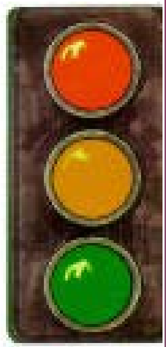
Oregon Department of Transportation

Traffic Signal Policy and Guidelines



July 2015

OREGON DEPARTMENT of TRANSPORTATION
HIGHWAY DIVISION
TRAFFIC-ROADWAY SECTION
TRAFFIC ENGINEERING UNIT
http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/Pages/traffic_engineering.aspx

(This page is intentionally left blank)

TABLE OF CONTENTS

(This page is intentionally left blank)

Preface

The Oregon Department of Transportation (ODOT) is responsible for installation, operation, and maintenance of most traffic signals on the State Highway System. The Oregon Transportation Commission has adopted as its policy, the Manual on Uniform Traffic Control Devices (MUTCD) and the Oregon Supplement to the Manual on Uniform Traffic Control Devices. The Traffic Signal Policy and Guidelines are based on the MUTCD and the Oregon Supplement to the MUTCD and address only items not included in these publications or items that need further clarification. They reflect the Oregon Revised Statutes and Oregon Administrative Rules; ODOT practices; and agreements with the League of Oregon Cities (LOC) and the Association of Oregon Counties (AOC). The use of the terms "shall", "should", and "may" in this document shall be identical to their meanings in the MUTCD.

These guidelines are for the use of individuals involved in the design, operation, or maintenance of traffic signals on the State Highway System in Oregon. The Oregon Traffic Control Devices Committee (OTCDC) recommends that other jurisdictions follow these guidelines. Additional guidance is available in the references cited above and in the ODOT Traffic Manual. The purpose of this document is to encourage uniformity in the location, operation, and maintenance of traffic signals in Oregon. These guidelines are only applicable for new signals or existing signals that will be modified as part of future projects.

These guidelines were produced in cooperation with the OTCDC, an advisory group to the state, cities, and counties in Oregon regarding traffic management issues.

OREGON DEPARTMENT OF TRANSPORTATION

Approved by the State Traffic Engineer,
in consultation with the Oregon Traffic Control Devices Committee

Bob Pappe, PE, PLS, State Traffic Engineer

Date: 8/25/2015

Jeff Wise, PE, PTOE, OTCDC Chairperson

Date: 9-1-2015

(This page is intentionally left blank)

1 Traffic Signal Approval Process

The State Traffic Engineer has been delegated the authority to approve the installation of traffic control devices on state highways. The traffic signal approval process is established by Oregon Administrative Rules OAR 734-020-0400 thru 734-020-0500 for the installation, modification, and removal of traffic signals under the authority of ODOT. All traffic signal installations and removals on state highways require approval from the State Traffic Engineer. All traffic signal modifications on state highways require approval from either the State Traffic Engineer or the Region Traffic Engineer/Manager, depending on the level of delegated authority. The ODOT Traffic Manual contains a summary of the delegated authorities and additional information related to the approval process.

All installations and modifications of traffic signals require two different approvals: operational and design approvals. Operational approval is required before design approval can be granted. Operational approval confirms the decision that the proposed installation, removal, or modification of the existing signal is the preferred method of traffic control for the intersection and covers how the intersection will operate. Design approval ensures the signal plans conform to ODOT standards and specifications. Appendix C shows the flowcharts for operational and design approval processes.

Operational approval for the installation or removal of a traffic signal requires an engineering study. The engineering study shall indicate the need for the traffic signal and demonstrate that the installation/removal of a traffic signal will improve the overall safety and operation of the intersection. The following elements should be included in the engineering study:

- Location (region, district, highway, milepoint, and side street name)
- Traffic volumes (am and pm volumes for base and future years)
- Traffic signal warrants analysis (per MUTCD)
- Signal progression analysis (refer to OAR 734-020-0480)
- Conceptual traffic signal design (if available)
- Vehicle turning template
- Safety analysis (including crash history)
- Operational analysis
- Documentation of Transportation Plan consistency
- Evidence of other agency support
- Comparison of reasonable alternatives (e.g. stop control, roundabout, intersection relocation or reconfiguration, and/or grade separation)

Modifications of existing signals that require approval from the State Traffic Engineer shall also be supported by an engineering study. The study should include appropriate elements mentioned above.

The engineering study shall have Region Traffic Engineer/Manager approval and be submitted to the office of the State Traffic Engineer with a detailed cover letter that includes the above-mentioned elements. The cover letter shall also be accompanied with the Preliminary Signal Operations Design Form (Appendix D). The State Traffic Engineer approval letter and summary will include requirements regarding the approved lane configuration and phasing.

For all signal modifications only requiring Region Traffic Engineer/Manager approval, documentation shall be sent to the Traffic-Roadway Section justifying and explaining the type of modification that is planned. This documentation is critical for the design review and approval process. The following information should be included in the summary documentation:

- Location (region, district, highway, milepoint, and side street name)
- Existing intersection configuration and operation
- Proposed intersection design configuration and operation
- Traffic volumes (am and pm volumes for base and future years)
- Reason for the proposed modification
- Any supporting information used in the Region approval

Design approval of a traffic signal requires traffic signal plans and specifications. The traffic signal plans and specifications shall follow the conditions of the operational approval. The requirements for design approval are covered in the ODOT Signal Design Manual.

1.1 Traffic Signal Warrants

For new signal installations, one or more of the Traffic Signal Warrants, mentioned in Chapter 4C of the MUTCD, shall be met unless the traffic signals meet the criteria for special applications discussed in Section 1.2 below. An analysis of compliance with each applicable warrant should be included in the engineering study.

1.2 Special Applications

1.2.1 Projected Signal Warrants

MUTCD Warrant 1, Condition A or Condition B may be projected by using future year Average Daily Traffic Volumes to determine the future need for a traffic signal. The Transportation Planning and Analysis Unit (TPAU) has developed a procedure (refer to the Analysis Procedure Manual) to project future traffic. Refer to OAR 734-020-0430 for limitations regarding future volume project.

For new intersections where hourly traffic volumes are not available, ADT – based Preliminary Signal Warrant Analysis, as presented in the Analysis Procedure Manual, may be used instead of MUTCD Warrant 1 for warrant analysis.

1.2.2 Bicycle and Pedestrian Activated Warning Systems

Bicycle and pedestrian activated warning systems include flashing beacons, pedestrian hybrid beacons, and rectangular rapid flashing beacons. These devices can be useful at intersections or mid-block locations where there are potential of conflicts between the vehicles and pedestrians/bicyclists or where there may be limited sight distance or lane width such as on narrow bridges or in tunnels. Installation of these devices requires approval from the State Traffic Engineer. Refer to Part 4 of the MUTCD, the ODOT Traffic Manual, and Section 5.4 of this document for guidance on these devices.

1.2.3 Emergency Traffic Signals

An Emergency Signal is a special traffic control signal that assigns the right-of-way to fire trucks and other vehicles providing emergency services. Refer to Chapter 4G of the MUTCD and Section 6.1 of this document for guidance on installation of emergency traffic signals.

1.2.4 Freeway Entrance Ramp Control Signals (Ramp Meters)

A ramp meter is a traffic signal on a freeway entrance ramp that controls the rate at which vehicles enter the freeway. All ramp meter installations, modifications, and removals on state highways require approval from the Region Traffic Engineer. The installation, modification, or removal of all ramp meters shall be supported by an engineering study that indicates the recommended action will improve safety and/or operations. Additional guidance can be found in Chapter 4I of the MUTCD and Section 6.2 of this document.

1.2.5 Temporary and Portable Signals

A temporary traffic signal is typically used to control traffic in work zones. A portable signal is a temporary signal mounted on a trailer. Installation of temporary and portable signals on state highways requires approval from the State Traffic Engineer. Refer to Chapter 4D of the MUTCD and Section 6.3 of this document for guidance on temporary and portable traffic signals. When considering the use of temporary or portable traffic signals, a site visit to observe field conditions should be conducted when investigating their possible use in work zones. Sight distance to the potential signal display locations shall be per MUTCD, Table 4D-2 “Minimum Sight Distance for Signal Visibility”.

1.2.6 Flashing Beacons

Flashing beacons, including warning beacons and stop beacons, are supplemental devices installed in conjunction with warning or regulatory signs. Refer to Part 4 of the MUTCD and the ODOT Traffic Manual for guidance on the installation of these devices.

1.3 Approved Traffic Signals

If a traffic signal is not advanced to construction within five years of the approval from the State Traffic Engineer, the approval is automatically rescinded (OAR 734-020-0430). ODOT Traffic-Roadway Section maintains a list of signals that have been approved for construction in state highways as well as the Traffic Signal Approval Letters for each traffic signal installation.

2 Design, Construction, Timing, and Maintenance Responsibilities

2.1 Signal Design

The ODOT Signal Design Manual shall be the primary source for information related to traffic signal design. Refer to Part 4 of the MUTCD for additional design information.

2.2 Signal Construction

All necessary approvals, as discussed in Section 1, shall be obtained prior to advancing to construction and the construction shall be done according to the construction plans, ODOT Standard Specifications, and Special Provisions.

2.3 Signal Timing

The primary responsibility for timing of traffic signals on state highways belongs to the Region Traffic Engineer/Manager or designated representative under the authority of the State Traffic Engineer unless an interagency agreement dictates otherwise. Copies of the current timing should be kept in the traffic signal controller cabinet and at the Region office. Traffic-Roadway Section staff is available for assistance with all aspects of signal timing.

2.4 Signal Maintenance

ODOT is typically responsible for the design, operation, inspection, and maintenance of all traffic signals at intersections of state highways. However, an Intergovernmental Agreement (IGA) between ODOT and a local agency may define other traffic signal maintenance and operation arrangements.

ODOT is generally responsible for design, operation, inspection, and maintenance of traffic signals at the intersection of a state highway and a county road or a city street. ODOT will typically develop an IGA with the local agency to clarify roles, arrange for maintenance, and allocate costs. ODOT, the Association of Oregon Counties (AOC), and the League of Oregon Cities (LOC) have established guidelines for the development of these agreements.

It is ODOT's intent to only allow traffic signals on state highways at intersections with public roads or roads that are identified on Transportation System Plans (TSP) or other local plans and will be public roads in the future. However, where signals are approved on state highways at intersections with private approaches, ODOT will normally complete a three-party agreement with the local agency and the private development regarding the design, construction, inspection, timing, cost allocation, maintenance, and removal of signal equipment.

When state or federal funds are used for the design or construction of a traffic signal not on a state highway, ODOT's responsibility is generally limited to design review and contract letting. However, ODOT may perform additional work as outlined in an IGA.

For specific information on maintenance activities refer to Activity 144, Traffic Signal Maintenance, in the ODOT Maintenance Guide.

The office of the State Traffic Engineer will determine the specific type and character of the hardware and software used on the state highways. Hardware includes, but is not limited to: control system, traffic structures, and any other components necessary to complete a traffic signal. Software includes, but is not limited to: controller software, adaptive software, or any other devices utilized to run the traffic signal controller.

