Oregon Department of Transportation

Railroad Preemption Design and Operation

October 19, 2005

OREGON DEPARTMENT of TRANSPORTATION
HIGHWAY DIVISION
TECHNICAL SERVICES
TRAFFIC ENGINEERING AND OPERATIONS SECTION
http://egov.oregon.gov/ODOT/HWY/TRAFFIC/

The material contained herein is for information purposes only and may be used to aid new employees, and those unfamiliar with ODOT Traffic Engineering practices, in accessing and applying applicable standards, statutes, rules, and policies related to railroad preemption design and traffic control signal operation.

Under Oregon law, ORS 824.202 'Policy; authority vested in state and department', the ODOT Rail Division is authorized to determine the character and type of traffic control devices used at all highway-rail grade crossings.

Railroad Preemption Design and Operation
Oregon Department of Transportation
Highway Division
Technical Services
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Railroad Preemption Design and Operation

CONTENTS

Railroad Preemption

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

Standard Practices for Installation and Operation *(ODOT Traffic Signal Policy and Guidelines)*

1. Preemption is required when railroad tracks are located on a roadway within 215 feet (65 m) of a signalized intersection. The distance is measured from the nearest rail at the crossing to the nearest stop location at the signalized intersection. Light rail transit lines, when operated in a street running mode, along with other traffic, may be exempted from this preemption requirement.

2. When a Vehicle Clear Out Interval (VCOI) is required, the indication for the clearance phases shall be green.

3. Advance railroad detection or other appropriate methods shall be used to provide a Pedestrian Clear Out Interval (PCOI) before the Vehicle Clear Out Interval. This should be designed to minimize the occurrence of abbreviated pedestrian clearance intervals.

Optional Practices *(ODOT Traffic Signal Policy and Guidelines)*

The road authority may submit an engineering study to the State Traffic Engineer to request a deviation from the standards. The State Traffic Engineer in consultation with the ODOT Rail Crossing Program Manager may authorize a signalized intersection operation consistent with the findings of the study.

Railroad Clearance Definitions (See pages 13 and 14 for additional definitions.)

1. *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. *The timing for this interval is calculated by the road authority and placed in the railroad controller by railroad employees.*

2. *Vehicle Clear Out Interval (VCOI)* - A traffic control 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). *The timing for the VCOI is calculated by the road authority and placed in the highway traffic signal controller.* The protective devices (gates and flashing lights) at the grade crossing are activated by the railroad at the beginning of the VCOI.

Determining the Pedestrian Clear Out Interval (PCOI)
(See Appendix C and Worksheet on last pages.)

The PCOI is determined by the flashing DON'T WALK interval (FDW) of the longest crosswalk that does **not** normally operate with the railroad clear phase(s). **If reducing the PCOI by a few seconds would significantly reduce the operational complexity of the railroad preemption operation, the use of a minimum critical FDW interval as determined by the ODOT *Traffic Signal Policy and Guidelines* may be considered.** Refer to the examples beginning on page 10. These examples all show phase 4 on the approach crossing the railroad. In actual use, if another phase were assigned to this approach, the numbering convention for the crosswalks would require revision. In the examples, Ped 8 can be replaced by the designation of the crosswalk to the left of the approach. Likewise, Ped 4 can be replaced by the designation of the crosswalk to the right of the approach, and Ped 2 and Ped 6 can be replaced by the designation of the crosswalks parallel to the railroad tracks. The next to the last sheet of this document contains a worksheet to aid in calculating the PCOI. *The timing for this interval is calculated by the road authority and placed in the railroad controller by railroad employees.*

Determining the Vehicle Clear Out Interval (VCOI) (See Appendix C and Worksheet on last pages.)

1. The VCOI can be determined by field observation or calculated using the following equation: VCOI = (D/L) x 2.0 seconds/vehicle

   Where: D = the distance between the stop location at the highway traffic signal and the railroad tracks, and
   L = the average vehicle length (typically 20 feet or 6 meters).

   Using typical values, this equation can be simplified to VCOI = D/10 (where D is expressed in feet) or VCOI = D/3 (where D is expressed in meters). Often this value is reduced by an amount equal to the vehicle clearance interval.

2. The VCOI should be set to the **greater** of either:

   a. The time needed for vehicles to clear the area between the railroad tracks and intersection stop location as shown above (but usually not more than 20 seconds); or
   b. The highest FDW value of **any** crosswalk[1] minus the PCOI value, but generally not less than 8 seconds. In some cases where vehicles are stopped prior to the railroad grade crossing and turns against a red indication are prohibited, a pedestrian clearance interval may still be required[2].

[1] The FDW value of any crosswalk is typically used in conjunction with flashing yellow clearance. For green clearance where advance preemption is provided by the railroad company, only those crosswalks that operate concurrently with the railroad clearance phase need be considered in the calculation of VCOI. Often the crosswalk that operates concurrently with the railroad clearance phase is longer than the crosswalk used to determine the PCOI. In such cases all or part of the VCOI time is used to allow pedestrians to clear the intersection prior to the start of limited service phases. Refer to the examples in Appendix C and the worksheet at the back of this document.

[2] Refer to Appendix A if a VCOI is not required.

ODOT Practice Regarding Vehicle Clearance

Often the area between the railroad and the highway is used to store vehicles. It is ODOT practice at these locations to provide for the clearance of queued vehicles at the beginning of the railroad preemption sequence using the VCOI. During preemption the signal phases for vehicles crossing the tracks are not served and vehicles not cleared could be subject to excessive delay. There is, however, no requirement that complete clearance be accomplished. This is particularly true if preemption duration is very short as with LRT operation. It is imperative, however, that motorists do not stop on the railroad or LRT tracks. For each vehicle in the queue at the start of the VCOI, approximately 1 to 1½ seconds of green time is required before a vehicle stopped on the tracks can begin moving. This is about half of the time required to completely clear the approach. The railroad crossing protection is activated 25 seconds before a train arrives at the crossing (subject to the requirements set forth in the ODOT Rail Crossing Order). For crossings located at, or over, 200 feet (60 meters) from railroad-interconnected traffic signalized intersections, a large portion of this time could pass before an inappropriately stopped vehicle is provided an opportunity to move clear of the tracks.

Miscellaneous Terms

1. In the following examples, the use of arrows are interpreted as follows:


Indicates vehicle movement to which other movements must stop or yield


Indicates vehicle movements that must yield to opposing traffic or pedestrians

Indicates active pedestrian phase

2. All pedestrians signals (Ped) in the following examples are assigned to concurrently timed vehicle phases (Ph) and numbered accordingly.

3. The railroad crossing protection equipment is referred to as the "**railroad active warning system**".

4. The railroad company generally provides what is referred to as "**normally closed 'dry' preemption relay contacts**" to operate the PCOI and VCOI circuits. In Oregon, traffic signal equipment supplies 120 VAC to these contacts. As of this writing, new traffic signal railroad interconnects have been providing eight No. 12 AWG wires including five spares available for future use in a supervised system.

5. Railroad companies refer to **MPT (Maximum Preemption Time)** equal to the sum of PCOI and VCOI. The PCOI is often referred to as **Advance Preemption Time (APT)** and VCOI as **Simultaneous Preemption**.

6. The railroad controller generally used to provide Oregon's green clearance operation is called a "**Constant Warning Time**" (CWT) controller.

Red Revert Timing

Model 170 controller software provides a red revert feature for each signal phase. This feature is used to guarantee a minimum red time, typically 2 to 5 seconds, following a yellow clearance interval. This is done because many motorists divert their attention from the traffic signal as they bring their vehicle to a stop. When railroad preemption becomes active during the yellow indication of a phase which is a *railroad clearance phase*, the yellow interval will be timed completely followed by a red interval equal to the amount of time specified by the red revert. In such cases the red revert time should be set at or near its two second minimum to allow a rapid return to the railroad clearance phase.

Left Turn Trap

When railroad preemption is initiated at a traffic signal that allows permissive left turn movements from the roadway crossing the railroad tracks (minor street), a left turn trap situation may occur for turning vehicles opposing the approach for which a VCOI is provided. The use of "protected only" left turn signals, if left turn lanes are provided, could eliminate this potential, but may increase overall intersection delay and increase the required PCOI time.

Preemption Matrix

A preemption matrix is a drawing that illustrates how a traffic signal moves through its various vehicle and pedestrian phases to accomplish the railroad preemption requirements. Generally both the PCOI and VCOI are provided along with a note designating limited service phases – those phases which are allowed to operate normally while a train is occupying the railroad crossing. The drawing should show only those phases provided at a location. The specific timing values for phases or intervals are not provided. Typical examples for six-phase and eight-phase locations follow this section.

A preemption matrix typically consists of three or four parts:

1. Normal phase rotation,
2. Phase rotation when (and if) the pedestrian inhibit (PCOI) is active,
3. Railroad clearance sequence (VCOI), and
4. Conditional service phases. The phase rotation of the conditional service phases is usually the same as that of normal phase rotation, however phases which would direct motor vehicle traffic over the grade crossing are not served and will remain red.

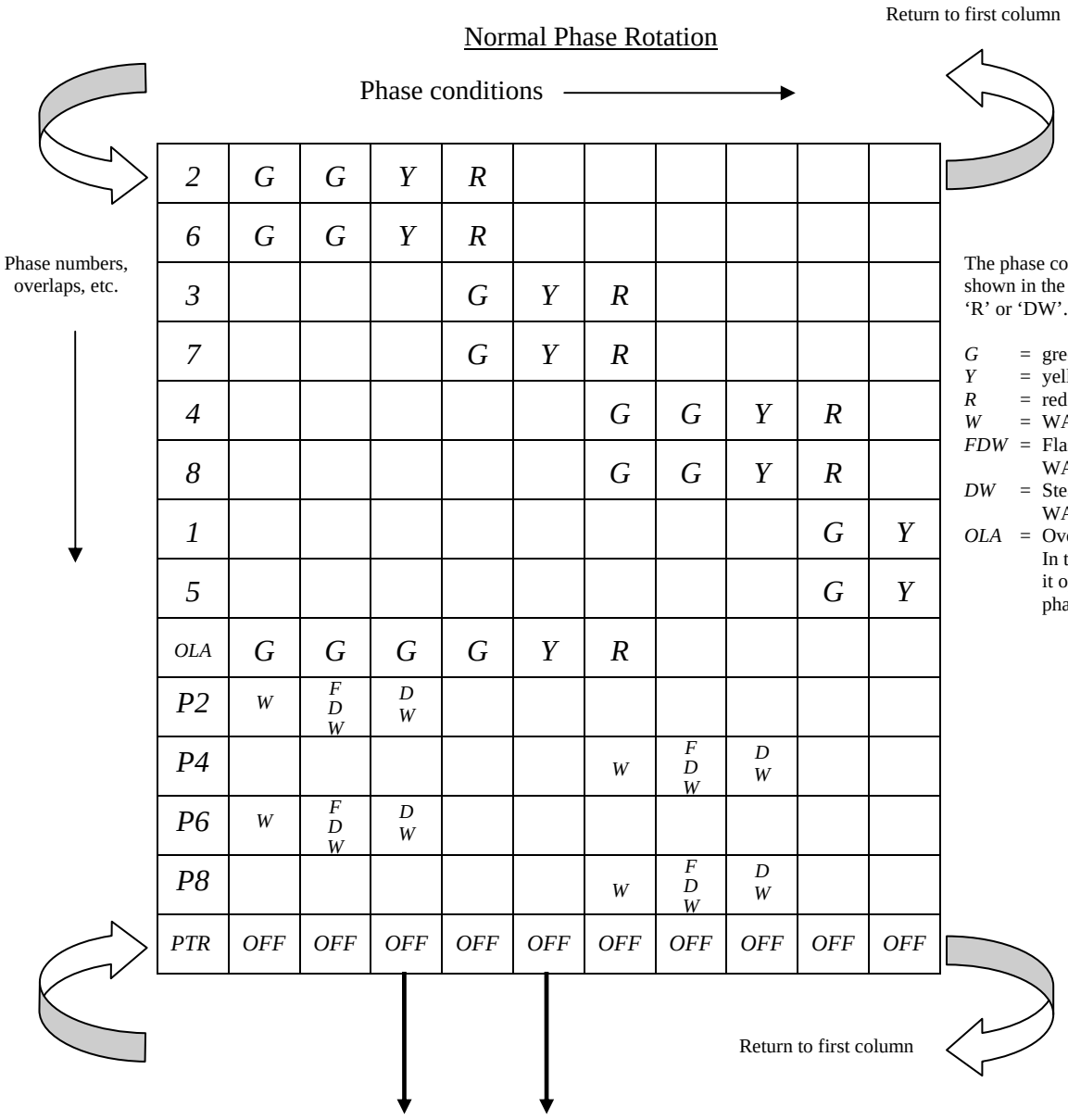
The matrix also identifies signal overlaps and part time restriction (PTR) sign status. The phase number is indicated down the left edge of the matrix and the phase condition is shown from left to right. Each column represents a distinct group of phase indications. The matrix should be interpreted one column at a time. A signal leaves normal phase rotation only when a preemption call is received (either PCOI or VCOI). Each column at which an exit can occur has a line that leads to the next part of the matrix where rotation from left to right can be resumed. **For normal phase rotation and pedestrian inhibit operation (usually**

located directly below), an exit will not occur until a call from the railroad controller is received. When signal operation moves to the right side boundary of the matrix, operation will return to the first column. (During pedestrian inhibit operation flashing DON'T WALK intervals will be served only if necessary upon entry to the matrix.) When a call for the VCOI (or simultaneous preemption) is received, the controller will immediately move to serve the track clearance phases regardless of the amount of time provided for the PCOI.

