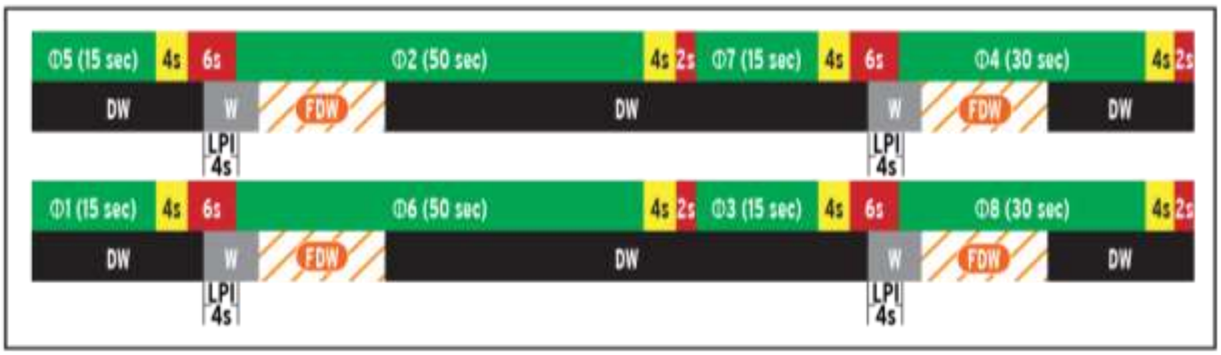
Time the pedestrian phases with LPIs concurrently, unless FYA signal heads are used for the conflicting left-turn movements. This prohibits permissive left-turning movements during the LPI.

Permissive left turn

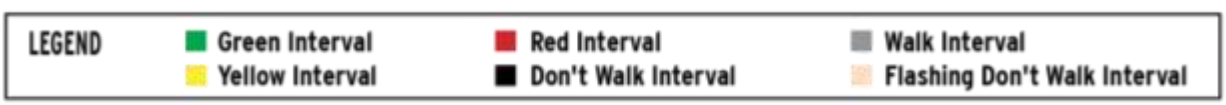
LPIs may be implemented with permissive left turns. Time the pedestrian phases with LPIs concurrently, unless FYA signal heads are used for the conflicting left-turn movements. This prohibits permissive left-turning movements during the LPI. See ***Figure 3.11-1*** for examples.

Figure 3.11-1. Schematic Diagram for Signal Timing with LPI

A - Lead/lead left turn



B - Lead/lag left turn



For corridors with LPIs at multiple intersections, consider using automatic pedestrian recall in conjunction with LPIs to maintain progression along the corridor.

Conducting field observations for safety improvement evaluations and overall intersection operations after LPI implementation is recommended. Potential further signal timing adjustments may be applied based on safety needs and engineering judgement.

3.11.6 FLASHING YELLOW ARROW (FYA) OMIT BY PED

Consider implementing FYA Omit by Ped at locations with protected-permissive signal phasing and 4-section signal heads.

FYA Omit by Ped may be programmed by time of day during higher pedestrian volume periods where the volume of pedestrians may inhibit permissive left turns from occurring, such as for:

- Intersections with high permissive left turning conflicts with pedestrians
- School arrival and dismissal periods
- Arrival and dismissal periods at event venues

Use of *Rest in Walk* is not recommended with *FYA Omit by Ped* as it results in a protected only left turn phase.

3.11.7 DELAYED TURN

Consider implementing *Delayed Turn* on approaches with dedicated lanes and signal heads for turning movements. This treatment also requires *No Turn On Red* signage. Left and right turn movements may be held for the duration of the *Walk* and *Flashing Don't Walk* intervals to achieve concurrent yet protected phasing. Use ***Formula 3.11.5.2-1*** and engineering judgement to calculate the duration of the turning movements.

Section 3.12

TRAFFIC SIGNAL RETIMING

3.12.1 PURPOSE

The purpose of this section is to provide guidance on the general frequency of when to retime a traffic signal to reduce travel delays, accident rates, and pollution from fuel consumption and emissions.

3.12.2 GENERAL

The Federal Highway Administration (FHWA) is currently engaged in informing local and regional traffic signal management centers on the effectiveness of signal retiming. Signal retiming is a low-cost approach to safely keep traffic moving smoothly while also helping:

- Reduce traffic congestion
- Reduce aggressive driving behavior/red-light running
- Reduce the number of injuries or serious injury crashes
- Reduce fuel consumption and emissions
- Reduce the need for increased road capacity construction

Retiming traffic signals every 3 to 5 years has become the standard engineering practice. The need to re-examine a signals timing within the 3-to-5-year window could be a result of:

- Increased capacity or turning movements
- Increased traffic congestion
- Increased truck percentage
- Construction activities (Road or Development)
- New traffic signals along the corridor

3.12.3 PROCEDURE

The Department has adopted this practice and expanded so urban signals are retimed every 3 years and rural signals are retimed every 5 years. The retiming of these signals run in cycles with 33% of urban and 20% of rural being retimed each year. This approach follows a regularly scheduled system for retiming signals on the State Highway System (SHS).

The districts can perform alternate approaches that include:

- Traffic Study based on observation of performance loss (queues not fully being discharged, spillback, and unused green time).
- Perform analysis of the existing timing against optimized timing performance developed through signal timing software.

These alternate approaches have been adopted for areas where traffic flows have matured and stabilized. Analyze traffic signals every 3 to 5 years whether or not the signal is being retimed.