2.5 Signal Hardware and Software Standards

The office of the State Traffic Engineer will determine the specific type and character of the hardware and software used on the state highways. Hardware includes, but is not limited to: control system, traffic structures, and any other components necessary to complete a traffic signal. Software includes, but is not limited to: controller software, adaptive software, or any other devices utilized to run the traffic signal controller.

3 Yellow Change and Red Clearance Intervals

The purpose of the yellow change and red clearance intervals is to provide a safe transition between two conflicting signal phases. This section discusses ODOT's policy regarding the yellow change and red clearance intervals.

3.1 Yellow Change Interval

The steady yellow signal indication is displayed following every steady green signal indication to warn vehicle traffic of an impending change in the right-of-way. The amount of time that the steady yellow signal is displayed is referred to as the yellow change interval. The duration of the yellow change interval is based on the driver's perception-reaction time, deceleration rate, the approach speed, and the approach grade. The duration of the yellow change interval should allow, at a minimum, for a driver to comfortably decelerate to a stop prior to entering the intersection.

The yellow change interval in use at traffic signals on state highways shall meet or exceed ODOT's minimum yellow change interval, as shown in Table 3-1. These yellow change intervals are based on Formula 1 from the Institute of Transportation Engineers (ITE) Informational Report, "Determining Vehicle Signal Change and Clearance Intervals". The ODOT minimum yellow change intervals shown in Table 3-1 are applicable for approaches where grades (downgrades) are 3 percent or less. For grades exceeding 3 percent, the ITE formula shown below, should be used. Left turns may be treated as 25 mph approaches. ODOT's minimum yellow change interval is 3.5 seconds and maximum yellow is 5.0 seconds.

$$y = t + \frac{v}{2a + 2Gg} \qquad (1)$$

Where:

y = length of the yellow interval, to the nearest 0.1 sec;

t = driver perception-reaction time, recommended as 1.0 sec;

v = velocity of approaching vehicle, in ft/sec;

a = deceleration rate, recommended as 10 ft/sec^2;

g = acceleration due to gravity, 32 ft/sec^2; and

G = grade of approach (3% downgrade would appear as -0.03)

3.2 Red Clearance Interval

Red clearance interval (also referred to as "all-red") provides additional time as a safety measure to any driver that may have entered the intersection legally during the yellow change interval to avoid conflict with traffic releasing from an opposing intersection approach. All traffic signals on state highways shall use ODOT's minimum red clearance interval, as shown in

Table 3-1. These values may be increased as deemed necessary by engineering judgment. Factors that should be considered for increasing red clearance interval include intersection width, vehicle and pedestrian conflict points, large percentage of trucks, and approach speed.

Table 3-1: ODOT Minimum Yellow Change and Red Clearance Intervals

Posted Speed (mph)	Minimum Yellow Change Intervals(1)(2) (sec)	Minimum Red Clearance(2) (sec)
25	3.5	0.5
30	3.5	0.5
35	4.0	0.5
40	4.3	0.5
45	4.7	0.7
50	5.0(3)	1.0
55	5.0(3)	1.0

(1) Applies to approaches with a downgrade of 3 percent or less.

(2) Some intersections may require more than the minimum times.

(3) ODOT limits the yellow change interval to 5 seconds. The sum of the yellow change and red clearance intervals shall exceed the length of yellow internal calculated from Formula 1.

4 Turn Signals

Left and right turns at signalized intersections may be made in three operational modes:

1. Protected only
2. Protected-permissive
3. Permissive only

The protected only mode allows vehicles to make turns in the absence of conflicting vehicular and pedestrian movements during the display of steady green arrow. The protected-permissive mode is the combination of the protected and permissive modes. Turning vehicles have the right-of-way during the protected portion and they need to yield to the conflicting vehicular and pedestrian movements during the permissive portion. The permissive only mode requires vehicles to yield to conflicting vehicular and pedestrian movements. Permissive left-turning vehicles yield to oncoming vehicles and pedestrians. Permissive right-turning vehicles yield to conflicting pedestrians.

4.1 Left-Turn Signals

This section discusses left-turn operation modes and phase sequences.

4.1.1 Left-Turn Signal Modes

The selection of the most appropriate mode of the left-turn operation should be supported by an engineering study and should consider factors such as left-turn and opposing through volumes, posted speed, number of left-turn and opposing lanes, sight distance, pedestrian volume, and crash history. The least restrictive form of left-turn mode that will accommodate all movements safely and efficiently should be used.

These guidelines are written in the suggested order in which an analyst might evaluate the best left-turn mode of operation (most to least restrictive- protected only, protected-permissive, and permissive only).

Opposing left-turn modes should be the same based on driver expectation. If one approach meets criteria for a more restrictive form of left-turn mode, the opposing left-turn mode should match the more restrictive mode. There may be unique circumstances where the use of mixed opposing left-turn modes may occur, for example, if one approach has a left-turn lane and the opposing approach has a shared through/left lane.

Variable left-turn mode of operation can be used based on time of day, presence of gaps in oncoming traffic, or the presence of conflicting pedestrians (refer to Section 4.1.1.2).

According to Section 4D.05 of the MUTCD, it is required to install a W25-2 sign (ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN) if preemption is allowed for an approach from where drivers are allowed to make left turn movements permissively. Historically, ODOT never installed this sign on state highways. Empirical evidence indicates there are no safety or operational problems due to the absence of this sign. Informal surveys also indicate this sign doesn't provide clear message to the drivers. Based on these factors, this sign is not used on state highways.

4.1.1.1 Protected Only Left-Turn Mode

This mode provides the safest left-turn operation; however, overall intersection delay may increase.

a) Protected only left-turn mode shall be provided when:

- Multiple left-turn lanes are provided.
- An engineering study indicates that sight distance to the oncoming traffic is less than the distances shown in Table 4-1 below.

Table 4-1: Sight Distance Requirements

Posted Speed (mph)	Required Sight Distance (ft)	
	One Opposing Through Lane	Two Opposing Through Lanes
20	165	180
25	205	225
30	245	270
35	285	310
40	325	355
45	365	400
50*	425	465
55*	495	540

Source: A policy on Geometric Design of Highways and Streets 2011, AASHTO – Table 9-14.
* For speeds higher than 45 mph, the stopping sight distance (higher value from Table 9-14) is used instead of intersection sight distance.

The above table is based on the AASHTO intersection sight distance for passenger cars. Different sight distance values should be used if there are more than two opposing through lanes or the left turning traffic has a high percentage of trucks. Refer to Tables 9-13 & 9-14 of "A Policy on Geometric Design of Highways and Streets" 2011, 6th Edition, AASHTO.

b) Protected only left-turn mode should be provided when,

- Crash history indicates five or more crashes involving left-turn movements (including crashes involving pedestrians) per approach in a consecutive 12-month period within the last three years.
- Left-turn volume routinely exceeds 300 vehicles per hour or the product of the opposing through and left-turn hourly volumes exceeds
  - 150,000; if there is one opposing through lane, or
  - 300,000; if there are two opposing through lanes.

  Note: Where there is a significant lane imbalance, twice the highest single lane volume can be substituted for the total opposing hourly volume when making this calculation. If there is a dedicated right-turn lane the right-turn volumes may be added to the opposing through volumes.
- The posted speed of opposing traffic exceeds 45 mph.
- The left-turn movement crosses three or more lanes of opposing through traffic.
- U-turns are permitted.
- There are high percentages of left-turning heavy vehicles.
- The opposing left-turn signal is protected only.
- Additional factors such as high pedestrian volumes, traffic signal progression, intersection geometry, maneuverability of particular classes of vehicles, adequacy of gaps, or preemption-related operational requirements unique to preemption systems make it necessary to provide protected only left-turn mode.

4.1.1.2 Protected-Permissive Left-Turn (PPLT) Mode

Protected-permissive left-turn (PPLT) mode is a very common and generally the most efficient mode of left-turn operation. It is typically used in situations where geometric conditions allow permissive left turns but traffic volumes are high enough that a left-turn phase is required for capacity reasons.

For all state highway installations the standard display for PPLT mode shall be the flashing yellow left-turn arrow (FYLTA) display. When PPLT mode is used, the determination of whether the protected portion is displayed before or after the permissive portion should be made on the basis of operational requirements and efficiencies. Irrespective of the order, the FYLTA shall only be displayed after a minimum delay of 3.0 seconds (also known as 'Red Transition' when the protected portion leads and 'Red Extension' when the protected portion lags) following the green indication for the opposing through traffic. A higher delay value may be used for better progression, high truck volume, or if there are concerns of pedestrian conflict.

Flashing yellow left-turn arrow signal heads may be used to provide variable left-turn mode of operation by time-of-day settings, which is also referred to as Variable Left Turn Mode. For example, traffic volumes during peak hours should warrant protected only left-turn operation. During these times, FYLTA signal head should be operated as protected only mode if possible. During the off-peak hours when traffic volumes don't warrant protected only left-turn operation, FYLTA signal head can be operated as PPLT. FYLTA signal heads may also be used to operate as gap-dependent FYLTA signal heads. This method prevents the display of the FYLTA if adequate gaps in the opposing through movements don't exist for left-turning vehicles to make left-turn maneuver safely.

Flashing yellow left turn arrow signal heads may also be used to operate in "not-ped" mode. "Not-ped" mode allows delaying or omitting the FYLTA in the presence of conflicting pedestrian(s) in the conflicting crosswalk. When a crosswalk is occupied by pedestrian(s), it is desirable to delay the FYLTA during the walk interval or walk and flashing don't walk intervals.

Although not used for new installations, there are many existing signal installations with 5-section (doghouse) signal heads for PPLT operation. For these cases, the protected portion of the cycle should precede the permissive portion of the cycle to prevent the yellow trap (refer to Section 4.1.2). However, the permissive portion can precede the protected portion if there is no opposing left-turn movement.

If criteria discussed in Section 4.1.1.1 have not been met for protected only mode, PPLT should be provided when any one of the following criteria is satisfied:

- Left-turn volume routinely exceeds 200 vehicles per hour <u>or</u> the product of opposing through and left-turn hourly volumes exceeds
    - 50,000; if there is one opposing through lane, or
    - 100,000; if there are two opposing through lanes.

  Note: Where there is a significant lane imbalance, twice the highest single lane volume can be substituted for the total opposing hourly volume when making this calculation. If there is a dedicated right-turn lane the right-turn volumes may be added to the opposing through volumes.

- Projected volumes warrant PPLT mode within five years after the traffic signal is placed in service.
- The opposing left turn approach has a PPLT turn signal or meets one or more of these criteria.

4.1.1.3 Permissive Only Left-Turn Mode

Permissive only mode is primarily used when traffic is light to moderate and when sight distance is adequate. This option provides the most efficient operation of the intersection; however, it can have adverse effect on safety in some situations. Permissive only mode may be used if none of the criteria discussed above is satisfied.

It is ODOT practice to not place a signal head over the left-turn lane with permissive only mode. Design of traffic signals not initially meeting protected-only or PPLT criteria should provide for their addition in the future.