The actual VCOI sequences are shown at the bottom of the matrix grouping as a series of columnar sub-groups, each with a unique entry and exit point. **In this part of the matrix an exit to the limited service phases is mandatory when signal operation reaches the right side boundary of any sub-group.**

The following sample illustrates the basic construction of the first – or 'Normal Phase Rotation' – part of the preemption matrix. The order of phases in a traffic signal controller may change by time of day or as a result of the requirements of a particular signal system plan. The 'Normal Phase Rotation' portion of the preemption matrix usually depicts the default (or "free") operation of the traffic signal, unless designated otherwise.

Sample Preemption Matrix
Typical 8-Phase

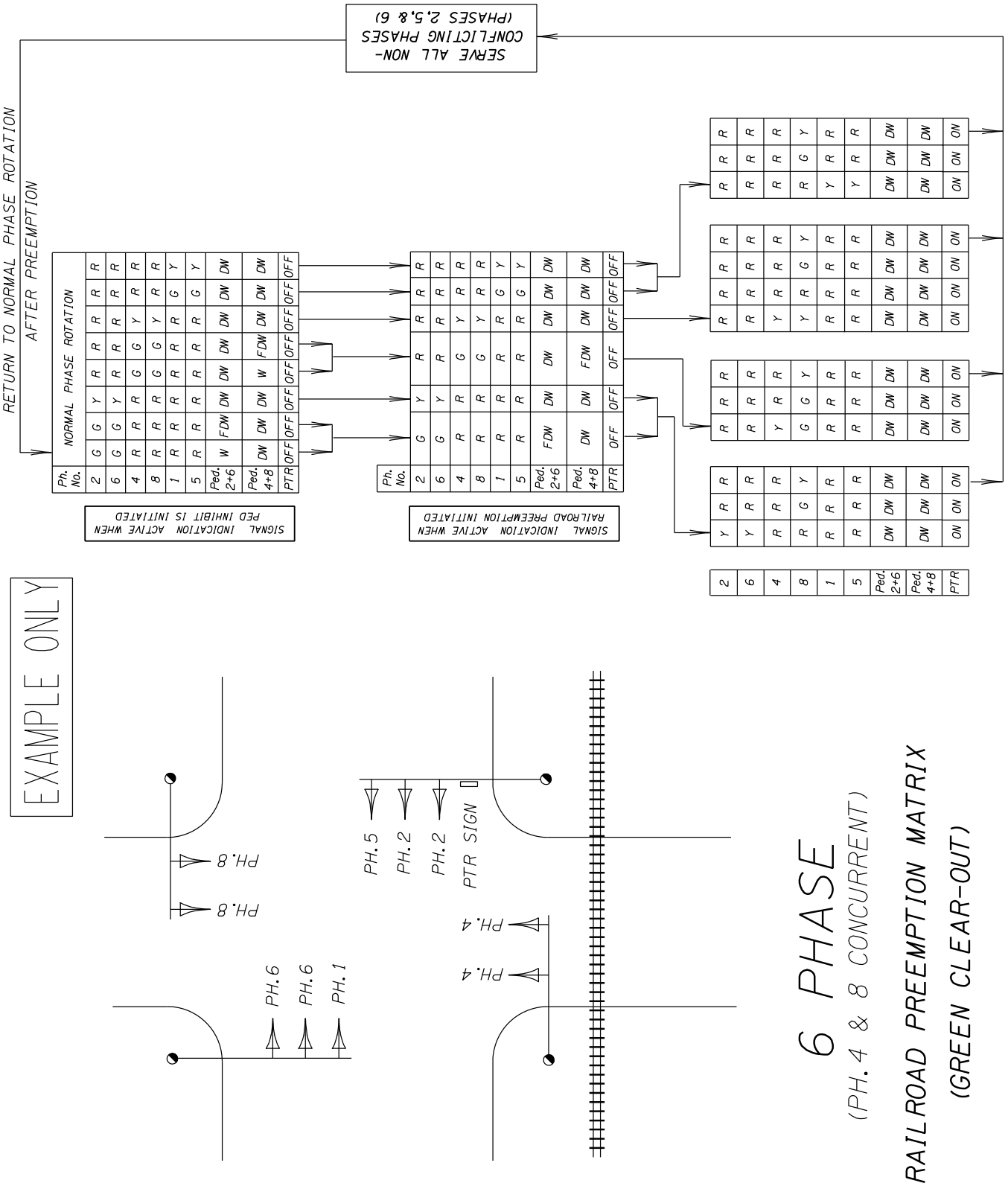


2	*G*	*G*	*Y*	*R*						
6	*G*	*G*	*Y*	*R*						
3				*G*	*Y*	*R*				
7				*G*	*Y*	*R*				
4						*G*	*G*	*Y*	*R*	
8						*G*	*G*	*Y*	*R*	
1									*G*	*Y*
5									*G*	*Y*
OLA	*G*	*G*	*G*	*G*	*Y*	*R*				
P2	*W*	*F D W*	*D W*							
P4						*W*	*F D W*	*D W*		
P6	*W*	*F D W*	*D W*							
P8						*W*	*F D W*	*D W*		
PTR	*OFF*	*OFF*	*OFF*	*OFF*	*OFF*	*OFF*	*OFF*	*OFF*	*OFF*	*OFF*

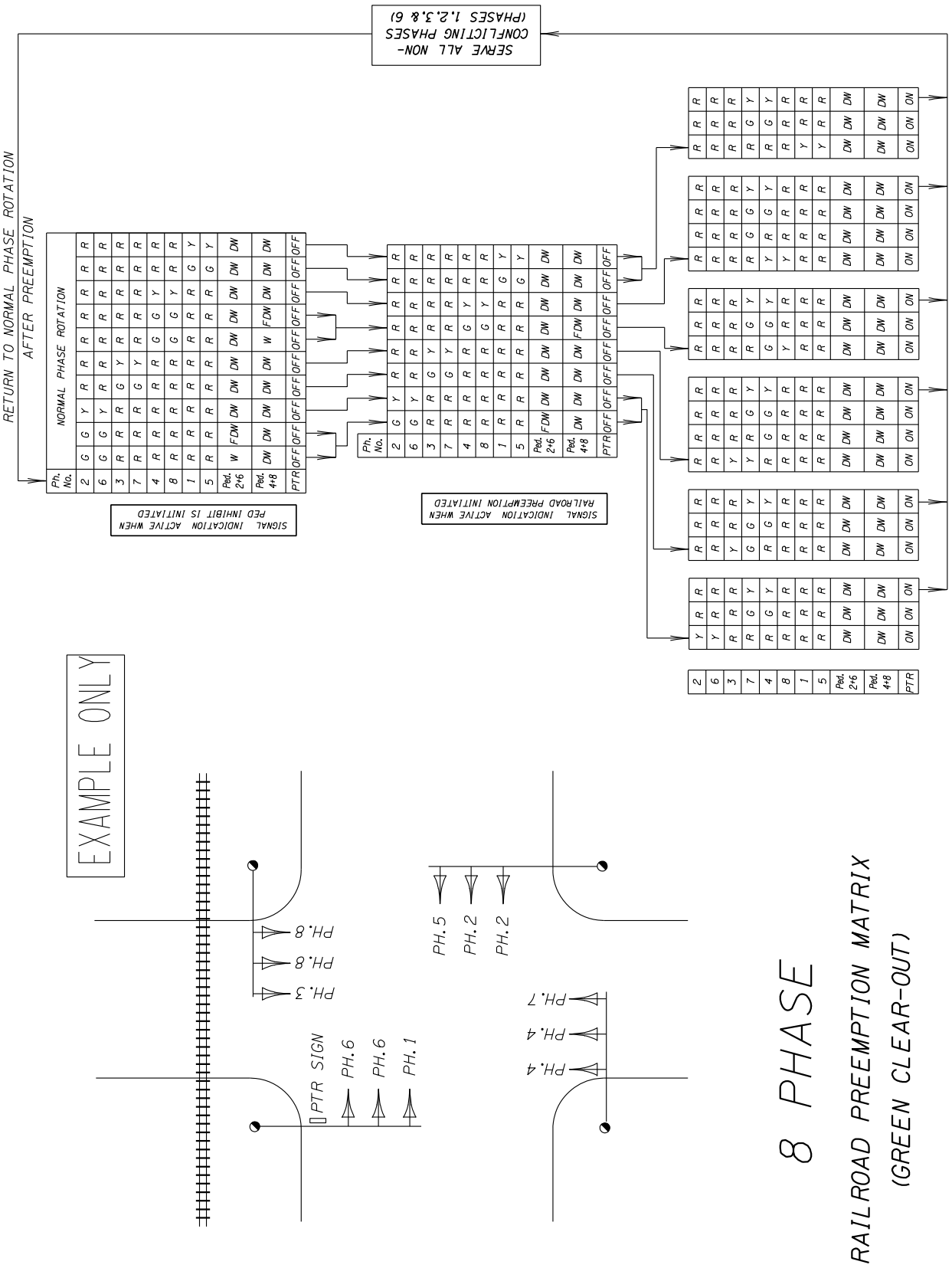
General Notes

1. The matrix should be arranged from left to right identical to the normal phase rotation diagram that accompanies the traffic signal design.
2. In many cases concurrently timed phases can be grouped together for simplicity such as phases 2 and 6, 3 and 7, etc.
3. Generally, the "start up phases" are the first phases shown in the left column.

6-Phase Railroad Preemption Matrix

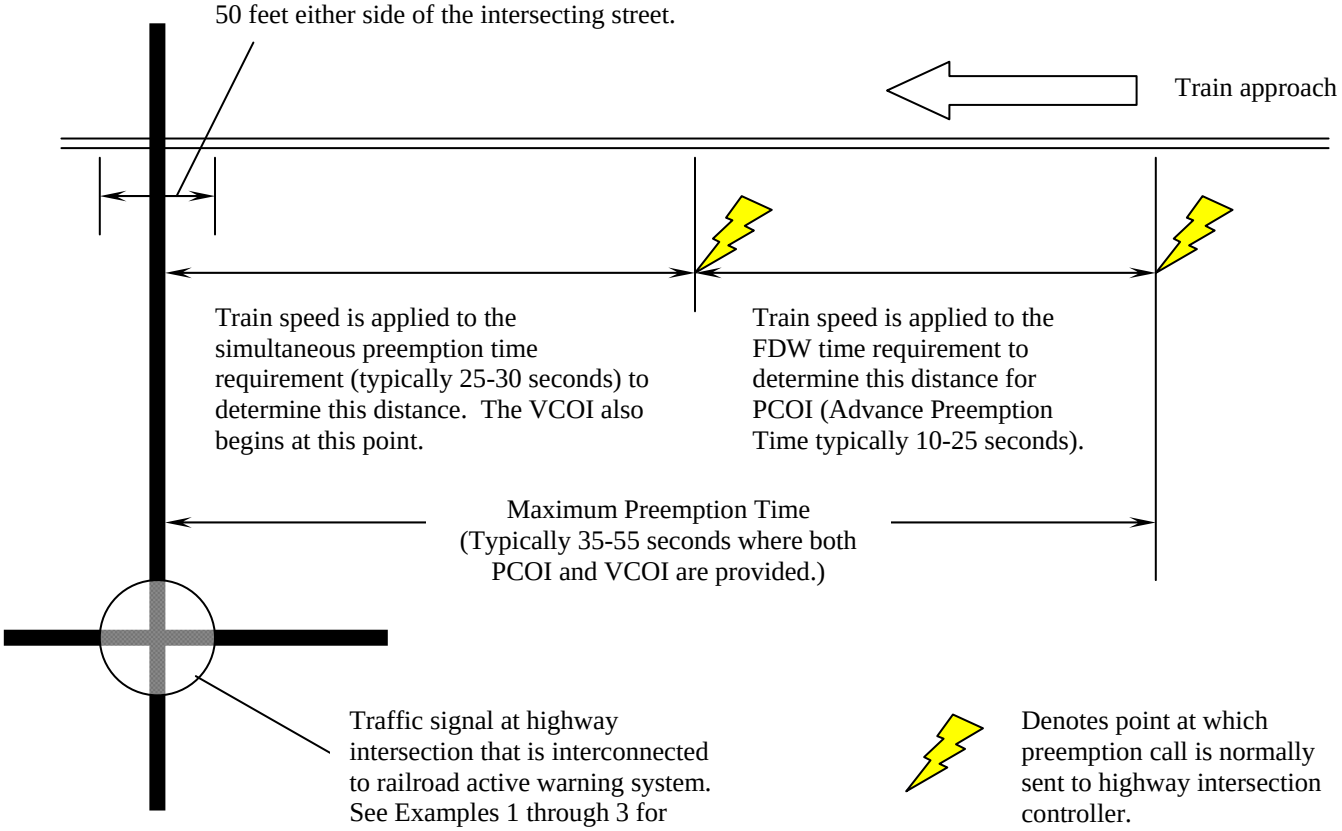


8-Phase Railroad Preemption Matrix

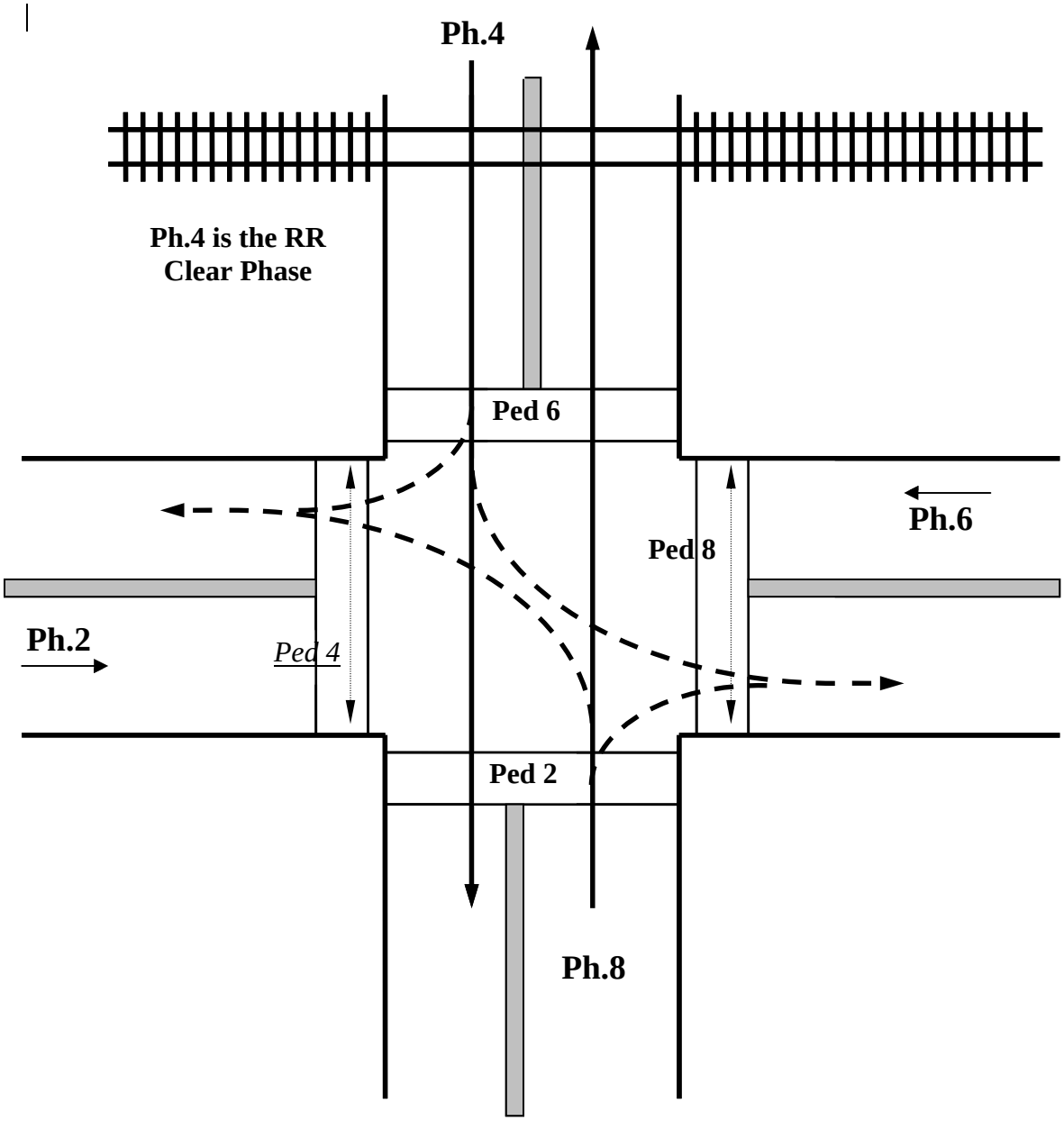


Elements of a Railroad Active Warning System

(As they relate to an Adjacent Highway Intersection)

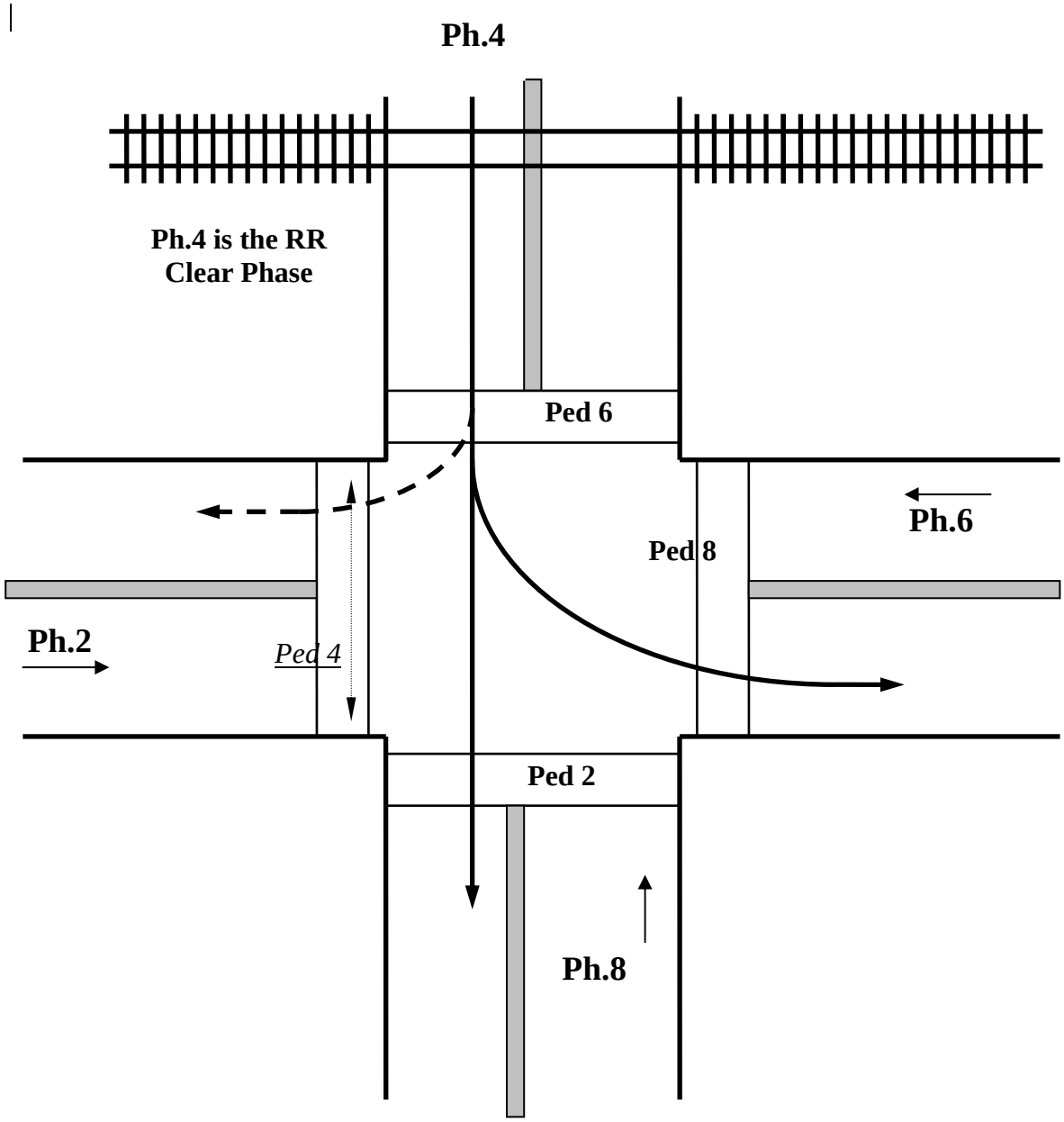


Example 1 – Concurrent Phasing without Left Turn Protection



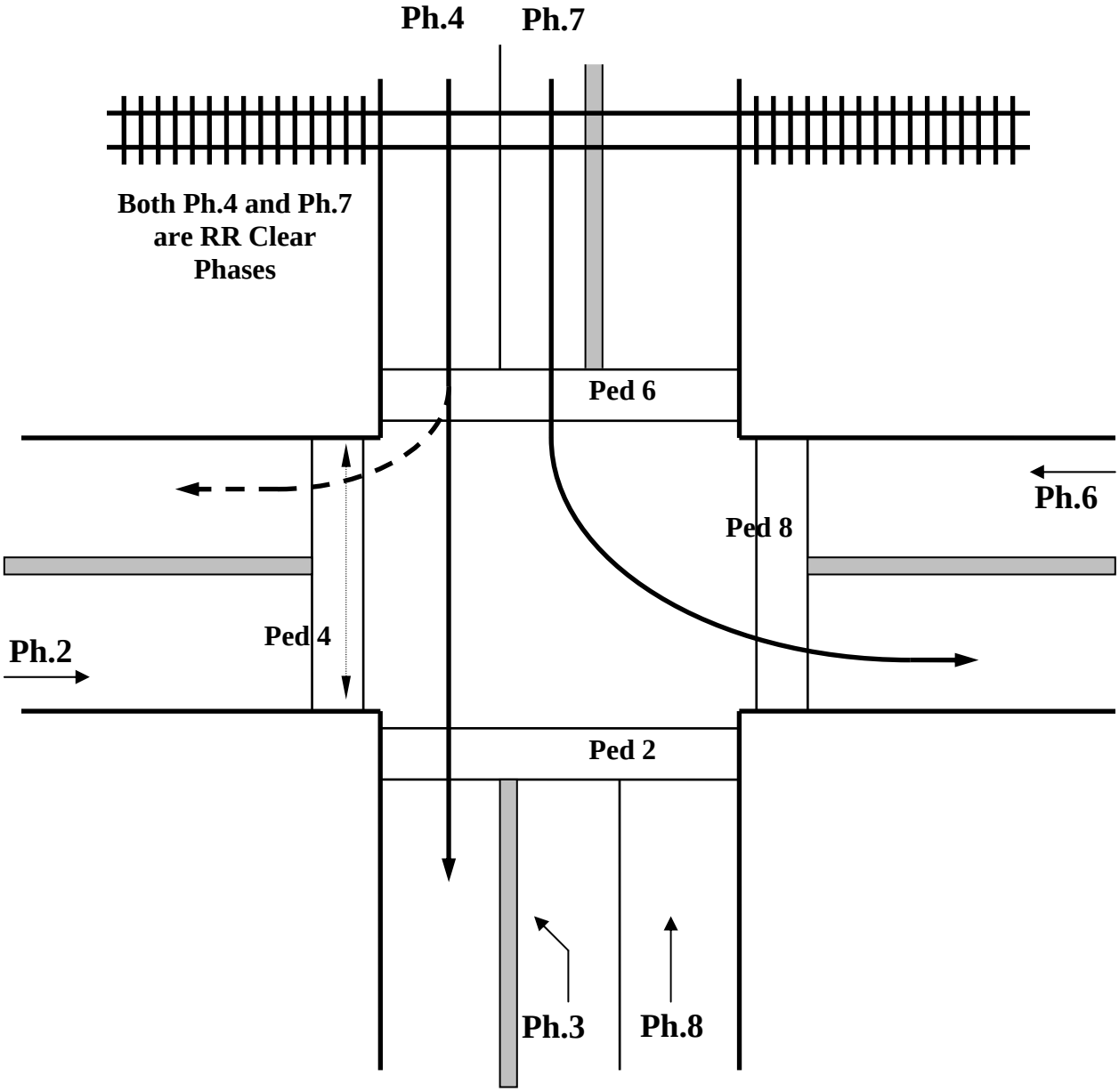
Example 1: If phases 4 and 8 operate concurrently, the PCOI is determined by the larger FDW interval of the Ped 2 or Ped 6 crossing.

Example 2 – Split (Non-concurrent) Phasing



Example 2: If phases 4 and 8 do not operate together (often referred to as "split phase" or non-concurrent operation) the PCOI is determined by the larger FDW interval of the Ped 2, Ped 6, or Ped 8 crossing.

Example 3 – Concurrent Phasing with Left Turn Protection



Example 3: If the railroad clear phases include a protected left turn movement the PCOI is determined by the larger FDW interval of the Ped 2, Ped 6, or Ped 8 crossing.

Railroad Pre-signals and Advance Signals - Definitions

- *Advance head* – A near side signal face. (See Figures 1, 2, 3, and 6.)

- *Displaced Stop Line* – A line used to indicate the point behind which vehicles are required to stop in compliance with a traffic control signal when such line is located other than at the expected location for a highway intersection stop line. A displaced stop line shall be supplemented by a "STOP HERE ON RED" sign. (See Figures 5 and 6.)

- *Near-Side Signal Face* (Also referred to as a *Supplemental near-side signal face*) – A traffic signal display located in advance of an intersection when engineering judgement has shown that it is needed to achieve intersection visibility both in advance of and immediately before the signalized intersection. If near-side signal faces are used, they should be located to provide optimum visibility for the movement to be controlled. Programmed visibility or placement alone may be sufficient to avoid motorist confusion as to the location of the intersection stop line. (See Figures 1, 2, 3, and 6.)