4.1.2 Left-Turn Signal Sequences

For protected only or protected-permissive left-turn mode of operation, it is important to determine the phase sequences. This section discusses the sequences of left-turn movements. The typical sequence options include:

- Leading or lead-lead phasing
- Lagging or lag-lag phasing
- Lead-lag phasing
- Split left-turn phasing

The terms leading or lagging indicate the order in which the left-turn phase is displayed, relative to the conflicting through movement.

Care should be taken in selecting appropriate sequence, as some sequences may result in an undesirable condition known as the “yellow trap”, especially if 5-section signal heads are used for PPLT operation. The “yellow trap” occurs when a driver, who has a permissive left-turn phase is waiting for a gap in the opposing through movement, sees a yellow indication for both through and left-turn movements, and mistakenly thinks that the signals for the opposing direction have become yellow simultaneously. It occurs when the permissive left-turn phase ends while the opposing through traffic continues to have a green signal indication, as in the case of lead-lag phasing using 5-section signal head. The “yellow trap” can be avoided by not using lead-lag phasing when 5-section signal heads are used for PPLT, or by using FYLTA for PPLT operation.

4.1.2.1 Leading or Lead-Lead Phasing

Lead-lead is a commonly used left-turn phase sequence in which both opposing left-turn phases start at the same time and precede the corresponding through movement. Lead-lead left-turn phasing is shown in Figure 4-1 for both major and minor roads. This operation is consistent with the driver expectation such that drivers react quickly to the leading green arrow indication. This operation also minimizes conflicts between left-turn and the through movements on the same approach when the left-turn volume exceeds its available storage length. This sequence typically yields more efficient operation when the left-turn volumes are lighter than their respective through volumes.

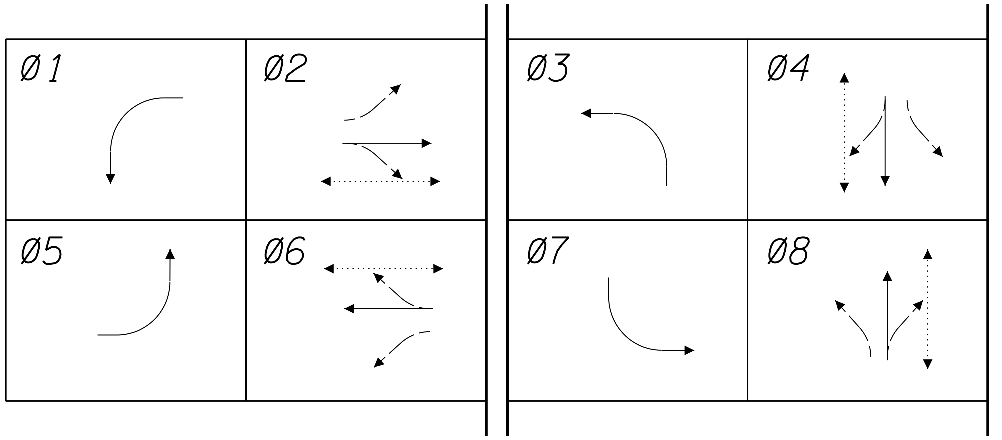


Figure 4-1: Lead-Lead Phasing for Both Major and Minor Roads

4.1.2.2 Lagging or Lag-Lag Phasing

In lag-lag phasing sequence both opposing left-turn phases start following the through movements and end simultaneously. Figure 4-2 shows lag-lag phasing for both major and minor roads. This mode of operation may result in wasted time if there is significant volume imbalance between the opposing left-turn lanes. This sequence is most commonly used in coordinated systems with closely spaced signals, such as diamond interchanges. However, lag-lag phasing may offer operational benefits for the following situations:

- When left-turn volume is greater than the opposing through volume.
- When coordinated signal timing requires a specific phase order to progress traffic.

Lagging left-turn phases may offer operational benefits when a left-turn movement exists only on one approach, for example, at

- “T” intersections.
- The intersection of a two-way street and a one-way street.

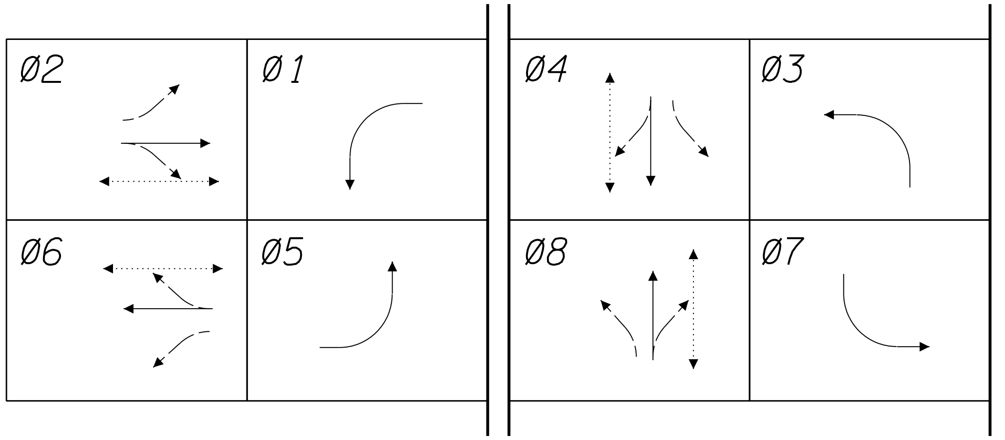


Figure 4-2: Lag-Lag Phasing for Both Major and Minor Roads

4.1.2.3 Lead-Lag Phasing

In lead-lag phasing sequence one of the opposing left-turn phases starts and operates concurrently with its corresponding through movement and the other left-turn phase starts following the opposing through movement and ends simultaneously with its concurrent through movement. Figure 4-3 shows lead-lag phasing for the major road. This phasing may offer operational benefits for the following situations:

- At intersections where the left-turn lanes are restricted from operating simultaneously due to geometric constraints.
- At intersections where the leading left-turn movement is not provided with an exclusive storage area or the available left turn storage is relatively short.
- When coordinated signal timing requires a specific phase order to progress traffic.

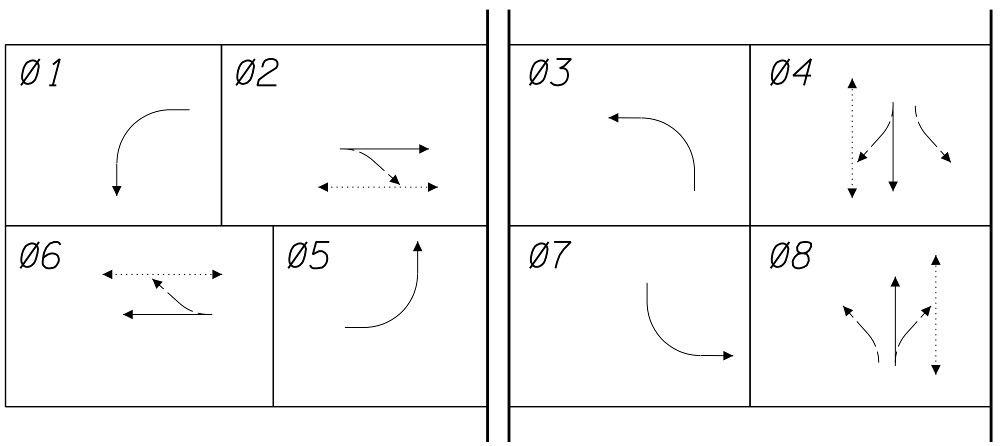


Figure 4-3: Lead-Lag Phasing for Major Road and Lead-Lead Phasing for Minor Road

4.1.2.4 Split Phasing

In split phasing each approach on the same street is serviced exclusively. Use of split phasing on state highways requires approval from the State Traffic Engineer. Figure 4-4 shows split phasing for the minor road. Typically, it is the side street that is split phased. This option is generally less efficient than the other phasing options as it typically creates additional overall intersection delay. Split phasing should only be used in unusual situations as follows:

- Left-turn movements from opposing approaches can't be made concurrently due to a conflict of overlapping turning paths within the intersection. Restrictive phasing is another available option for this situation.
- The left-turn lane volumes on opposing approaches are approximately equal to the through traffic lane volumes and the total approach volumes are significantly different on two approaches.
- The width of the road is constrained such that an approach lane is a shared through and left-turn lane, yet left-turn volume is sufficient to justify an exclusive left-turn lane and phase or sight distance is restricted.
- Drivers are permitted to turn left from more than one lane, but drivers are also permitted to use the rightmost left-turn lane as a through lane.
- Crash history suggests an unusually high number of side-swipe or head-on crashes in the middle of the intersection that involve left-turning vehicles.
- For actuated control one of the approaches has heavy volume, the other approach has minimal volume. In this situation, the phase associated with the low-volume approach would rarely be called and the intersection would function like a "T" intersection.

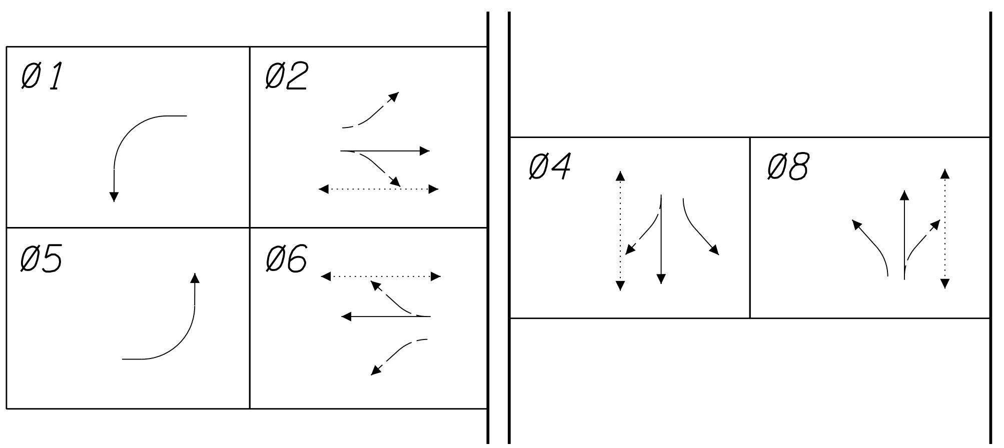


Figure 4-4: Split Phasing for Minor Road

4.1.3 Modifying Left-Turn Signals

The modification of left-turn mode from protected only mode to PPLT or permissive only mode shall be supported by an engineering study. The engineering study should consider each of the criteria given in Section 4.1.1.1 as well as the following:

- The crash history prior to the installation of the protected left-turn. If the signal was installed due to left-turn type crashes, protected only mode should be maintained unless the engineering study indicates a reduction in potential vehicle conflicts.
- The recent crash history to determine if there is evidence that a reduction in rear-end crashes may be achieved.
- An estimate of the expected reduction in delay per vehicle entering the intersection if the left-turn mode is changed.

4.2 Right-Turn Signals

By Oregon law, right-turn movement by a vehicle facing a circular red or a red arrow indication is permitted after stopping unless a sign is posted to the contrary. Signalizing a right-turn lane on state highways requires approval from the Region Traffic Engineer.