  Discussion: The purpose of a near-side signal face is to either:
  1. Enhance the visibility of a traffic signal by overcoming obstructions to a driver's view of the intersection, or
  2. Enhance the visibility of the primary signal faces if these are more than 180 feet from the intersection stop line.

  There is no requirement that such a signal face be placed at or near the intersection stop line nor is there a requirement that a railroad stop clearance line (SCL) on an approach with a supplemental near-side signal face be interpreted as an intersection stop line unless marked by an official sign: "STOP HERE ON RED".

  A near-side signal face should always display the same indications as the primary signal faces on an approach. If placed on an approach that is a clearance phase during railroad preemption, the face may display red during the VCOI.

- *Pre-signal* – Supplemental traffic signal equipment typically employed to control a highway intersection approach at its intersection with a highway-railroad grade crossing. A pre-signal is located *in advance of* the primary traffic signal display at the highway intersection. (A pre-signal is also referred to as a "queue cutter" signal – See Figure 4.)

  Discussion: The purpose of a pre-signal is to minimize the occurrence of vehicles stopping on the railroad tracks when the highway-railroad grade crossing is near the highway intersection. The signal heads for the pre-signal are generally located between the railroad tracks and the highway and the stop location for the pre-signal is usually the same as that defined by the stop clearance line (SCL) for the highway-railroad grade crossing. The number of signal heads and their location beyond the SCL is defined by the *MUTCD* and ODOT design practice. The beginning of both the yellow and red indications on the pre-signal precede those of the highway

intersection signal on every cycle to provide the desired clearance time. During the vehicle clear out interval (VCOI), pre-signal indications are red.

- *Pull-Through Signal* – A traffic signal display located *beyond* the primary vehicle heads on an intersection approach that provide for vehicular clearance through a large or directionally divided intersecting roadway. (See Figure 7.)

  Discussion: Although not required, a pull-through signal may have a stop location defined using a displaced stop line if a vehicle storage area is provided. The beginning of both the yellow and red indication is delayed on each signal cycle to provide the desired clearance interval.

- *Stop Line (Highway Intersection)* – A pavement marking used to indicate the point behind which vehicles are required to stop, in compliance with a STOP sign, traffic control signal, or some other traffic control device. If used, stop lines should be placed 4 feet (1.2 m) in advance of and parallel to the nearest crosswalk line. In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point, but should be placed no more than 30 feet (9 m) nor less than 4 feet (1.2 m) from the nearest edge of the intersecting traveled way. The outermost line of a 10-foot wide crosswalk is used as the stop line at signalized intersections. (See crosswalk line in all Figures.)

- *Stop Line (Highway-Rail Grade Crossing)* [3] – (*MUTCD*) A transverse line at a right angle to the traveled way at a point where a vehicle is to stop or as near as possible to that point. The stop line should be placed approximately 2.4 m (8 ft) from the gate (if present), but no closer than 4.6 m (15 ft) from the nearest rail.

- *Stop Line (Highway-Rail Grade Crossing)* – The stop line shall be a stop clearance line (SCL) as defined by Oregon Administrative Rule 741-110-0030 (2)(e) "Stop Clearance Line is a stop line as set forth in Section 3B.16 of the MUTCD, which is 24 inches wide." The SCL shall be located perpendicular to the roadway centerline at a point not less than 12 feet (3.7 m) minimum from the nearest rail. Further, where automatic gates are installed, the line shall be located 1 foot (0.3 m) in advance of where the gate arm crosses the roadway surface. (See Figures 3 through 6.) The SCL in this position helps to ensure that vehicles required to always stop at a highway-rail grade crossing will do so at a point of maximum visibility in both directions along the railroad tracks.

[3] The definition shown is that in *2003 MUTCD*.

Supplemental near side signal face

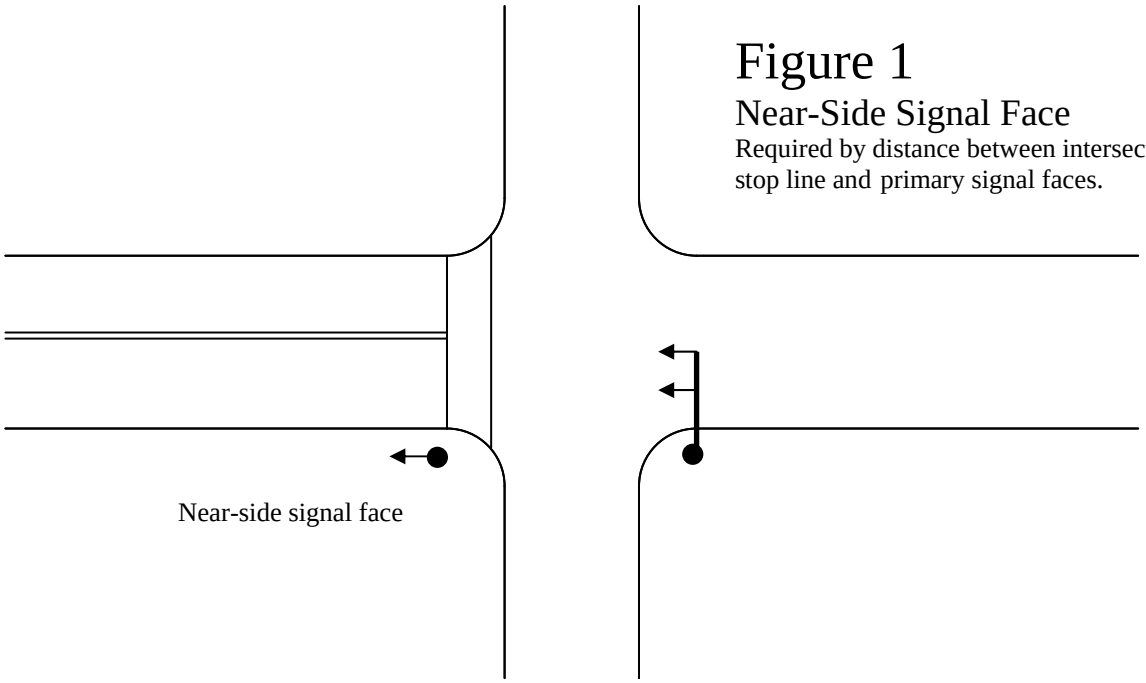


Figure 1
Near-Side Signal Face
Required by distance between intersection stop line and primary signal faces.

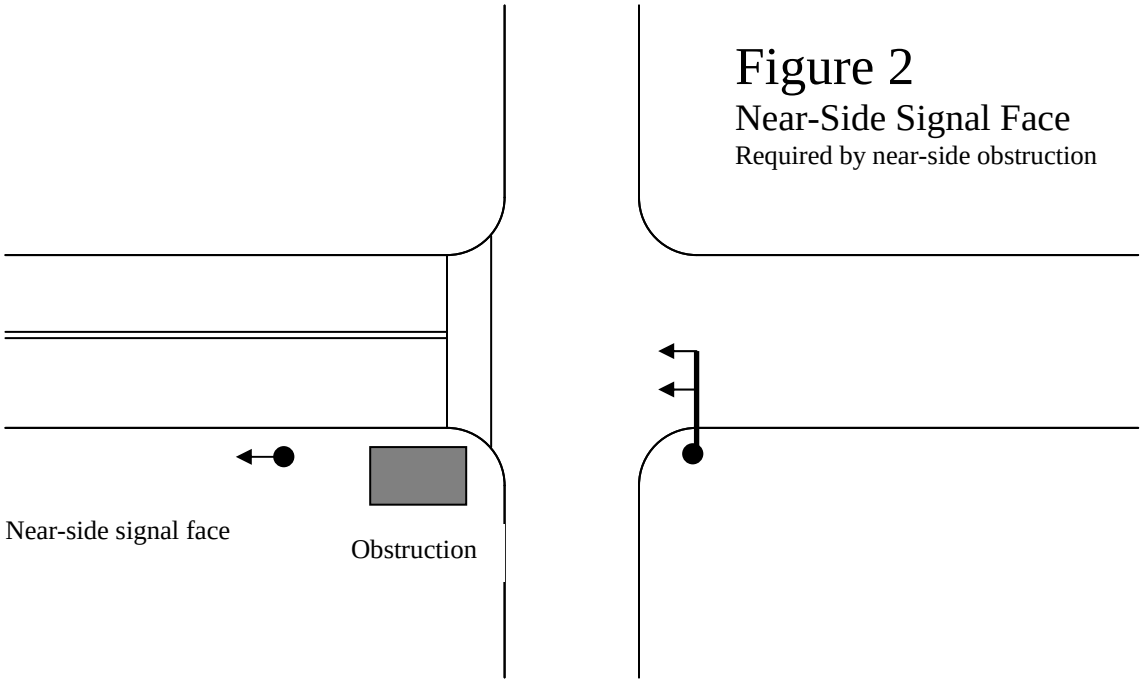


Figure 2
Near-Side Signal Face
Required by near-side obstruction

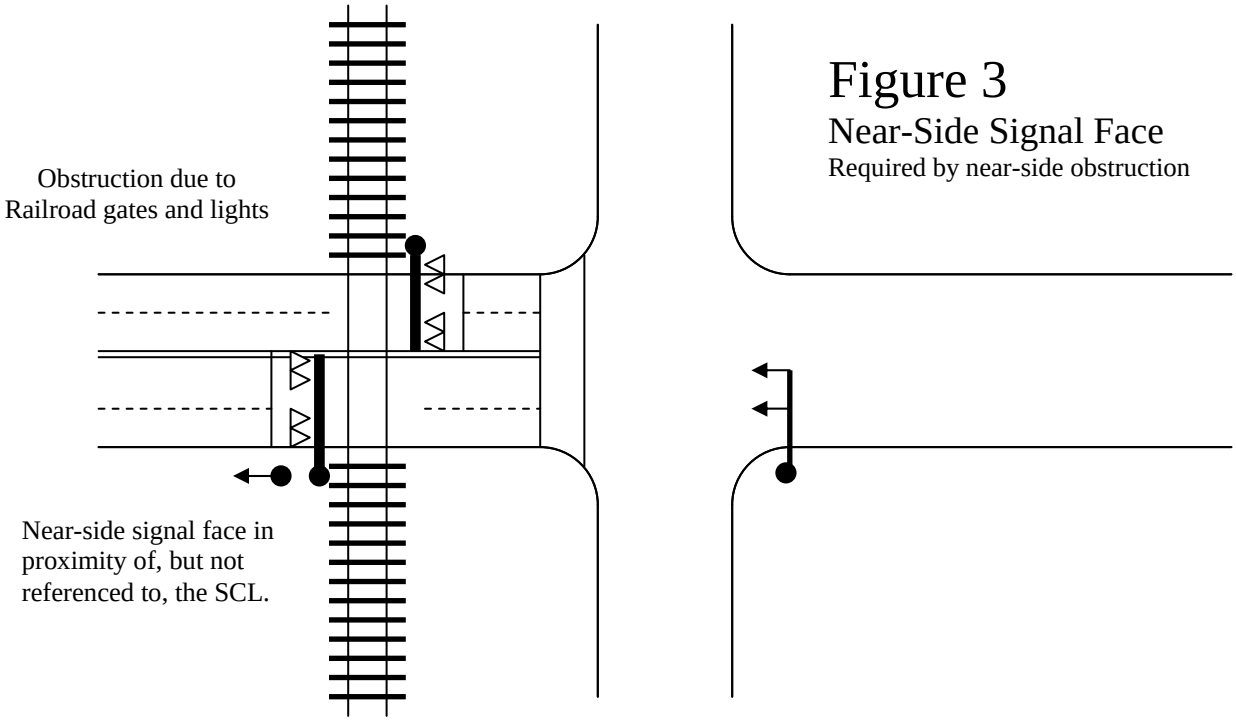


Figure 3
Near-Side Signal Face
Required by near-side obstruction

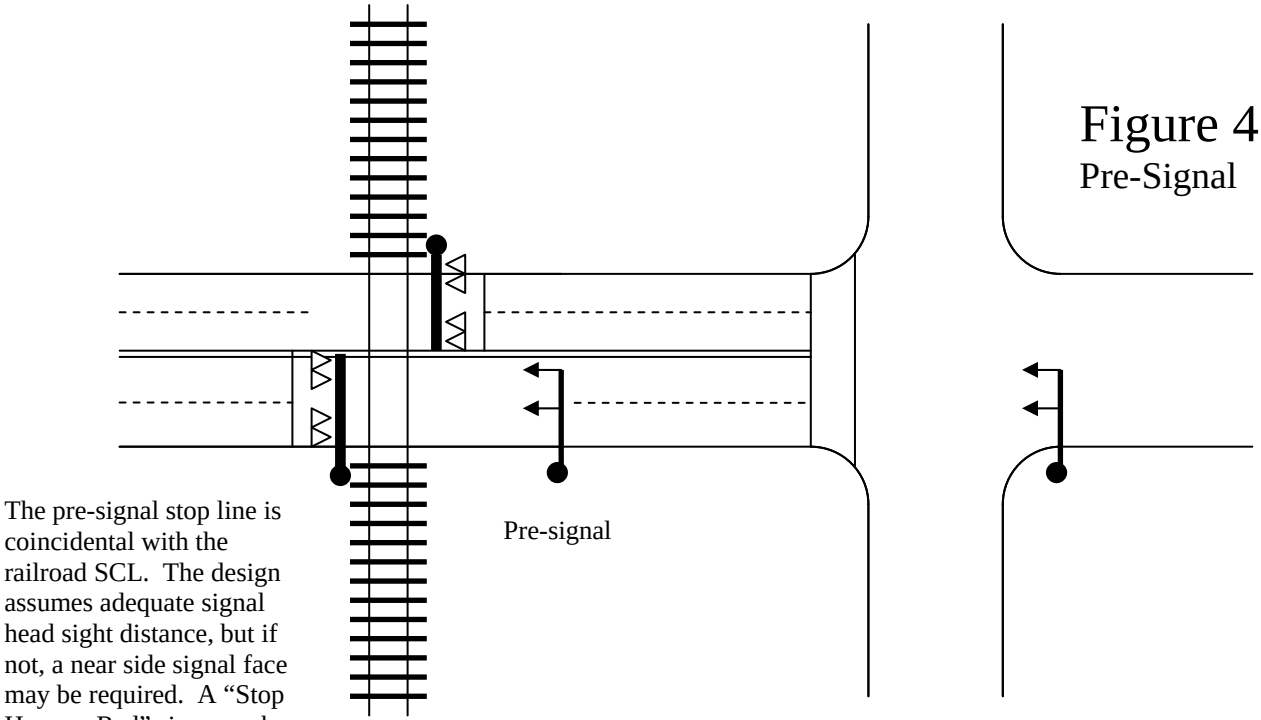


Figure 4
Pre-Signal

The pre-signal stop line is coincidental with the railroad SCL. The design assumes adequate signal head sight distance, but if not, a near side signal face may be required. A "Stop Here on Red" sign may be required.

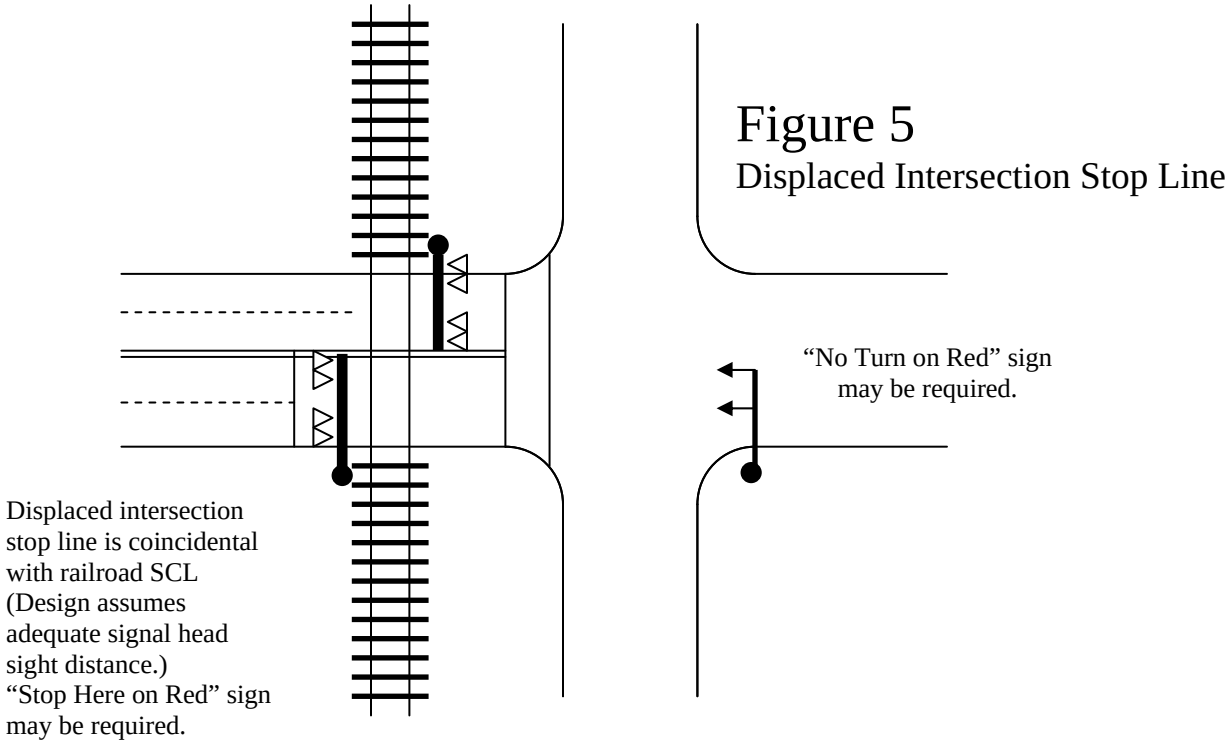


Figure 5
Displaced Intersection Stop Line

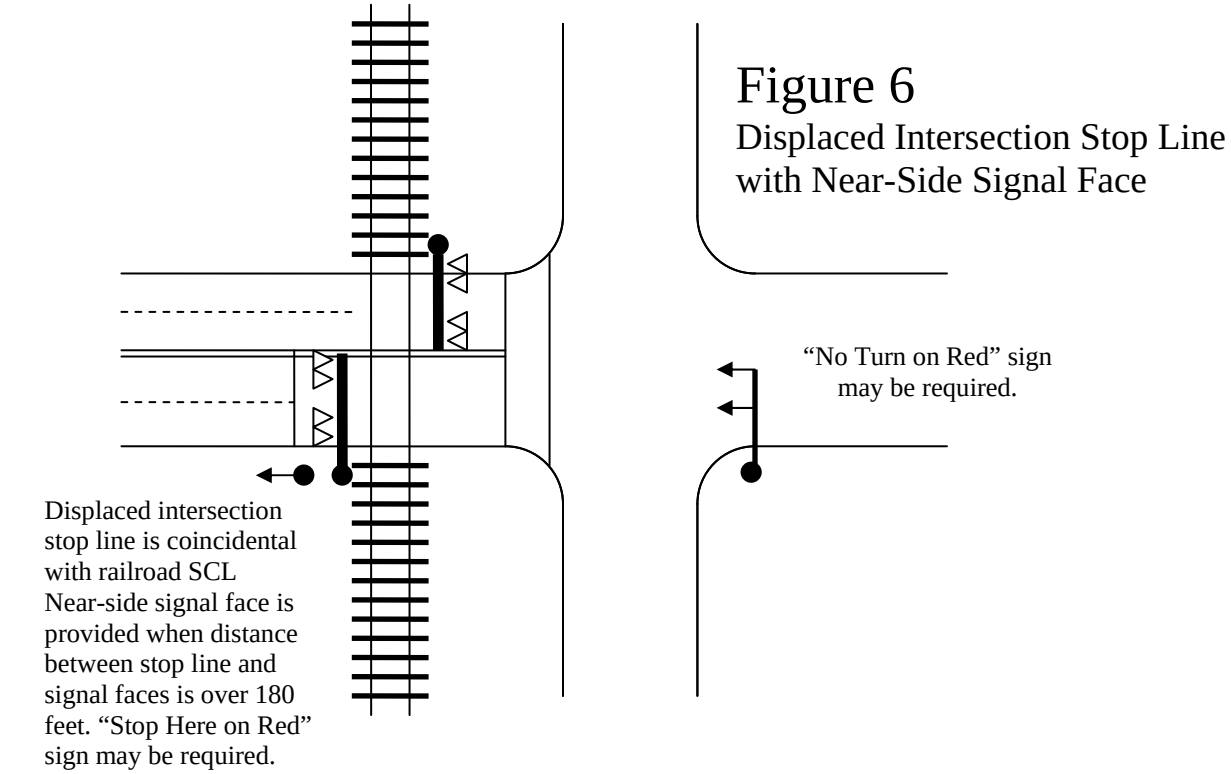


Figure 6
Displaced Intersection Stop Line with Near-Side Signal Face

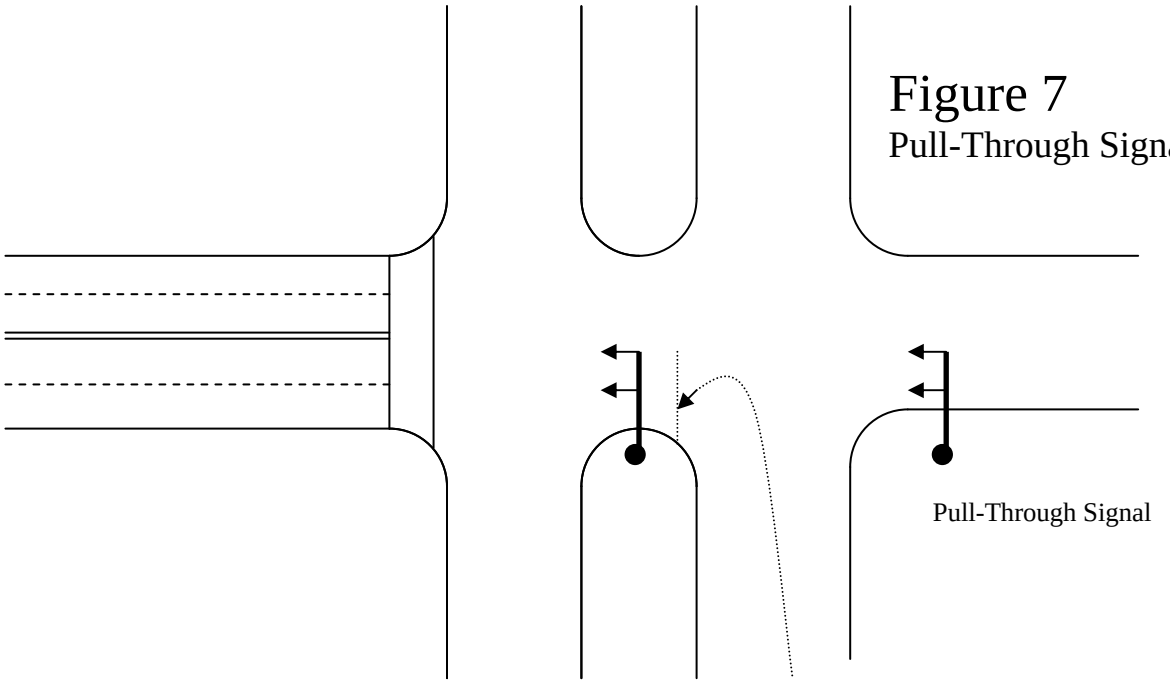
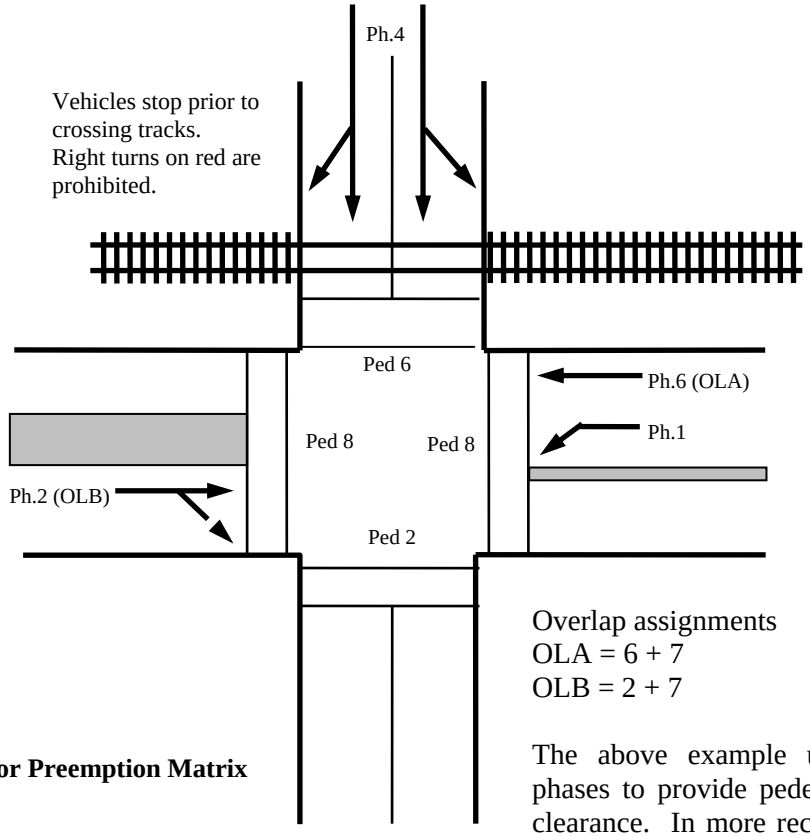


Figure 7
Pull-Through Signal

Appendix A
Pedestrian clearance where VCOI is not required
Method 1 - Using a dummy phase

The following example illustrates a special application of traffic signal phases to provide for pedestrian clearance when a Vehicle Clear Out Interval (VCOI) is not required. The example is for a one-way street intersection and makes use of traffic signal phases not used. The actual intersection now uses the command box method described on page 21.