4.2.1 Right-Turn Signal Modes

The right-turn signal installations and mode of operation shall be supported by an engineering study. Factors that improve capacity; and reduce congestion and related crashes shall be considered in the engineering study. These factors include presence of right-turn lane(s), right-turn volume, presence of a conflicting crosswalk, etc.

Right-turn movements controlled by a separate signal head which operates as an overlap with a complementary left-turn phase that also allows U-turn movements should not occur at the same signalized location.

4.2.1.1 Protected Only Right-Turn Mode

The protected only right-turn mode may be used concurrently with any other non-conflicting pedestrian or vehicular movements such as protected left-turn from a complementary left-turn lane. Generally, this mode is used for an exclusive right-turn lane. The standard practice for operating a protected right-turn signal at a location with a crosswalk adjacent to the right-turn lane is to assign the right-turn signal to an overlap phase that will not permit a green indication concurrently during the walk or flashing don’t walk pedestrian intervals for the adjacent crosswalk. This is known as “not-ped” overlap.

4.2.1.2 Protected-Permissive Right-Turn (PPRT) Mode

When the right-turn movement is protected during one part of the cycle and permissive during another part of the cycle, the mode is referred to as protected-permissive mode. As shown in Figure 4-5, the protected right-turn operation generally occurs during the complementary left-turn phase on the cross street. The permissive right-turn operation occurs during the adjacent through movement phase.

Although PPRT is typically not used on state highways, in some situations it may be beneficial to use this mode. For example, when there is heavy right-turn volume, use of this mode may provide operational benefits.

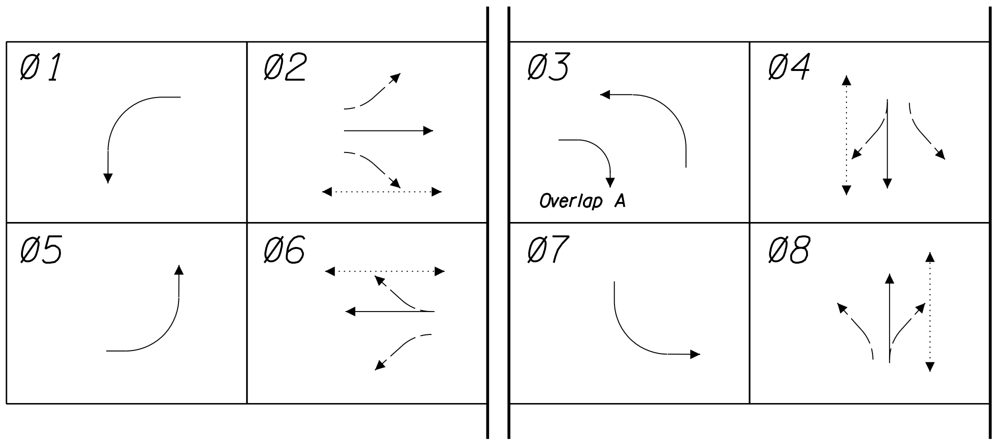


Figure 4-5: Protective-Permissive Right-Turn Mode

4.2.1.3 Permissive Right-Turn (PPRT) Mode

This is the most commonly used right-turn mode. No additional signal head is needed for this operation. Right-turn movements are served concurrently with the corresponding through movements, but right-turn movements must yield to the conflicting pedestrian movements. Right-turn on red is also permitted after stopping unless posted otherwise.

4.2.2 Modifying Right-Turn Signals

Engineering judgment should be exercised in the modification or removal of right-turn signals.

4.3 U-Turn

By Oregon law (ORS 810.130, ORS 810.200 and ORS 811.365), U-turn movements are not permitted at signalized intersections unless otherwise posted. As such, State Traffic Engineer approval is required for allowing U-turn movements at signalized intersections on state highways. An appropriate sign shall be used where U-turn movements are permitted. Refer to Sign No. OR3-12 in the ODOT Sign Policy and Guidelines for ODOT policy regarding U-turn signs.

When U-turn movements are accommodated at an intersection, such movements shall always be made from a left-turn lane. Refer to Section 2.6 and Section 4.3.4.2(G) of the ODOT Highway Design Manual for more information on accommodating U-turns. The following criteria should be used when considering whether or not to permit U-turn movements:

4. The width of the receiving lanes of the intersection. The width should be sufficient to accommodate U-turn movements made by the design vehicle. U-Turns may be permitted for all vehicles at a signalized intersection if a 62 foot width (measured from the right edge of the left turn lane to the curb) for turning exists. U-Turns may be permitted for all vehicles except trucks if a 52 foot to 61.5 foot width (measured from the right edge of the Left Turn lane to curb) for turning exists.
5. The design vehicle. Turning templates should be developed to demonstrate that the width is adequate to accommodate U-turn movements made by the design vehicle. Region Traffic staff should coordinate with the roadway designer to determine the appropriate design vehicle. Vehicles other than trucks may be used as the design vehicle.
6. Speed of the highway.
7. Volume of traffic opposing and executing the U-turn.
8. Adjacent roadside culture.
9. Near-by locations where U-turn movements are permitted.
10. Left-turn mode of operation for which U-turn is being considered. Protected only left-turn mode should be used for the approach.
11. Impact of U-turn movements on the conflicting right-turn movement. U-turn movements should not be allowed where there are conflicting right-turn overlap movements.

5 Pedestrian Crossing and Signals

5.1 Pedestrian Crossing at Signalized Intersections

The design and operation of traffic control signals shall take into consideration the needs of pedestrians to cross the roadway safely at all locations even those locations where there may be few pedestrians or seemingly none. It is desirable to keep all crosswalks open for pedestrians, but sometimes it may be necessary to close one or more crosswalks at a signalized intersection.

The State Traffic Engineer shall approve all crosswalk installations and closures at signalized intersections on state highways, based on an engineering study. When supported by the study, generally only one crosswalk may be closed, which allows pedestrian access to all four quadrants of an intersection. The primary reason for closing a crosswalk is safety. Geometric and operational factors may also be considered.

The following points shall be considered regarding the design and operation of crosswalks at signalized intersections:

- Oregon statute (ORS 801.220) provides for crosswalks across all roadways at every intersection. Crosswalks shall be marked for all approaches of signalized intersections unless the crosswalk is closed by official action and signs are posted.
- Pedestrian signal heads shall be provided for all marked crosswalks at signalized intersections. For all new installations, countdown pedestrian signal heads shall be installed. Refer to Chapter 4E of the MUTCD and the ODOT Signal Design Manual for more information on countdown signal heads.
- Pedestrian detection/activation shall be provided where pedestrian signal heads are provided except when the pedestrian phase is recalled at all times, as is the case at signalized intersections in a central business district.

There are several options available in the controller software, which may provide safer and more efficient operations of pedestrian crossings including:

- Push and hold for extended walk (allows for a longer walk time)
- Flashing yellow left-turn arrow “not-ped” mode (refer to Section 4.1.1.2)
- Right turn overlap “not-ped” mode (refer to Section 4.2.1.1)
- Leading pedestrian interval

5.2 Half Signals

A half-signal is a traffic control signal in which only two directions are controlled by the signal and the other two directions are typically controlled by stop signs. In the past, these devices were installed on state highways to assist with pedestrian crossings at intersections. The potential for driver uncertainty exists when mainline stops and the side street is facing a stop sign with conflicting pedestrians.

The MUTCD recommends that if a traffic signal is installed to accommodate pedestrian volumes, the minor street should be signalized. Therefore, new half-signals shall not be installed on state highways. When a project involves modifications to a roadway where there is an existing half-signal, an engineering study shall be conducted to determine if the half-signal will remain in place.

5.3 Accessible Pedestrian Signals

Accessible pedestrian signals provide information in a non-visual format such as audible tones, speech messages, and/or vibrating and tactile surfaces.

If a signalized intersection presents difficulties for pedestrians who have visual disabilities, an accessible pedestrian signal may be provided to augment the standard pedestrian signal. The installation of accessible pedestrian signals should be based on an engineering study that indicates an improvement in safety and/or operation. Follow the guidance provided in Chapter 4E of the MUTCD.

Unless the local jurisdiction has a policy to install accessible pedestrian signals at a signalized intersection, the following are required:

- A user request that demonstrates the need for an accessible pedestrian signal.
- An engineering study that identifies the information needs of pedestrians with visual disabilities and any unique intersection characteristics.

5.4 Pedestrian Activated Warning Beacons

Pedestrian activated warning beacons may be installed to alert drivers of the presence of pedestrians in the marked crosswalks. These beacons are typically installed to supplement pedestrian and school warning signs at crossings across uncontrolled approaches. Installation of these beacons on the state highway system shall follow the guidance provided in the ODOT Traffic Manual and will require approval from the State Traffic Engineer.

5.4.1 Pedestrian Warning Beacons

Pedestrian warning beacons shall only be used to supplement advance pedestrian warning signs such as the Pedestrian Crossing sign (Sign W11-2).

5.4.2 Rectangular Rapid Flashing Beacon (RRFB)

All RRFB installations shall comply with the FHWA Interim Approval for Operational Use of Rectangular Flashing Beacons.

The duration of the flashing indication shall include the amount of time appropriate for a pedestrian to traverse the crosswalk, following MUTCD procedures for timing of pedestrian clearance times for pedestrian signals, plus a buffer interval to account for driver perception/reaction time, and stopping time. The minimum buffer interval should be the amount of time required for a vehicle to travel the safe stopping sight distance (refer to AASHTO Green Book) at the posted speed limit.

When requested, an audible message may be included with the activation of the RRFB device to instruct users to wait for vehicles to stop before crossing. Follow the guidance provided in Section 4E.11 of the MUTCD.

5.4.3 Pedestrian Hybrid Beacon

Pedestrian hybrid beacons are also known as High-intensity Activated crossWalK (HAWK) beacons. A pedestrian hybrid beacon may be considered for installation for pedestrian crossings at a location that doesn't meet traffic signal warrants or at a location that meets traffic signal warrants but a decision is made to not install a signal. Chapter 4F of the MUTCD presents guidelines for the installation of pedestrian hybrid beacons based on pedestrian and vehicular traffic.

6 Special Applications

6.1 Emergency Traffic Signals

An emergency traffic signal is a special traffic control signal that assigns the right-of-way to fire trucks and other vehicles providing emergency services. An emergency traffic signal is typically located at the access to a fire station. Emergency traffic signals shall not be used at roundabouts.

6.1.1 Basis for Installation

- An emergency traffic signal may be installed at a location that does not meet other traffic signal warrants.
- Generally the fire station should be located either adjacent to the highway or no more than one block from the intersection.
- Either of the following criteria should be met:

a) The highway volumes should meet or exceed the minimum vehicular volume signal warrant as shown below:

Table 6-1: Minimum ADT for Emergency Traffic Signal

	Standard Warrant	70% Warrant*
2-lane highway	8,850	6,200
4-lane highway	10,600	7,400

* May be used when posted speed exceeds 40mph or within an isolated community with a population less than 10,000.

b) The sight distance from the normal stop position at the fire station exit should be less than that shown below:

Table 6-2: Minimum Highway Sight Distance for Emergency Traffic Signal

Speed (mph)	Minimum Sight Distance (ft)
20	120
25	160
30	210
35	260
40	320
45	380
50	450
55	520

6.1.2 Standard Practices

- Emergency-Vehicle Hybrid Beacon shall not be used as emergency traffic control signal.
- When the emergency traffic signal is at an intersection, a fully-actuated signal operation shall be provided. Displays on all approaches should follow the standard design criteria.
- When the emergency traffic signal is located at a mid-block location, a circular green shall be displayed to the highway traffic when not in preemption.