Overlap assignments
OLA = 6 + 7
OLB = 2 + 7

See Next page for Preemption Matrix

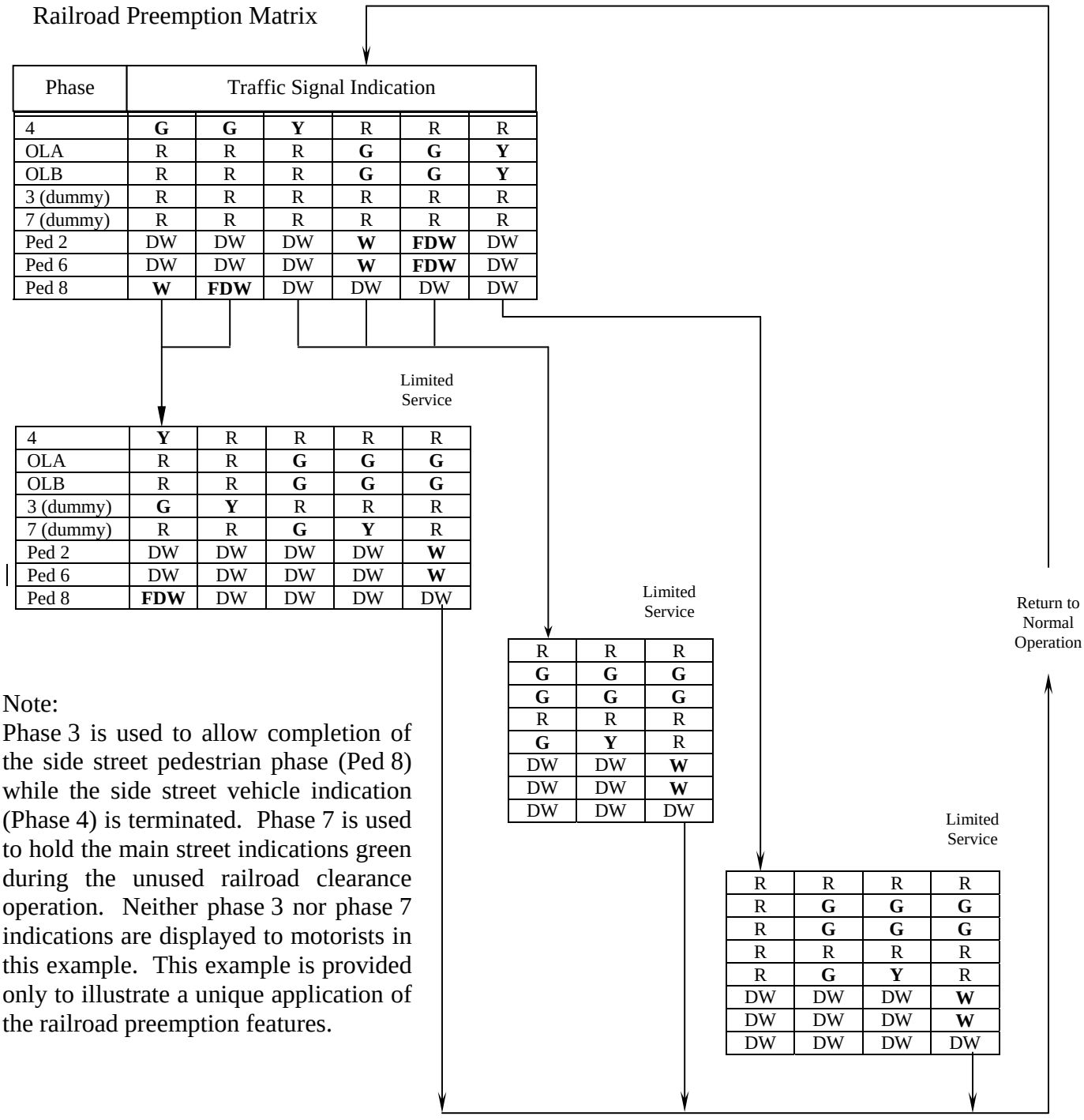
Discussion:

Field observations have noted that if motorists perceive there is sufficient space between the railroad tracks and highway for their vehicle, they will often occupy this area regardless of turn restrictions or "STOP HERE ON RED" signs. It may be appropriate to provide a VCOI to allow a trapped vehicle to move clear of the crossing area. This need is particularly acute if few acceptable gaps are found in traffic on the highway parallel to the railroad.

The above example uses two dummy phases to provide pedestrian and vehicle clearance. In more recent applications, a single dummy phase along with a command box application has been used. The necessary command box codes are provided in Appendix A on page 21. Phase 3 provides a railroad clearance phase for pedestrians only. If Ped 8 is active when the railroad preemption call is received, Phase 3 is served which stops vehicles on Phase 4. Upon completion of Ped 8, normal railroad preemption occurs using Phase 7 as an exclusive railroad clearance phase that drives overlap signals for Phase 2 and Phase 6 vehicles.

Example continued on next page.

Appendix A - Continued
Pedestrian clearance where VCOI is not required
Method 1 - Using a dummy phase



Note:
Phase 3 is used to allow completion of the side street pedestrian phase (Ped 8) while the side street vehicle indication (Phase 4) is terminated. Phase 7 is used to hold the main street indications green during the unused railroad clearance operation. Neither phase 3 nor phase 7 indications are displayed to motorists in this example. This example is provided only to illustrate a unique application of the railroad preemption features.

Appendix A - Continued

Pedestrian clearance where VCOI is not required

Method 2 - W4IKS Traffic Signal Controller Command Box Application

In some cases, such as where the approach across the railroad is one way away from the intersection or when the stop line for the approach is held behind the tracks, a railroad clearance phase is usually not required. The W4IKS traffic signal controller program requires a railroad clearance phase anytime railroad interconnection is used. A dummy phase that provides a short clearance is used in these cases. This command box application lengthens the dummy railroad clearance phase if any pedestrian phases are active at the time of railroad preemption. This avoids any conflict between the railroad permit phases and pedestrian phases[4]. This command box routine provides a constant "DON'T WALK" and will be modified. The modification, however, introduces some anomaly with minimum green time.

Step	Command	Description	Notes
1	205	Turn on command box output	Steps 1 - 10 provide normal RR preemption
2	1	#1	
3	24	not when	
4	22	input	
5	28	C1-54 is on	J11-U (Model 332 Cabinet)
6	206	Turn on input	
7	26	C1-52 (RR)	
8	24	not when	
9	22	input	
10	28	C1-54 is on	J11-U (Model 332 Cabinet)
11	208	Start timer	
12	1	#1	
13	24.0	for 24.0 seconds	24.0 = Phase 8 FDW time
14	21	if phase condition	
15	8	of phase 8	
16	2	is WALK	
17	208	Start timer	
18	1	#1	
19	13.0	for 13.0 seconds	13.0 = Phase 2 FDW time
20	21	if phase condition	
21	2	of phase 2	
22	2	is WALK	
23	206	Turn on input	
24	68	C1-82 (Stop Time)	
25	21	if phase condition	
26	4	of phase 4	dummy RR clear phase
27	11	is any green	
28	20	and	
29	27	timer	
30	1	#1 is running	

[4] This example is for US 30 at Columbia Boulevard in St. Helens. Other examples would have different pedestrian phases and/or dummy phase. The dummy phase should not be permitted and should be exclusive if compatible with any permitted phase.

Appendix B
Railroad Preemption
AC Isolator Conversion (332 cabinet)
W4IKS Command Box Application

Railroad Preemption has previously been done using a relay and test switch, resulting in a specially built and wired cabinet. The use of an AC isolator (ACI) with the W4IKS traffic signal control program allows the same operation with very little modification to the cabinet. The cabinet does not need to be fitted with the typical relay base and test switch.

This is a fail-safe circuit. Loss of the 'AC return' signal from the railroad triggers and holds the controller in the railroad preemption sequence. An ACI converts the AC level signal to DC logic signals for the traffic signal controller. The ACI output signal is TRUE when the preemption signal from the railroad company is FALSE. This signal is opposite of what the program is expecting, so it must be inverted, by the command box. A typical Model 332 cabinet setup requires:

1. TB0-1 AC+ supply **to** railroad cabinet through 2-amp in-line fuse (supplied AC+ from T1-5).
2. ACI in slot J11 (upper channel) with the Vehicle Clear-Out (simultaneous preemption) AC+ signal **from** the railroad cabinet wired through TB0-2 to J11-D.
3. ACI in slot J11 (lower channel) with the Ped Inhibit (advance preemption) AC+ signal **from** the railroad cabinet wired through TB0-3 to J11-J.
4. AC- to J11-E&K from T16-2.
5. Output file terminal 105 to Part Time Restriction (PTR) sign. Table 11 software output assignment at location D+B+1+7 = 53 (C1-37, Phase 4 Ped Yellow). Cancel the original Phase 4 Ped Yellow assignment with a "99" code at A+2+2 on Table 10.
6. Output file terminal 111 to fiber-optic sign *if* using a flashing yellow railroad clearance indication. Table 11 software output assignment at location D+B+1+5 = 54 (C1-38, Phase 8 Ped Yellow). Cancel the original Phase 8 Ped Yellow assignment with a "99" code at A+2+3 on Table 10.
7. Command box codes in Table 14 as follows:

Step	Command	Description	Notes
1	206	Turn on input	
2	26	C1-52	RR Preemption input
3	24	not when	
4	22	input	
5	28	C1-54 is on.	J11U (simultaneous preemption from RR)
6	206	Turn on input	
7	25	C1-51	Pedestrian Inhibit input
8	24	not when	
9	22	Input	
10	61	C1-75 is on.	J11L (advance preemption from RR)

Appendix B - Continued
Railroad Preemption
AC Isolator Conversion (*336 cabinet*)
W4IKS Command Box Application

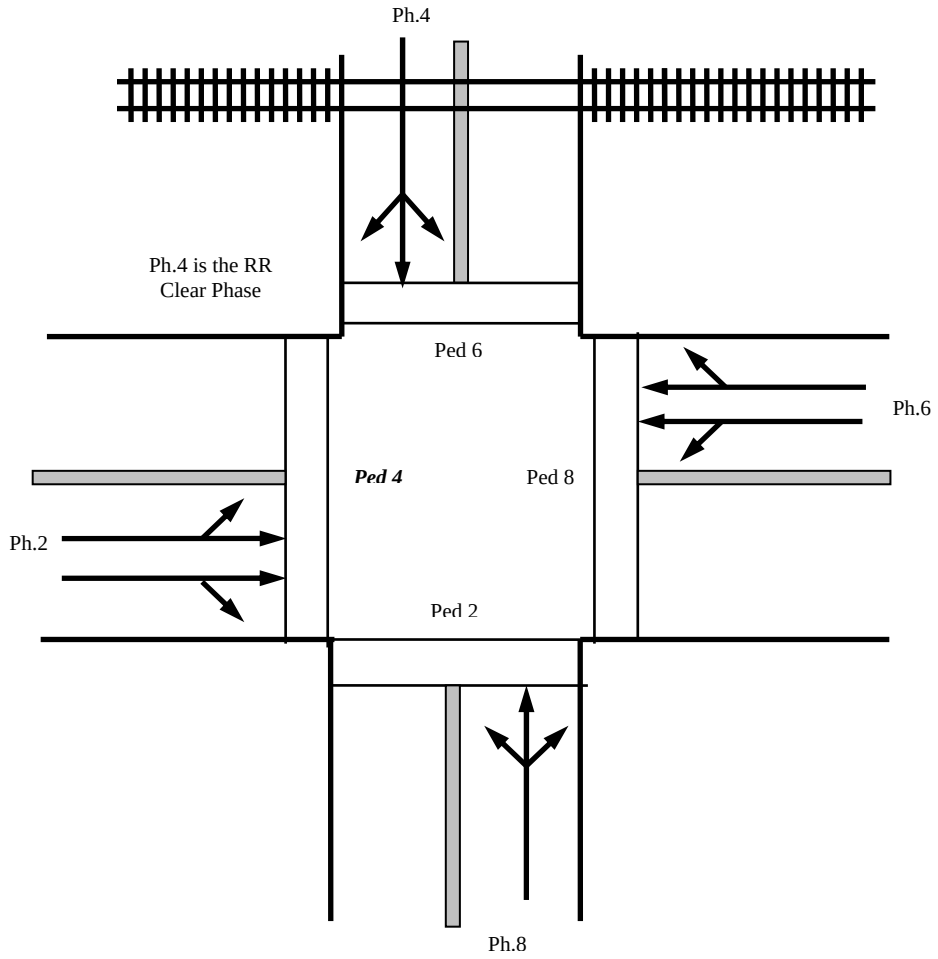
Railroad Preemption has previously been done using a relay and test switch, resulting in a specially built and wired cabinet. The use of an AC isolator (ACI) with the W4IKS traffic signal control program allows the same operation with very little modification to the cabinet. The cabinet does not need to be fitted with the typical relay base and test switch.

This is a fail-safe circuit. Loss of the 'AC return' signal from the railroad triggers and holds the controller in the railroad preemption sequence. An ACI converts the AC level signal to DC logic signals for the traffic signal controller. The ACI output signal is TRUE when the preemption signal from the railroad company is FALSE. This signal is opposite of what the program is expecting, so it must be inverted, by the command box. A typical Model 336 cabinet setup requires:

1. TB3-1 AC+ supply **to** railroad cabinet through 2-amp in-line fuse (supplied AC+ from T1-5).
2. ACI in input file slot 10 (upper channel) with the Vehicle Clear-Out (simultaneous preemption) AC+ signal **from** the railroad cabinet wired through TB3-2 to slot 10-D.
3. ACI in input file slot 10 (lower channel) with the Ped Inhibit (advance preemption) AC+ signal **from** the railroad cabinet wired through TB3-3 to slot 10-J.
4. AC- to slot 10-E&K from T16-2.
5. Add the following Table 9 software input reassignments (reassigns slot 10 C1-pin functions):
   A+4+F=47; A+5+E=28; A+5+F=61; A+6+8=48
6. Output file terminal 105 to Part Time Restriction (PTR) sign. Table 11 software output assignment at location D+B+1+7 = 53 (C1-37, Phase 4 Ped Yellow). Cancel the original Phase 4 Ped Yellow assignment with a "99" code at A+2+2 on Table 10.
7. Output file terminal 111 to fiber-optic sign *if* using a flashing yellow railroad clearance indication. Table 11 software output assignment at location D+B+1+5 = 54 (C1-38, Phase 8 Ped Yellow). Cancel the original Phase 8 Ped Yellow assignment with a "99" code at A+2+3 on Table 10.
8. Command box codes in Table 14 as follows:

Step	Command	Description	Notes
1	206	Turn on input	
2	26	C1-52	RR Preemption input
3	24	not when	
4	22	input	
5	28	C1-54 (reassigned 10U) is on.	10U (simultaneous preemption from RR)
6	206	Turn on input	
7	25	C1-51	Pedestrian Inhibit input
8	24	not when	
9	22	Input	
10	61	C1-75 (reassigned 10L) is on.	10L (advance preemption from RR)

Appendix C
PCOI and VCOI Sample Calculation #1



In the above example, the distance between the railroad tracks and the stop location at the highway intersection is 100 feet. The crosswalk length for Ped 2 and Ped 6 is 40 feet and the crosswalk length for Ped 4 and Ped 8 is 60 feet.

1. The **PCOI** is determined by the flashing DON'T WALK interval time for either Ped 2 or Ped 6:

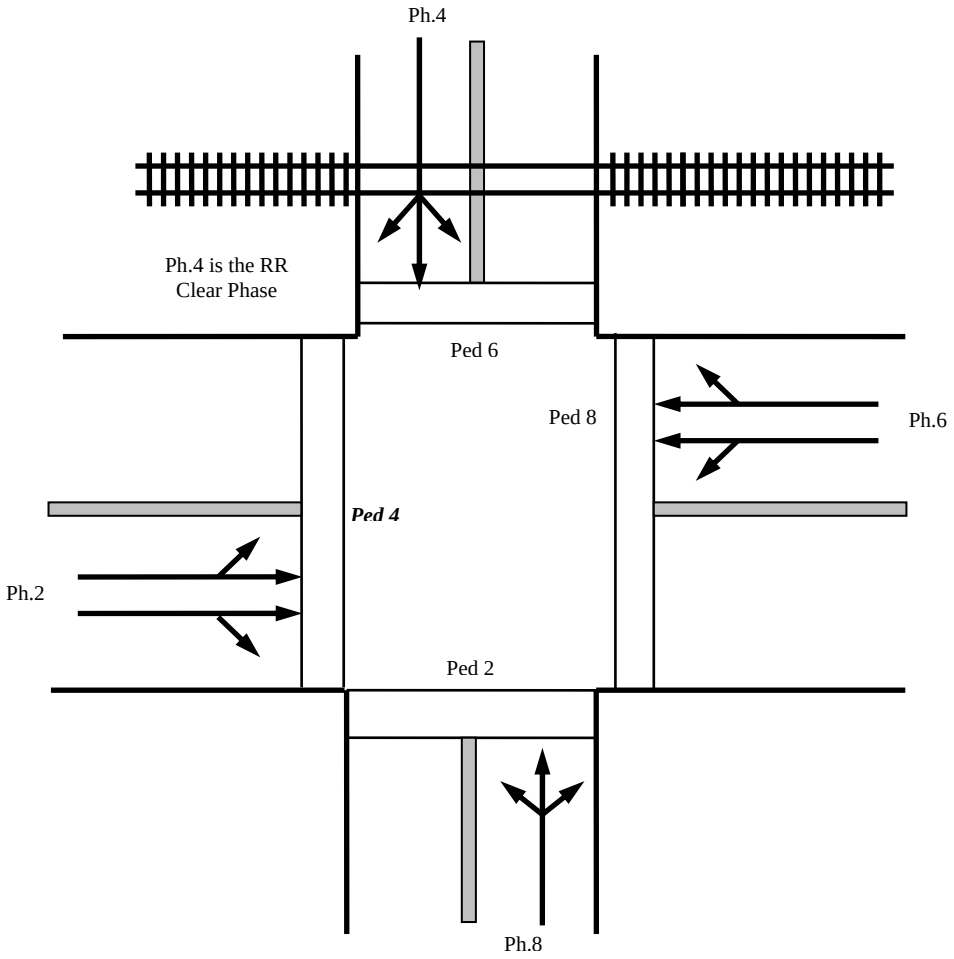
$$PCOI = FDW_2 = \frac{40 \text{ feet}}{4 \text{ feet/second}} = \textbf{10 seconds}$$

2. The **VCOI** is the greater of the time needed to clear the area between the tracks and the highway or the highest FDW minus the PCOI. Typically the VCOI if required, is not less than 8 seconds.

$$VCOI = FDW_8 - PCOI = (60/4) - 10 = 5 \text{ seconds; or}$$

$$VCOI = \left(\frac{100 \text{ feet}}{20 \text{ feet/vehicle}}\right) \text{ X } 2.0 \text{ seconds/vehicle} = 10 \text{ seconds} \quad \leftarrow \text{use } \textbf{10 seconds}$$

Appendix C - Continued
PCOI and VCOI Sample Calculation #2



In the above example, the distance between the railroad tracks and the stop location at the highway intersection is 50 feet. The crosswalk length for Ped 2 and Ped 6 is 40 feet and the crosswalk length for Ped 4 and Ped 8 is 100 feet.

1. The **PCOI** is determined by the flashing DON'T WALK interval time for either Ped 2 or Ped 6:

$$PCOI = FDW_2 = \frac{40 \text{ feet}}{4 \text{ feet/second}} = \textbf{10 seconds}$$

2. The **VCOI** is the greater of the time needed to clear the area between the tracks and the highway or the highest FDW minus the PCOI. Typically the VCOI if required, is not less than 8 seconds.

$$VCOI = FDW_8 - PCOI = (100/4) - 10 = 15 \text{ seconds; or}$$

$$VCOI = \left(\frac{50 \text{ feet}}{20 \text{ feet/vehicle}}\right) \text{ X } 2.0 \text{ seconds/vehicle} = 5 \text{ seconds} \quad \nwarrow \text{use } \textbf{15 seconds}$$ [5]

[5] In this example, when VCOI time is used to cover the completion of pedestrian clearance time, the display to the pedestrian will be a steady "DON'T WALK".

Appendix D
2003 MUTCD Oregon Supplements[6] Related to Railroads

4D.13 Preemption and Priority Control of Traffic Control Signals

Delete subsection "B" of "During the transition into preemption control:" in the Standard subsection and replace with the following:

Standard:

B. The shortening or omission of any pedestrian change interval shall be prohibited unless the shortening or omission results from an unexpected railroad or drawbridge preemption.

Insert the following at the end of the Standard subsection:

Support:

OAR 734-020-0320(4)(e) prohibits the termination of an active pedestrian or vehicular clearance interval by emergency preemption or bus priority

8A.01 Introduction

Insert the following at the beginning of the section:

Standard:

Authority to control and regulate the construction, alteration, and protection of railroad-highway crossings is vested exclusively in the state, and in the Department of Transportation as provided in ORS 824.200 to 824.256. Authority to alter, construct, or eliminate a highway-rail grade crossing, including all traffic control devices at the crossing, must be obtained from the State through the issuance of a crossing Order by the Rail Division of the Department of Transportation.

Insert the following at the end of the section:

Standard:

24. 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. The PCOI is initiated by the "advance preemption" provided by the railroad.

25. Vehicle Clear Out Interval (VCOI)—a traffic control 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). The VCOI is initiated by the "simultaneous preemption" provided by the railroad.

[6] The *2003 MUTCD* and *Oregon Supplements to the MUTCD* adopted July 2005 (OAR 734-020-0005).

Appendix D - Continued
2003 MUTCD Oregon Supplements Related to Railroads

Section 8B.02 Sizes of Grade Crossing Signs

Insert the following after the Standard subsection:

Standard:

The size of STOP (R1-1) and YIELD (R1-2) signs installed at highway-rail grade crossings shall be no less than listed in Table 2B-1 for a Conventional Road.

Section 8B.03 Highway-Rail Grade Crossing (Crossbuck) Sign (R15-1) and Number of Tracks Sign (R15-2)

Delete the Option subsection and insert the following:

Standard:

The supplemental Number of Tracks sign shall be used at highway-rail grade crossings with automatic gates.

Section 8B.04 Highway-Rail Grade Crossing Advance Warning Signs (W10 Series)

Delete the first Standard subsection and replace with the following:

Standard:

A Highway-Rail Grade Crossing Advance Warning (W10-1) sign (see Figure 8B-2) shall be used on each highway in advance of every Highway-Rail grade crossing.

Option:

A Highway-Rail Grade Crossing Advance Warning (W10-1) sign may be omitted in the following circumstances:

A. On an approach to a highway-rail grade crossing from a T-intersection with a parallel highway, if the distance from the edge of the track to the edge of the parallel roadway is less than 100 ft; or

B. On low volume, low speed highways where pavement markings are installed crossing minor spur tracks that are infrequently used if an engineering study indicates such installation would be of minimal benefit, and absence of the sign is authorized in a crossing Order; or

C. In business districts where active highway-rail grade crossing traffic control devices are in use and pavement markings are installed, if an engineering study indicates such installation would be of minimal benefit, and absence of the sign is authorized in a crossing Order; or

D. Where physical conditions do not permit even a partially effective display of the sign as determined by engineering judgment, pavement markings are installed, and absence of the sign is authorized in a crossing Order.

Standard:

Placement of the Highway-Rail Grade Crossing Advance Warning sign shall be in accordance with Figure 8B-6(OR).

Section 8B.08 STOP (R1-1) or YIELD (R1-2) Signs at Highway-Rail Grade Crossings

Add the following at the end of the Standard subsection:

Standard:

Authority to install STOP or YIELD signs at highway-rail grade crossings shall be obtained from the Rail Division of the Department of Transportation through the issuance of a crossing Order.

Section 8B.17 Low Ground Clearance Highway-Rail Grade Crossing Sign (W10-5)

Delete the Standard subsection and replace with the following:

Guidance:

Because this symbol might not be readily recognizable by the public, the Low Ground Clearance Highway-Rail Grade Crossing (W10-5) warning sign should be accompanied by an educational plaque, LOW GROUND CLEARANCE. The LOW GROUND CLEARANCE educational plaque should remain in place for at least 3 years after the initial installation of the W10-5 sign (see Section 2A.13).

Option:

When the Low Ground Clearance sign is authorized for installation in conjunction with the side road Advance Warning sign (W10-2, W10-3, or W10-4), the Low Ground Clearance sign or the educational plaque may be mounted on the same post, with the Low Ground Clearance sign or educational plaque located below the Advanced Warning sign.

Section 8B.20 Pavement Markings

Delete the entire Standard subsection and replace with the following:

Standard:

All highway-rail grade crossing pavement markings shall be retroreflectorized white. All other markings shall be in accordance with Part 3.

Pavement markings in advance of a highway-rail grade crossing shall consist of an X, the letters RR, a no-passing marking (two-lane highways where centerline markings are used), and certain transverse lines as shown in Figures 8B-6(OR) and 8B-7.

Identical markings shall be placed in each approach lane on all paved approaches to highway-rail grade crossings.