6.2 Freeway Entrance Ramp Control Signals (Ramp Meters)

Ramp meters can improve safety, travel time, throughput, and environmental impacts on the freeway, freeway ramps, and adjacent arterials. Ramp meters can be effective for delaying or preventing breakdown of stable flow on the freeway. Ramp meters should not be intended to cause additional delay, divert or store traffic on local arterials but rather as a tool to balance the demand. Ramp meters are typically installed to increase vehicle headway by metering vehicles before the merge point of an entrance ramp and freeway.

The installation of a ramp meter shall be based on an engineering study that indicates the ramp meter will improve safety and/or operation of the freeway ramp, freeway, or adjacent arterials. The engineer study should include geometry; freeway and ramp traffic volumes; crash history; and operating speeds, travel time, and delay on the freeway and alternate surface routes.

Ramp meters may include High Occupancy Vehicle (HOV) and/or transit bypass lanes. Such lanes should be metered in a way that would reduce the delay for the HOV and/or the transit vehicles. Metered bypass lanes may be provided for prioritizing trucks and transit vehicles.

Refer to the ODOT Signal Design Manual for the design of ramp meters.

6.3 Temporary and Portable Traffic Signals

Temporary and portable signals are generally used in work zones. Temporary traffic signals are typically described as signal displays supported by wood poles and span wires. Portable traffic signals are signal displays mounted on a trailer. Typical applications include but not limited to: one-lane two-way configuration, installation of new traffic signals, and reconstruction of an intersection or interchange. State Traffic Engineer approval is required for installation of temporary and portable traffic signals on state highways. ODOT Traffic Control Plans (TCP) Design Manual lists a number of criteria for the applicability of temporary traffic signals. Temporary traffic signal designs and layout shall conform to the ODOT Traffic Signal Design Manual.

6.4 Bicycle Signals

Signalized intersections may be operated with phases specifically intended for bicyclists. These bicycle phases are used in combination with an intersection traffic control signal to control the movements of bicycles through an intersection. While less restrictive means of handling conflicts between bicyclists and motorists should be considered first, bicycle signal phases can be a useful tool to improve the safety or service of bicyclists through an intersection. Bicycle signal phases shall direct bicyclists to take specific actions and may be used to improve an identified safety or operational problem involving bicyclists.

A bicycle signal phase may be considered for use when an engineering study finds that a significant number of bicycle/motor vehicle conflicts occur or may be expected to occur at the intersection and that other less restrictive measures would not be effective. Proximity to schools, parks, and popular bike routes should be considered. Additional delay to all roadway users should be considered. One of the following criteria below should be met:

- Two or more reported bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over three years.
- Geometric factors are present that are best mitigated through the use of a bicycle signal phase.
- An approach to a signalized intersection is intended for bicycles only and it is desirable to signalize that approach.

Examples of geometric configurations that might benefit from the use of a bicycle signal phase include:

- A bike lane to the right of a high volume right-turn lane.
- A multi-use path that comes into the intersection in such a way that motorists may not see or yield to bicyclists approaching the intersection.

Installation of bicycle signals requires experimental approval from the Federal Highway Administration prior to installation. Refer to FHWA Experimentation website for more information on experimentation approval process.

In late 2013, the Federal Highway Administration issued an Interim Approval for the optional use of bicycle signals. All bicycle signals installed in the state of Oregon shall meet the requirements set forth in the Interim Approval. For installation on state highways, Regions should consult with the Traffic-Roadway Section regarding the phasing and operational issues related to bicycle signals.

7 Traffic Signal Removal

This section discusses the removal of existing permanent traffic signals (OAR 734-020-0500). This section does not apply to relocations of the roadway; the removal of temporary traffic signals used for construction or maintenance activities; or signalized locations that are to be functionally replaced in the same location as a part of a highway reconstruction project. The State Traffic Engineer shall approve the removal of any permanent traffic signal on state highways.

7.1 Basis for Removal

A traffic signal should be removed if MUTCD traffic signal warrants are no longer met. This may be due to significant changes in geometry or traffic flow patterns that eliminate the need for the traffic signal.

7.2 Removal Request Process

The Region Traffic Manager or Engineer shall complete the following:

- Review traffic signal pre-installation warrants and original State Traffic Engineer Approval letter. If the traffic signal was originally installed in response to Warrant 7 (Crash Experience), it should not be removed unless an engineering study indicates a reduction in potential vehicular conflicts.
- Determine the appropriate traffic control and any necessary mitigation to be used after the removal of the signal. Conduct a sight distance study if the traffic signal is to be permanently replaced by stop sign control.
- Contact all local agencies affected by the removal of the traffic signal, including the agency responsible for maintenance.
- Provide an inventory of current site conditions, which may include any of the following:
    - A summary of crash history at the intersection
    - Posted speed
    - Traffic volumes including a summary of heavy turning movements if appropriate
    - Pedestrian volumes
    - Proximity to other traffic signals
    - Agency and road user cost
    - Sight distance study
- Prior to making the decision to request the removal of a traffic signal, contact local business leaders, council persons, neighborhood associations, the local and state police, and other emergency service providers and inform them of the intent. Address all stakeholder concerns.

- As discussed in Section 1, submit a cover letter and corresponding engineering study to the Traffic-Roadway Section for review and approval by the State Traffic Engineer.

7.3 Public Notification

For any permanent traffic signal removal public notification shall be provided and may include any or all of the following:

- **News Release** - A news release may be distributed to local newspapers, radio, and television stations.
- **Letter** - A letter may be sent directly to the residents and commercial establishments within the immediate vicinity.
- **Public Meeting** - If the proposed signal removal is a part of a highway reconstruction project, public notification may be provided during a public meeting or other methods available to the project team.

7.4 Removal of Traffic Signal Hardware

- Crashes and intersection operations should be monitored during the 90 day Interim Intersection Control period prior to removing the remaining hardware (e.g., poles, mast arms, controller, cabinets, etc.). The remainder of the signal hardware may be removed if the engineering data confirms that the signal is no longer needed.
- An existing signal being functionally replaced as part of a highway project by a new signalized location within close proximity, as determined by engineering judgment, may circumvent the Interim Intersection Control period and be removed in its entirety immediately upon activation of the new signal.

8 Traffic Signal Preemption and Priority Systems

Traffic signal preemption and priority systems are traffic control devices. Use of preemption and priority systems to modify the operation of traffic signals is limited to trains; drawbridge operations; and emergency vehicles, bus, and traffic signal maintenance vehicles authorized by the traffic control signal owner. Traffic signal preemption equipment may be used in either failsafe systems or signal preemption device systems.

Failsafe systems are used by heavy rail and drawbridge operations and have priority over emergency vehicle preemption and bus priority systems. Failsafe systems are hard wired to the traffic signal controller and operate independently of any other signal function. The default state of a failsafe system is preemption.

Signal preemption device systems are used by emergency vehicles, buses, and traffic signal maintenance vehicles and are subject to the provisions of ORS 810.260, ORS 815.445, and OAR 734-020-0300 to -0330. These systems require the installation of hardware at the intersection that reacts to a device on or inside a vehicle. The default state of a signal preemption device system is normal traffic signal operation. The signal preemption device may respond to a single activation or may respond in recognition of priorities assigned to different users in a multi-priority system.

Both failsafe systems and signal preemption device systems may exist in a multi-priority system, however, only signal-preemption-device systems respond to levels of priority.

8.1 Railroad Preemption (Heavy Rail)

Under Oregon law (ORS 824.200 to 824.256), ODOT is authorized to determine the character and type of traffic control devices used at all railroad-highway grade crossings (refer to OAR 741-110-0030). The ODOT Rail Division has been delegated authority for this responsibility.

Preemption is required when railroad tracks are located on a roadway within 215 feet of a signalized intersection. The distance is measured from the nearest rail at the crossing to the nearest stop location at the signalized intersection. Refer to the ODOT Railroad Preemption Design and Operation Guide for guidance on railroad preemption at the railroad-highway grade crossings. The following are the standard ODOT practices for railroad preemption:

- When a vehicle clear-out interval (VCOI) is required, the indication for the clearance phases shall be green. VCOI operation shall include a green left-turn arrow if a left turn movement exists, even if the left-turn movement operates permissively. Under normal operation, if the left-turn movement is permissive only, the display of the left-turn green arrow shall be used during rail preemption only. The use of green arrow is not allowed for use by emergency vehicle preemption and transit priority users.
- Advance railroad detection or other appropriate methods shall be used to provide a pedestrian clear-out interval (PCOI) prior to the vehicle clear-out interval (VCOI). This should be designed to minimize the occurrence of abbreviated pedestrian clearance

intervals. In absence of pedestrians, a portion or the entire duration of the PCOI may be utilized to serve the clear-out phase(s), if mentioned in the Crossing order.

- Part Time Restriction sign(s) shall be posted to prohibit specific turning movement(s) toward the highway-rail grade crossing during preemption, if called for in the Crossing Order.

8.2 Railroad Preemption (Light Rail)

When light rail transit lines operate in a street running mode along with other traffic, they may be exempted from the preemption requirements mentioned in the ODOT Railroad Preemption Design and Operation Guide. Refer to Chapter 8C of the MUTCD for additional guidance.

8.3 Drawbridge Preemption

Traffic signals on highways adjacent to drawbridges should be interconnected with the drawbridge control, if indicated by engineering considerations. Drawbridge operations are under the jurisdiction of the local Port Authority and/or the U.S. Army Corps of Engineers. Chapter 4J of the MUTCD provides more guidance on drawbridge preemption.

8.4 Emergency Preemption Systems

Emergency preemption systems provide emergency vehicles the capability to modify the green intervals or change the display sequence of a traffic signal.

- When multiple users of traffic control signal operating devices are authorized, the signal preemption device shall recognize and respond to the priority of each user as established in OAR 734-020-0330.
- Emergency service providers who want to use signal preemption devices on their emergency response vehicles for use on state highways shall make a written request for authorization. The form in Appendix E shall be completed, reviewed by the ODOT Region Traffic Manager, and approved by the State Traffic Engineer. Traffic-Roadway Section maintains a list of agencies that have been approved to use signal preemption devices on their emergency response vehicles on state highways.
- Signal preemption devices may include an identification system to recognize authorized vehicles at a signalized intersection.

8.5 Bus Priority Systems

Bus priority systems provide buses the capability to modify the length of green intervals but not the display sequence of a traffic signal.

- When multiple users of traffic control signal operating devices are authorized, the signal preemption device shall recognize and respond to the priority of each user as established in OAR 734-020-0300 and -0330.

- Agencies operating buses shall make a written request for authorization to use a traffic control signal operating device on a state highway. The form in Appendix F shall be completed, reviewed by the ODOT Region Traffic Manager, and approved by the State Traffic Engineer.
- The transit authority and the road authority (Region Traffic) shall sign an agreement that covers cost, installation, operation, maintenance, and use.
- Signal preemption devices may include an identification system to recognize authorized vehicles at a signalized intersection.

9 Flashing Operation of Traffic Signals

Traffic signals can flash in two different modes: controller flash and cabinet flash. Controller flash is a mode of traffic control operation that flashes the signal indications as dictated by the signal controller software using the standard output switchpacks. Controller flash is often referred to as "time of day" or "nighttime flash". In the past, this mode of operation was used to reduce energy consumption and motorist delay during off-peak hours. The potential for driver uncertainty exists when the motorist on the side street facing a flashing red indication assumes the mainline traffic also has a flashing red indication. New studies have shown that controller flash operation is associated with a higher crash rate. As a result, this mode of operation should no longer be used on state highways. Removal of existing controller flash at traffic signals may require adding signal equipment upgrades such as vehicle and pedestrian detection systems. Projects to remove flashing operations should be prioritized and completed as budget allows or during highway reconstruction projects.

Cabinet flash is a mode of traffic control signal operation that flashes the signal indications through the use of flashers provided in the signal control cabinet, independent of the operation of the traffic signal controller or its software. Cabinet flash is often referred to as "maintenance flash". This mode of operation is only used when maintenance is being performed on the traffic signal equipment, there is a conflict in the controller software, there is an equipment failure, or there is a power failure.

If used, controller flash indications provided by the signal software should be the same as those provided by the cabinet flash. In general, the following criteria apply to both controller and cabinet flashing operation:

- Flashing red should be displayed to all approaches**.** Flashing yellow may be provided for the major through movements when the ratio of the average weekday traffic volume of the major to minor movements is 4 to 1 or greater.
- Flashing operation of nearby traffic signals should be treated in a consistent manner.

Refer to MUTCD Chapter 4D for more discussion on flashing operation.

Appendix A Definitions

Approach - [OAR 734-020-0420(1)] All lanes of traffic moving toward an intersection or mid-block location from one direction.

Bicycle Signal - A bicycle signal provides indications for signal phases intended exclusively for controlling bicycle traffic.

Bus - [ORS 184.675] A motor vehicle designed for carrying 15 or more passengers, exclusive of the driver, and used for the transportation of persons.

Bus priority system - [OAR 734-020-0310] A traffic control signal system that includes a traffic control signal operating device and signal preemption device designated to provide buses the capability to modify the green intervals but not the display sequence of a traffic control signal.

Cabinet flash - A mode of traffic control signal operation that flashes red or yellow indications through the use of flashers provided in the signal control cabinet, independent of the operation of the traffic signal controller or its software. Cabinet flash is often referred to as "maintenance flash".

City street - A public road which is owned and operated by a city government intended for use of the general public for vehicles or vehicular traffic.

Controller flash - A mode of traffic control signal operation that flashes red or yellow indications as dictated by the signal controller software using the standard output switchpacks. Controller flash is often referred to as "nighttime flash".

County road - A public road which is owned and operated by a county government intended for use of the general public for vehicles or vehicular traffic.

Crossing order - A written authorization issued by the State of Oregon through the Rail Division of its Department of Transportation granting or denying applications from public road authorities or railroads seeking to alter, construct, change protective devices, or eliminate highway-rail or highway-LRT grade crossings (in semi-exclusive alignments). It prescribes the time and manner of such alteration, change, installation or alteration, and the terms and conditions thereof.

Crosswalk - [ORS 801.220] Any portion of a roadway at an intersection or elsewhere that is distinctly indicated for pedestrian crossing by lines or other markings on the surface of the roadway that conform in design to the standards established for crosswalks under ORS 810.200. Whenever marked crosswalks have been indicated, such crosswalks and no other shall be deemed lawful across such roadway at that intersection. Where no marked crosswalk exists, a crosswalk is that portion of the roadway described in the following:

(1) Where sidewalks, shoulders or a combination thereof exists, a crosswalk is the portion of a roadway at an intersection, not more than 20 feet in width as measured from the prolongation of the lateral line of the roadway toward the prolongation of the adjacent property line, that is included within:

(a) The connections of the lateral lines of the sidewalks, shoulders or a combination thereof on opposite sides of the street or highway measured from the curbs, or in the absence of curbs, from the edges of the traveled roadway; or

(b) The prolongation of the lateral lines of a sidewalk, shoulder or both, to the sidewalk or shoulder on the opposite side of the street, if the prolongation would meet such sidewalk or shoulder.

(2) If there is neither sidewalk nor shoulder, a crosswalk is the portion of the roadway at an intersection, measuring not less than six feet in width, that would be included within the prolongation of the lateral lines of the sidewalk, shoulder or both on the opposite side of the street or highway if there were a sidewalk.

Doghouse - A 5-section traffic control signal head used for control of protected-permissive operations of left and right turn lanes consisting of a single, circular red indication centered at the top with circular and arrow indications for yellow and for green, respectively, in the middle and lower portion of the display.

Emergency preemption system - [OAR 734-020-0310] A traffic control signal system that includes a traffic control signal operating device and signal preemption device for the purpose of providing emergency vehicles the capability to modify the green intervals of a traffic control signal or change the display sequence.

Emergency vehicle - [ORS 801.260] A vehicle that is equipped with lights and sirens as required under ORS 820.350 and 820.370 and that is any of the following:

(1) Operated by public police, fire or airport security agencies.

(2) Designated as an emergency vehicle by a federal agency.

(3) Designated as an emergency vehicle by the Director of Transportation.

Engineering study - [OAR 734-020-0420] A documented comprehensive analysis and evaluation of available pertinent information, and the application of appropriate principles, standards, guidance, and practices as contained in the MUTCD and other sources, for the purposes of deciding upon the applicability, design, operation, or installation of a traffic control device.

Flashing Yellow Left-turn Arrow (FYLTA) signal - A vertically stacked 4-section, all-arrow signal head constructed in the following arrangement: red, yellow, flashing yellow, and green – from top to bottom, respectively. This is the standard display for PPLT operation. A 3-section 'bimodal' signal head may be used instead of a 4-section head where signal height limitations will not permit the use of the 4-section head. The bimodal head consists of a red arrow, yellow arrow, and a green arrow/flashing yellow arrow. The bottom section displays green arrow during protected left-turn movement and flashing yellow arrow during permissive left-turn movement.

Highway - [ORS 801.305] Every public way, road, street, thoroughfare and place, including bridges, viaducts and other structures within the boundaries of this state, open, used or intended for use of the general public for vehicles or vehicular traffic as a matter of right.

Lag-lag phasing - A signal phase rotation in which both opposing left-turn movements start following the corresponding through movements and end simultaneously.

Lead-lag phasing - A signal phase rotation in which one of the opposing left-turn phases starts and operates concurrently with its corresponding through movement, and the other left-turn phase start following the opposing through movement and ends simultaneously with its concurrent through movement. The former left-turn phase is the "lead" phase, while the latter left-turn phase is the "lag" phase.

Lead-lead phasing – A signal phase rotation in which both opposing left-turn phases start at the same time and precede the corresponding through movement.

Maintenance flash - See Cabinet Flash.

Overlap - A traffic control signal display that provides a green indication concurrent with one or more compatible parent phases.

Part Time Restriction (PTR) sign - A sign designed to provide instructions only during operation when such sign is illuminated.

Pedestrian Clear-Out Interval (PCOI) - The interval prior to the start of a railroad preemption sequence at a traffic control signal, during which active pedestrian "WALK" intervals will be terminated and pedestrian clearance intervals will be provided.

Permissive left-turn – A left-turn mode during which left-turn movements may be made on the CIRCULAR GREEN or FLASHING YELLOW ARROW indication after yielding to on-coming traffic and pedestrians.

Permissive right-turn - A right-turn mode during which right-turn movements may be made on the CIRCULAR GREEN indication after yielding to pedestrians. Unless otherwise posted, right-turn movements are also permitted on the CIRCULAR RED or RED ARROW indication after yielding to conflicting vehicles.

PPLT or PPRT - An abbreviation for traffic signal operation for protected-permissive left or right-turn movements.

Private approach - [OAR 734-020-0420(3)] - A private roadway or connection that is legally constructed and recognized by the Department with OAR 734-051.

Protected turn – A turn mode during which a turn may be made on a GREEN ARROW indication having right-of-way over any conflicting vehicular or pedestrian movement.

Public road - [OAR 734-020-0420(4)] A public roadway, or similar facility under the jurisdiction of a public entity and open to public travel.

Road authority - [ORS 801.445] The body authorized to exercise authority over a road, highway, street or alley under ORS 810.010.

Roadway - [ORS 801.450] The portion of a highway that is improved, designed or ordinarily used for vehicular travel, exclusive of the shoulder. In the event a highway includes two or more separate roadways the term "roadway" shall refer to any such roadway separately, but not to all such roadways collectively.

Sight distance – The unobstructed distance of roadway ahead visible to the driver. There are multiple types of sight distance that include stopping sight distance, passing sight distance, decision sight distance, and intersection sight distance.

Signal preemption device - [OAR 734-020-0310] Traffic control signal equipment that reacts to a traffic control signal operating device and produces signal preemption and/or signal priority.

Signal preemption device system - An emergency preemption system or a bus priority system consisting of a signal preemption device installed at a signalized intersection and a traffic signal control operating device fixed to, or carried within, a vehicle.

Signalized intersection - The area within the identified stop locations of intersecting roadway approaches controlled by a traffic signal.

Split phasing - A signal phase rotation in which each approach on the same street is serviced exclusively with GREEN signal indications.

State highway - A highway that is part of the State Highway System as designated by the Oregon Transportation Commission, including the Interstate system.

State highway system – [OAR 734-020-0420(6)] The group of roads and highways, so designated by law or by the Oregon Transportation Commission pursuant to ORS 366.220.

Street - A public road, generally within a city, town or a development center, but often used synonymously with the term highway or road.

Traffic control device - [ORS 801.540]

(1) Any sign, signal, marking or device placed, operated or erected by authority under ORS 810.210 for the purpose of guiding, directing, warning or regulating traffic.

(2) Any device that remotely controls by electrical, electronic, sound or light signal the operation of any device identified in subsection (1) of this section and installed or operated under authority of ORS 810.210.

(3) Any stop sign that complies with specifications adopted under ORS 810.200 that is held or erected by a member of a highway maintenance or construction crew working in the highway.

Traffic control signal - [OAR 734-020-0310] A type of highway traffic signal by which traffic is alternately directed to stop and permitted to proceed.

Traffic control signal operating device - [OAR 734-020-0310] Any active or passive device that is affixed to, or carried within, a vehicle that causes a change in the operation of a traffic control signal located at an intersection.

Traffic signal - [OAR 734-020-0420(7)] See traffic control signal.

Variable Left Turn Mode – The operating mode of left-turn signals changes among the protected only, PPLT, and permissive only mode during different periods of the day or as traffic conditions changes.