Delete Figure 8B-6 and replace with Figure 8B-6(OR)

Appendix D - Continued
2003 MUTCD Oregon Supplements Related to Railroads

Delete the first sentence of the Guidance subsection

Insert the following at the end of the section:

Option:

Pavement markings may be omitted at highway-rail grade crossings in the following circumstances:

A. The posted or statutory highway speed is 40 km/h (25 mph) or less; and

B. An advance warning sign is installed; and

C. An engineering study indicates that other installed devices provide suitable warning and control; and

D. The absence of the markings is authorized in a crossing Order.

Section 8B.21 Stop Lines

Insert the following at the beginning of the section:

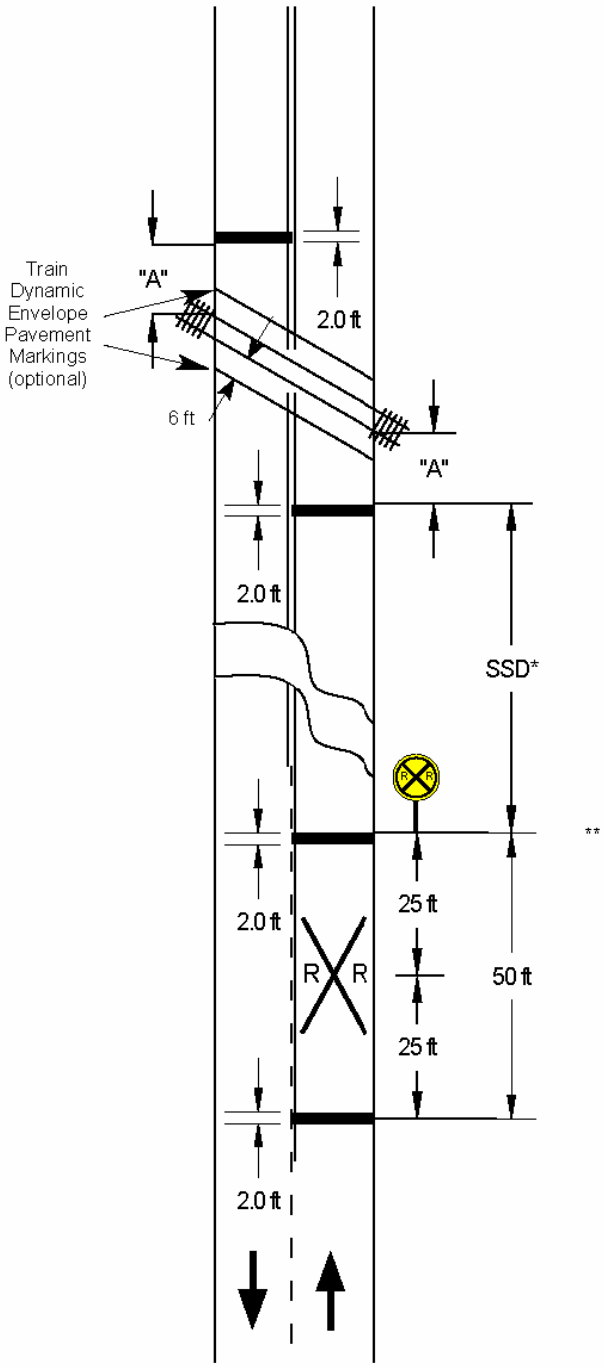
Standard:

Stop lines shall be placed at all highway-rail grade crossings as shown in Figure 8B-6(OR).

Delete the second sentence of the Guidance subsection

Appendix D - Continued
2003 MUTCD Oregon Supplements Related to Railroads

Figure 8B-6(OR). Example of Placement of Warning Signs and Pavement Markings at Highway-Rail Grade Crossings



A three-lane roadway should be marked with a centerline for two-lane approach operation on the approach to a crossing

On multi-lane roads, the transverse bands should extend across all approach lanes, and individual RXR symbols should be used in each approach lane.

** When used the toe of the pavement marking should be directly opposite the Advanced Warning Sign (W10-1). If needed, supplemental pavement marking symbol(s) may be placed between the Advance Warning Sign and the crossing, but should be at least 50 ft. from the stop line.

"A" Stop clearance line location is 12ft minimum from the nearest rail or 1ft in advance of the location where an automatic gate arm crosses the roadway

Note:
In an effort to simplify the figure to show warning sign and pavement marking placement, not all required traffic control devices are shown.

*Safe stopping distances (SSD) based on vehicle speed approaching grade crossings:

SPEED MPH	SSD FEET
15	80
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645

Legend
Direction of travel

Appendix D - Continued
2003 MUTCD Oregon Supplements Related to Railroads

Section 8D.02 Flashing-Light Signals, Post-Mounted

Delete the first Option subsection and replace with the following:

Standard:

Bells or other audible warning devices shall be included in the assembly and shall be operated in conjunction with the flashing lights to provide additional warning for pedestrians and bicyclists.

Section 8D.06 Train Detection

Delete the entire Option subsection

Section 8D.07 Traffic Control Signals at or Near Highway-Rail Grade Crossings

Insert the following at the end of the second Standard subsection:

Standard:

When a vehicle clear out interval (VCOI) is required, the indication for the clearance phases shall be green.

Advance railroad detection or other appropriate methods shall be used to provide a pedestrian clear out interval (PCOI) before the vehicle clear-out interval. This should be designed to minimize the occurrence of abbreviated pedestrian clearance intervals.

Appendix E
Railroad Preemption Timing Data for use in W4IKS program

The following locations are used to enter railroad preemption data for the W4IKS program:

Note	Sheet No.	Location	Parameter	Possible Values
2	2	E+9	Railroad Delay	0 to 255 seconds Typically 0
3	2	E+A	Railroad Minimum Time	0 to 255 seconds Typically 8 to 20
4	2	E+B	Railroad Clearance Phases	Call/Active Display 1-8
5	2	E+C	Railroad Permit - Phases	Call/Active Display 1-8
6	2	E+D	Railroad Permit - Overlaps	Call/Active Display 1-4 where 1 = OLA
7	2	D+5+E	Railroad Red Clear (length of all red after flashing red clearance)	0 to 255 seconds (not used)
1	2	D+5+F	Railroad Clear Color	0 = Green 1 = Flashing Yellow 2 = Flashing Red
2	3	9+6	Railroad Preemption Delay Type	1 = Hold 2 = Latch 3 = Hold & Latch
9	3	9+7	Pedestrian Inhibit Timer	0 to 255 seconds (not used)
8	6	E+F+0	Railroad Max 2	0 to 255 minutes

Appendix E - Continued
Railroad Preemption Timing Data for use in W4IKS program

1. Setting up railroad preemption should begin by designating the railroad preemption clearance color at location D+5+F on sheet 2. Typically clearance option "0" for green is used. An "all red" flash is also available if no clearance phases are identified as will be discussed later. The clearance color can be determined from the Railroad Preemption Matrix on the signal plan sheet by looking in the lower portion of the matrix labeled "Railroad Preemption Sequence". All traffic signal heads that face traffic crossing the railroad tracks will have the clearance color associated with their phase number shown in the second to last column in the matrix

2. The railroad delay time (sheet 2, location E+9) is usually set at zero. A possible application may exist where a railroad uses train speed predictor circuits that may go true momentarily then drop as a result of a slow train. A short delay time would prevent the controller from latching the call and running an unnecessary preemption. Values set here can be modified by the Preemption Delay Type assignment at location 9+6.

3. Railroad minimum time (location E+A) is that time that the track clearance phases, if any, will be serviced. This is also known as the Vehicle Clear Out Interval, VCOI, which begins at the start of "simultaneous preemption" from the railroad. This interval may be referred to as "track clearance time", "clearance time", or similar terminology in other firmware packages. During this clearance period if a flashing yellow clearance has been designated at location D+5+F (paragraph 1) an "extended output" will need to be assigned on timing sheet 13 to drive the fiberoptic sign informing motorists to "PROCEED ON FLASHING YELLOW". Railroad minimum time should always be fit to the location considering design elements and driver behavior. See the discussion on VCOI.

4. Railroad clearance phases are assigned at location E+B and are those that control vehicle movements crossing the tracks prior to entering the highway intersection. One or two phases can be designated. If two phases are assigned they **must** be concurrent. In some cases, usually involving external logic, the clearance phase may be a non-permitted phase. If no phases are designated, the controller will go immediately to the limited service (railroad permit) phases. If no permitted phases are designated the controller will go to an "all red" flash. If a Model 170 controller is activated while the railroad preemption is active, the output to all field lights will remain off. The controller keyboard will not function in such a situation and only the nine light on the call/active display will be illuminated.

5. Generally railroad permit phases (location E+C) are those which do not direct motor vehicles across the railroad tracks. These phases are also referred to as "limited service phases" and are identified in the note box on the return path in the preemption matrix.

Appendix E - Continued
Railroad Preemption Timing Data for use in W4IKS program

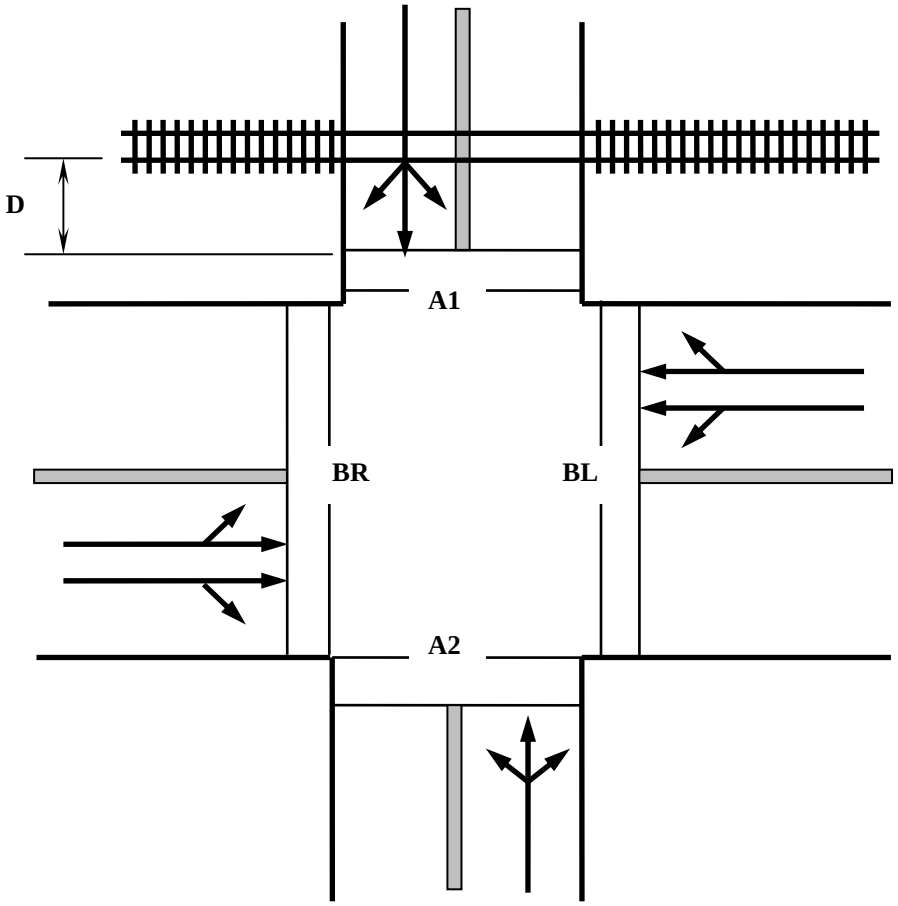
6. Permitted overlaps are assigned at location E+D where call/active lights 1 through 4 represent overlaps A through D respectively. Overlaps that have a parent phase designated as a railroad clearance phase and are also designated as a "permitted overlap" will display steady green if either flashing yellow ***or*** green clearance has been selected at D+5+F (see paragraph 1). If a flashing red clearance is selected, the overlap will display steady red during the preemption clearance period.

7. Location D+5+E is used to specify the length of steady "all red" vehicular clearance following an "all red" flashing period (0 to 255 seconds). *This is not used in Oregon*.

8. Location E+F+0 provides for automatically invoking Max 2 timing on all phases for a user-specified period of time following railroad preemption. This time is settable in one-minute increments up to 255 minutes. If a handicap pedestrian phase has been designated, Max 2 timing is not available and this location should be set to zero.

9. Location 9+7 provides for setting a timer which will maintain the pedestrian inhibit feature beyond the point when the railroad drops the call to the controller. *This timer is generally not used* since the railroad provides a constant, rather than intermittent call during Pedestrian Clear Out Interval (PCOI) or Advance Preemption Time (APT). The PCOI is calculated by ODOT using the methodology provided on page 2 and the worksheet on the following page. (Also refer to examples found in Appendix C.) The calculated value is provided to the railroad company installer who enters it into the railroad controller – not into the Model 170. The elements of a railroad active warning system are shown on page 9.

PCOI and VCOI Worksheet



1. The PCOI is determined by the longest flashing DON'T WALK interval time of either Ped A1, Ped A2, or if there is a separate left turn phase for vehicles clearing the crossing area, Ped BL:

$$\textbf{PCOI} = \textbf{FDW}_{\text{A1, A2 or BL}} = \frac{\text{feet}}{\textbf{4 feet/second}} = \boxed{\text{seconds}}^{7}$$

2. The VCOI is the **greater** of the time needed to clear the area between the tracks and the highway *or* the highest FDW minus the PCOI. Typically the VCOI, if required, is not less than 8 seconds.

2(a) $$\textbf{VCOI} = \left(\frac{\textbf{D in feet}}{\textbf{20 feet/vehicle}}\right) \textbf{X (2.0 seconds/vehicle)} = \frac{\textbf{D x 2.0}}{\textbf{20}} = \boxed{\text{seconds}}$$

OR

(See over)

[7] The PCOI time is provided to the railroad company for use in their controller.

Use PCOI value from Step 1 on other side:

2(b) **VCOI = $FDW_{BL \text{ or } BR}$ – PCOI =** $\dfrac{\text{feet}}{\text{4 feet/second}}$ **- PCOI =** **seconds** [8]

The VCOI calculated above in 2(b), if a positive value and greater than the value calculated in 2(a), should be used.

[8] When VCOI time is used to cover the completion of pedestrian clearance time, the display to the pedestrian will be a steady "DON'T WALK". The VCOI time is placed in the Model 170 Traffic Signal Controller.