Vehicle Clear-Out Interval (VCOI) - A traffic signal interval during which motor vehicles are permitted to advance through a highway intersection and away from a railroad grade crossing. The controllers for both the highway intersection and the railroad grade crossing are electrically interconnected. Generally the VCOI follows a pedestrian clear-out interval (PCOI).

Appendix B References

Manual on Uniform Traffic Control Devices (MUTCD), 2009 Edition, U.S. Department of Transportation, Federal Highway Administration (FHWA), May 2012

Oregon Supplement to the Manual on Uniform Traffic Control Devices, 2009 Edition, Oregon Department of Transportation, November 2011

ODOT Traffic Manual, 2015 Edition, Oregon Department of Transportation, Traffic-Roadway Section, Traffic Services Unit, June 2015

Oregon Administrative Rules (OAR), Chapter 734, Oregon Department of Transportation, Revised March 2012

Oregon Revised Statutes (ORS), 2013 Edition, Oregon State Legislature, 2013

Oregon Transportation Plan, Oregon Department of Transportation, Planning Section, October 2006

ODOT Signal Design Manual, Oregon Department of Transportation, Traffic-Roadway Section, Traffic Standards Unit, OCT 2014

Analysis Procedures Manual, Version 2, Oregon Department of Transportation, Planning Section, Transportation Planning Analysis Unit, 2015

ODOT Maintenance Guide, Oregon Department of Transportation, Maintenance Division, July 2011

Determining Vehicle Signal Change and Clearance Intervals, Institute of Transportation Engineers (ITE), August 1994

Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections, NCHRP Report 731, Transportation Research Board, 2012

Agent, K., N. Stamatiadis, and B. Dyer. Guidelines for the Installation of Left-Turn Phasing. Research Report KTC-95-23, Kentucky Transportation Center, December 1995

A Policy on Geometric Design of Highways and Streets, 6th Edition, American Association of State Highways and Transportation Officials (AASHTO), 2011

Traffic Signal Timing Manual, Publication No. FHWA-HOP-08-024, Federal Highway Administration (FHWA), June 2008

Rodegerdts, L.A., B. Nevers, B. Robinson, J. Ringert, P. Koonce, J. Bansen, T. Nguyen, J. McGill, D. Stewart, J. Suggett, T. Neuman, N. Antonucci, K. Hardy, and K. Courage. *Signalized Intersections: Informational Guide*. Report FHWA-HRT-04-091. Federal Highway Administration (FHWA), August 2004

Traffic Control Devices Handbook, Institute of Transportation Engineers (ITE), 2001
Sign Policy and Guidelines, Oregon Department of Transportation, Traffic-Roadway Section, Traffic Standards Unit, May 2012

ODOT Highway Design Manual, Oregon Department of Transportation, Traffic-Roadway Section, Roadway Engineering Unit, 2012

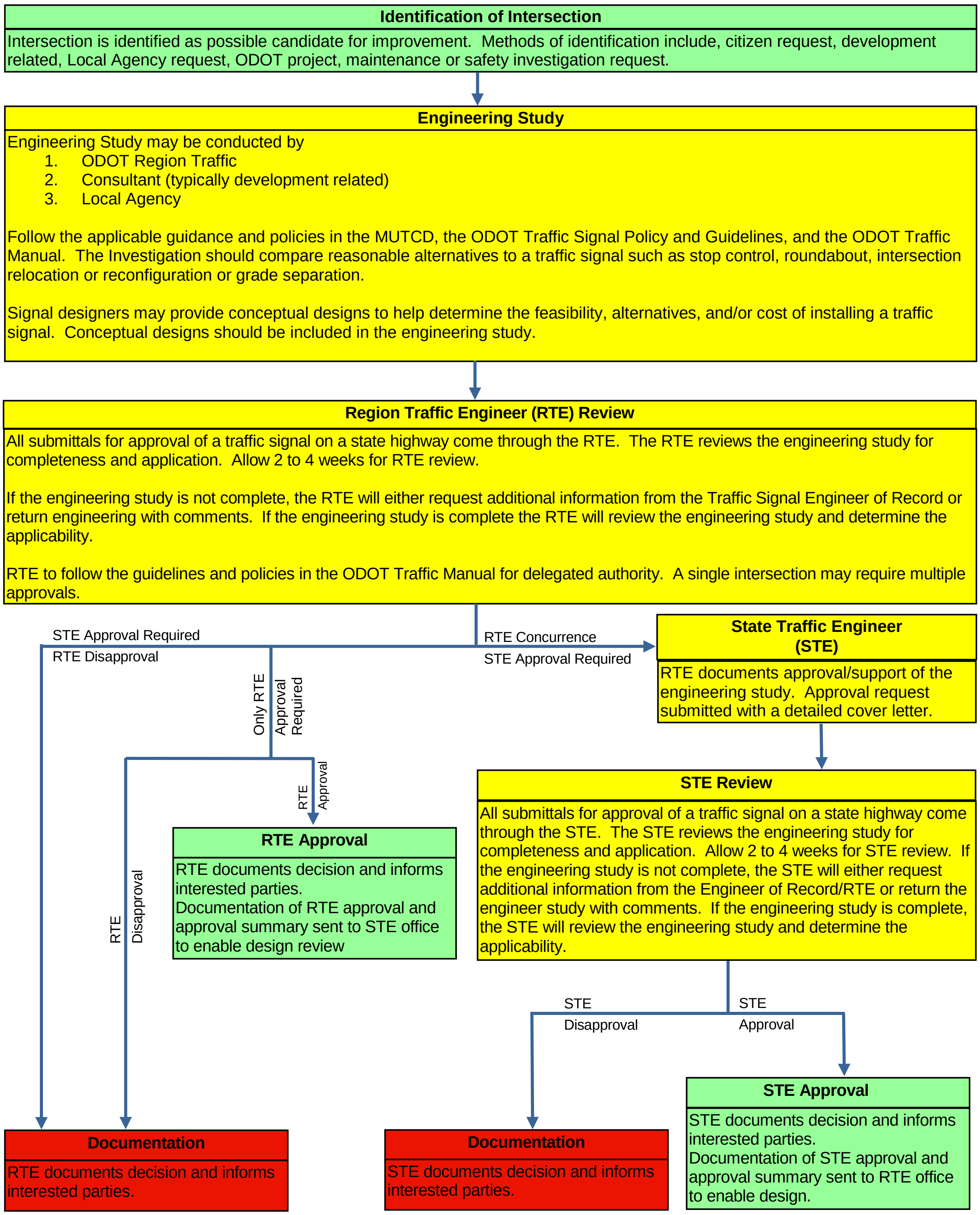
Oregon Standard Specifications for Construction, Oregon Department of Transportation, Traffic-Roadway Section, Office of Project Letting (OPL) unit, 2015

ODOT Traffic Controls Plan Design Manual, Oregon Department of Transportation, Traffic-Roadway Section, Traffic Standards Unit, April 2015

ODOT Railroad Preemption Design and Operation, Oregon Department of Transportation, Traffic-Roadway Section, Traffic Services Unit, December 2005

Appendix C Traffic Signal Approval Process

Traffic Signal Operational Approval



Traffic Signal Design Approval

Traffic Signal Design Begins

The signal designer shall have STE operational approval prior to traffic signal design. STE operational approval contains specific design requirements for the traffic signal.

Design Standards:

1. ODOT owned and maintained = full ODOT standards.
2. ODOT owned, Local Agency maintained = partial ODOT standards (negotiated)
3. Local Agency owned, ODOT maintained = partial ODOT standards (negotiated).
4. Local Agency owned and maintained = full local standards.

Pending Jurisdiction Transfers will not be considered when determining appropriate design standards.

Traffic Signal Design - Plans

Traffic signal plans that require STE design approval:

1. Signals (permanent or temporary)
2. Ramp Meters
3. Actuated Flashing Beacons (RRFB, Tunnel and Bridge)
4. Flashing Beacon mounted over roadway.

Jurisdiction and maintenance agreements that require STE design approval:

1. ODOT owned and maintained
2. ODOT owned and Local Agency maintained
3. Local Agency owned and ODOT maintained

STE design approval is not required for:

1. Portable Temporary Signals
2. Local agency owned and maintained signals. Federally funded projects may request a courtesy review for compliance with minimum Federal standards.

Cost Estimate

Prepared by the designer. No STE office review required.

Specifications

Prepared by the designer. No STE office review required unless changes are made to the specifications.

Traffic Signal Design Submitted to State Traffic-Roadway Engineer (STRE) Office

The Traffic signal design shall be submitted to the Office of the STE at all major project milestones, including DAP, Preliminary, Advance and Plans-in-Hand.

The traffic signal design should also be submitted for review to the Region Traffic Engineer, Region Electricians and other interested parties.

The STE Office is available to meet with designers to go over project details. This is recommended for complex projects and may reduce the STE review time and/or comments.

Design Work

Signal designer addresses comments.

STE Office Design Review

The STE office reviews the traffic signal design. Allow a minimum of 2 weeks for review. Prior to final plans and after all comments have been resolved, the signal designer requests TRS Drawing Numbers from the STRE Office.

STE Office Comments

Documentation

STE Office provides a list of comments to be addressed.

All STE Office Comments Resolved

STE Office Design Approval

Final Plans (Mylar's) are signed by the STE Office.
For ODOT advertised projects, submit one set of mylars to the STE Office. For non-ODOT advertised projects, submit two sets of mylars to the STE Office (one retained by ODOT for archiving and the other returned for distribution).

Preliminary Signal Operations Design Form

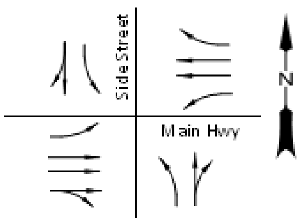
Preliminary Signal Operations Design

Traffic-Roadway Section
Traffic Engineering Unit
Phone: (503) 986-3568

Project: ____________ Key #: ____________ Date: ____________
Location: ____________ City: ____________ County: ____________
Highway: ____________ Hwy No: ____________ Mile Point: ____________

Existing Information

Lane Configuration



Crosswalks

- ☐ North Approach
- ☐ South Approach
- ☐ East Approach
- ☐ West Approach

Bike Lanes

- ☐ North Approach
- ☐ South Approach
- ☐ East Approach
- ☐ West Approach

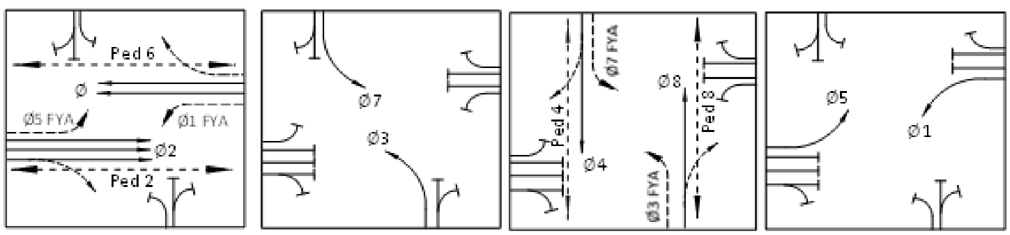
Traffic Control

- ☐ 2-Way Stop
- ☐ All-Way Stop
- ☐ Signalized

Posted Speed Limit

Highway: ______ mph
Side Street: ______ mph

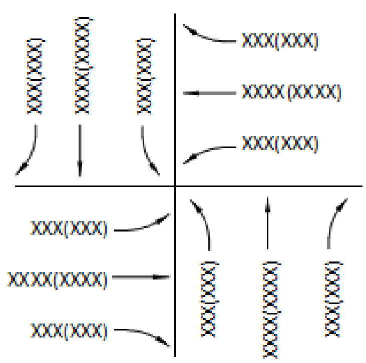
Existing Vehicle and Pedestrian Phasing (if Signalized)

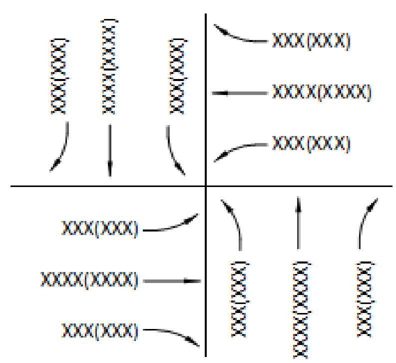


Ø2+Ø6 Ø3+Ø7 Ø4+Ø8 Ø1+Ø5

Traffic Volumes

Existing Year 20XX AM(PM) *Future Year* 20XX





Other Relevant Information

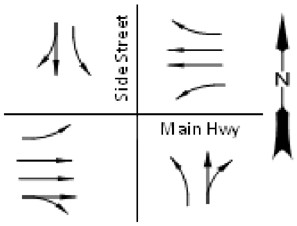
Page 1 of 2

Preliminary Signal Operations Design

Traffic-Roadway Section
Traffic Engineering Unit
Phone: (503) 986-3568

Recommended Signal Design

Lane Configuration



Crosswalks

- ☐ All crosswalks provided
- ☐ Following crosswalks closed
  - ☐ North Approach
  - ☐ South Approach
  - ☐ East Approach
  - ☐ West Approach

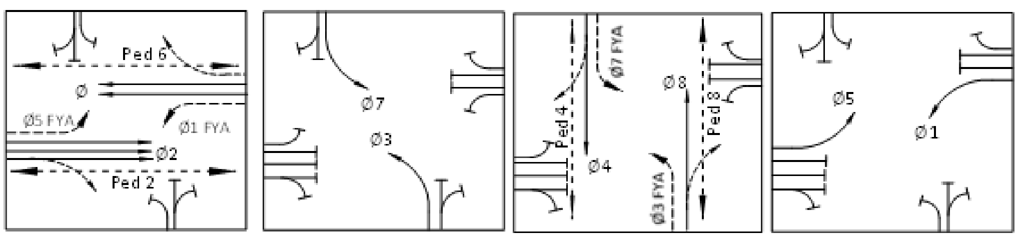
Bike Lanes

- ☐ North Approach
- ☐ South Approach
- ☐ East Approach
- ☐ West Approach

Other Required Features

- ☐ Signal interconnect to: ______________________
- ☐ Communication type: ______________________
- ☐ 2070 controller
- ☐ Illumination
- ☐ Audible/accessible pedestrian signals
- ☐ Railroad preemption
- ☐ Other: ______________________

Recommended Vehicle and Pedestrian Phasing



Ø2+Ø6 | Ø3+Ø7 | Ø4+Ø8 | Ø1+Ø5

Notes regarding right-turn lane control

Primary considerations used to determine left-turn phasing

Considerations for mitigating bike-vehicle conflicts (if any)

Design Vehicle Information (to be confirmed with Roadway Designer)

☐ Design for

☐ Accommodate

Design Vehicle: [▾] If Bus or Other, specify: ____________

Recommended by: ______________________________________
Region Signal Operations Engineer

Page 2 of 2

Oregon Department of Transportation

Left Turn Signal Phasing Investigation

Traffic-Roadway Section
Traffic Engineering Unit
Phone: (503) 986-3568
Fax: (503) 986-4063

General Information

Project Name: ______________________ EA: ______________
Highway Name: ____________ Route No.: ______
Highway Number: ____________ Milepoint: ______ County: ______________
Minor Street: ______________________ City: ______________
District: ______________

Investigation Information

Investigator: ____________ Date: ______ Time: ______ Reviewed by ____________ Date: ______

1.) New signal: ☐ Existing signal: ☐
 a.) Basis for Signal Approval: ____________
 b.) Plans to improve/modify intersection: ☐ YES ☐ NO

2.) Existing phases[3]:
 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ Ped 2 ☐ Ped 4
 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ Ped 6 ☐ Ped 8

 Investigated phases:
 ☐ 1 ☐ 3
 ☐ 5 ☐ 7

3.) Signal is located in a traffic signal system: ☐ YES ☐ NO
 a.) If yes, lead/lag phasing existing: ☐ YES ☐ NO
  If no, location of closest signals: ________
  If no, location of signals proposed in TSP: ________
 b.) Pending developments in area*: ☐ YES ☐ NO

4.) Traffic volumes meet minimum left-turn criteria[1]: ☐ YES ☐ NO
 a.) If no, will traffic volumes meet
  minimum criteria within 5 years[1]: ☐ YES ☐ NO

6.) Crashes at intesection last three years[2]:

Year	Total crashes	Left turn crashes for investigated phase			
		Ø 1	Ø 3	Ø 5	Ø 7

 a.) Nearby accesses/intersections with
  relevent left turn crash history*: ☐ YES ☐ NO
 b.) Top 10% SPIS site: ☐ YES ☐ NO Year: ______

7.) Intersection geometry[3]:
 ☐ 4-leg intersection ☐ Interchange ramp
 ☐ T-intersection ☐ Other
 a.) Geometry is appropriate
  for PPLT phasing: ☐ YES ☐ NO

8.) Number of opposing through lanes: ☐ 1 ☐ 2 ☐ 3+

9.) Multiple left turn lanes: ☐ YES ☐ NO

10.) U-turns permitted: ☐ YES ☐ NO

11.) Opposing left turn: ☐ YES ☐ NO
 a.) Prohibited ☐ YES ☐ NO
 b.) Exists ☐ YES ☐ NO

12.) Major street posted speed limit: _____ MPH

13.) Minor street posted speed limit: _____ MPH

14.) Sight distance to oncoming traffic (ft):
- Phase 1 _____
- Phase 3 _____
- Phase 5 _____
- Phase 7 _____

15.) Pedestrian concerns*: ☐ YES ☐ NO

16.) School Crossing: ☐ YES ☐ NO

17.) Railroad Preemption: ☐ YES ☐ NO

Comments: ____

____
____
____

[1] See attached volume analysis
[2] See attached accident analysis and PRC
[3] See attached T.M.S. DWG, V-file, sketch, or pictures

*If answer is yes, please provide details in comment area

Reference: ODOT Traffic Signal Policy and Guidelines, November 2013

Appendix E Emergency Vehicle Preemption Request Form

Request for Approval to Operate Traffic Signal Control Operating Devices on State Highways

ORS 810.260 and 815.445 and OAR 734-020-0300 to -0330 provide for the use of traffic control signal operating devices by emergency vehicles. Each emergency service provider seeking to use a traffic control signal operating device on a State Highway must make a formal request to the Oregon Department of Transportation.

To make a request, please provide the information requested below and submit it to the ODOT Region where the emergency preemption system will operate. The Region Traffic Manager will review the request and submit a recommendation to the State Traffic Engineer. The State Traffic Engineer has approval authority for all requests.

Contact the Traffic Engineering and Operations Unit, Oregon Department of Transportation at 503-986-3568, if you have questions about completing this form.

Emergency Service Provider____________________________________Telephone__________________________

Address______________________________________ City________________________ Zip Code _______________

Contact ________________________________ Title ______________________Email ________________________

Indicate whether your organization is a ____ Public agency or ___ Private emergency service provider

Private emergency service providers should provide verification that the vehicles to be equipped with traffic control operating devices have been designated as emergency vehicles by ODOT's Transportation Safety Division per OAR 737-100-0030. (Contact Program Manager Michele O'Leary at 503-986-4198 for more information about this requirement.)

1. List the types of vehicles that you want to equip with traffic control signal operating devices.

   Type of Vehicle Gross Vehicle Weight Purpose of Vehicle

2. Describe the geographical area where the emergency vehicles operate or provide a map.

3. Sign this request form and submit it to the ODOT Region Traffic Manager for review.

Signature of Applicant____ Date________________

ODOT Region Review

Review the Request Form, check the following, and submit to the State Traffic Engineer for approval.

____ Region is in substantial agreement with the information supplied by the applicant.

Region Traffic Manager____ Region_______ Date____________

State Traffic Engineer Review

__________________________________(name of emergency service provider) is authorized to operate traffic control signal operating devices on state highways in vehicles providing emergency services as provided for in ORS 810.260 and 815.445 and OAR 734-020-0300 to -0330.

State Traffic Engineer____ Date________________

Appendix F Transit Priority Preemption Request Form

Request for Approval to Operate Traffic Signal Control Operating Devices on State Highways

ORS 810.260 and 815.445 and OAR 734-020-0300 to -0330 provide for the use of traffic control signal operating devices by buses and emergency vehicles. A transit authority seeking to use a traffic control signal operating device on a State Highway must make a formal request to the Oregon Department of Transportation.

To make a request, please provide the information requested below and submit it to the ODOT Region where the bus priority system will operate. The Region Traffic Manager will review the request and submit a recommendation to the State Traffic Engineer. The State Traffic Engineer has approval authority for all requests.

Contact the Traffic Engineering and Operations Unit, Oregon Department of Transportation at 503-986-3568, if you have questions about completing this form.

Transit Authority____Telephone_______________________________

Address____________________________________ City ________________________ Zip Code ______________

Contact ______________________________ Title _______________________ Email _______________________

4. List the types of vehicles that you want to equip with traffic control signal operating devices.
   Type of Vehicle   Gross Vehicle Weight   Purpose of Vehicle

5. Describe the geographical area where the buses operate or provide a map.

6. Describe any emergency vehicle preemption or bus priority systems currently operating in the area in which you wish to operate.

7. Describe the impact the proposed bus priority system would have on the efficiency of public transit operations and effect the system will have on traffic safety and efficient traffic flow.

8. Sign this request form, and submit it to the ODOT Region Traffic Manager for review. Attach a copy of the agreement required per OAR 734-020-0320 that you have entered into with the road authority

Signature of Applicant____ Date_______________________

ODOT Region Review

Review the Request Form, check the following, and submit to the State Traffic Engineer for approval.

____ Region is in substantial agreement with the information supplied by the applicant.

Region Traffic Manager ______ Region Date ______

State Traffic Engineer Review

________________________________(name of transit authority) is authorized to operate traffic control signal operating devices on state highways in buses as provided for in ORS 810.260 and 815.445 and OAR 734-020-0300 to -0330.

State Traffic Engineer____ Date_______________________