TRAFFIC CONTROL DEVICES

GENERAL DISCUSSION

The purpose of traffic control at highway-rail grade crossings is to permit safe and efficient operation of rail and highway traffic over such crossings. Highway vehicles approaching a highway-rail grade crossing should be *prepared to yield and stop if necessary* if a train is at or approaching the crossing.

PASSIVE DEVICES

A passive highway-rail grade crossing is described as follows:

> **All highway-rail grade crossings having signs and pavement markings (if appropriate to the roadway surface) as traffic control devices that are not activated by trains**.

The following tables describe a variety of devices that can be used at a passive controlled highway-rail grade crossing, or supplement active devices. Table 5A are devices currently referenced in the 2000 MUTCD edition. Table 5B lists devices that are not currently proposed in the MUTCD, and any jurisdiction wishing to use these devices to experiment must request permission from the FHWA.

TABLE 5A - CURRENT MUTCD DEVICES

MUTC	Traffic Control	Application or Indication of Need
R15-1	CROSSBUCK sign	Required device
R15-2	“Multiple Tracks” sign	Standard device, with 2 or more tracks; optional with gate.
W10-1	Advance warning sign	Required device, with MUTCD exceptions
	RR Pavement Markings	All paved roads, with MUTCD exceptions
R1-1	STOP sign	As indicated in MUTCD reference 1993 memorandum.
W3-1, 1a	STOP AHEAD sign	Where STOP sign is present at crossing.
R1-2	YIELD sign	As indicated in MUTCD reference 1993 memorandum.
W3-2, 2a	YIELD AHEAD sign	Where YIELD sign is present at crossing.
R3-1, -2	Turn Restriction sign *	Use with interconnected, preempted traffic signals. Install on the nearby parallel highway to control turns toward the tracks.
R3-4	U-Turn Prohibition sign	Use in median of divided highways at highway-rail grade crossings to inhibit turning vehicles from using the track zone for illegal movement as necessary.
R4-1, W14-3	DO NOT PASS sign	Where passing near the tracks is observed.
R8-8	DO NOT STOP ON TRACKS sign	Where queuing occurs, or where storage space is limited between a nearby highway intersection and the tracks. May be supplemented with a flashing light activated by queuing traffic in the exit lane(s) from the crossing. (See discussion on Queue Cutters Signals.)
R8-9	TRACKS OUT OF SERVICE sign	Applicable when there is some physical disconnection along the railroad tracks to prevent train using those tracks.
R10-5	STOP HERE ON RED sign	Use with pre-signal and/or Stop Line pavement markings to discourage vehicle queues onto the track.
R10-11	NO TURN ON RED sign	Use with pre-signal and/or where storage space is limited between a nearby-interconnected traffic signal controlled intersection.
R15-3, W10-1	EXEMPT sign	School buses and those commercial vehicles that are usually required to stop at crossings are not required to do so where authorized by ordinance.
R15-4	Light Rail Transit Only Lane sign series	For multilane operations where roadway users might need additional guidance on lane use and/or restrictions.
R15-5, 5a	DO NOT PASS Light Rail Transit signs	Where vehicles are not allowed to pass LRT vehicles loading or unloading passengers where no raised platform physically separates the lanes.

R15-6, 6a	No Vehicles on Tracks signs	Used where there are adjacent vehicle lanes separated from the LRT lane by a curb or pavement markings.
R15 -7, 7a	DIVIDED HIGHWAY sign	Use with appropriate geometric conditions.
R15-8	LOOK, Supplementary sign	➢ Multiple tracks ➢ Collision experience ➢ Pedestrian presence
W10-2, 3, 4	Advance Warning Signs Series	Based upon specific situations with a nearby parallel highway.
W10-5	LOW GROUND CLEARANCE CROSSING sign	As indicated by MUTCD guidelines, incident history or local knowledge.
W10-8, 8a	TRAINS MAY EXCEED 80 MPH (130 KM/H) sign	Where train speed is 80 mph (130 km/h) or faster
W10-9	NO TRAIN HORN sign	Shall be used only for crossings in FRA-authorized quiet zones.
W10-10	NO SIGNAL sign	May be used at passive controlled crossings.
W10-11, 11a	Storage Space signs	Where the parallel highway is close to crossing, particularly with limited storage space between the highway intersection and tracks.
W13-1	“Advisory Speed” plate	➢ May be used with any advance warning sign where appropriate, e.g. advance warning, humped crossing, rough crossing, super-elevated track or other condition where a speed lower than the posted speed limit is advised.
I-12	Light Rail Station sign	Used to direct road users to a light rail station or boarding location.
I-13, 13a	Emergency Notification sign	Post at all crossings to provide for emergency notification.
	Dynamic Envelope Delineation, pavement markings	Where there is queuing or limited storage space for highway vehicles at a nearby highway intersection..
	Signs on both sides of highway	➢ For extra emphasis ➢ Multi lane ➢ One-way roads ➢ Curved approaches
	Increased retroreflectivity on highway signs	➢ Nighttime train operations.
	Roadway delineators, post-	➢ Frequent inclement weather ➢ Crossing narrower than approach pavement

	mounted on shoulders	➢ Isolated crossings ➢ May be used as an alternative to illumination
	Flashing lights on signs and lighted signs	➢ Presence of competing stimuli, “visual clutter” ➢ Restricted sight distance to the crossing ➢ High speed highway traffic approach ➢ Isolated crossing ➢ Heavy volume or queued traffic in advance of the crossing
	Overhead signs	➢ Multi-lane approach ➢ High speed highway approach ➢ If a sign cannot be placed on the roadside ➢ May be used as an alternative to the double signs
	Crossing illumination:	➢ Nighttime train operations ➢ Crossings are blocked for long periods ➢ Train speeds are low ➢ Nighttime collision experience ➢ Curved approach (vertical and horizontal curves) ➢ Frequent occurrence of fog or smoke.
	Stop and flag	➢ Railroad option, but may be considered by traffic engineer. ➢ Combination of low train frequency, short trains, high-volume highway traffic, multilane highway
TABLE 5B - NOT CURRENTLY PROPOSED IN THE MUTCD - *EXPERIMENTAL DEVICES*		
	SECOND TRAIN and other supplemental signs	➢ Multiple tracks ➢ Collision experience ➢ Pedestrian presence
	Buckeye	Among a number of special signs under current research.

HIGHWAY-RAIL GRADE CROSSING (CROSSBUCK) SIGNS

The MUTCD states, “The Highway-Rail Grade Crossing (R15-1) sign, commonly identified as the Crossbuck Sign, shall be retroreflectorized white with the words RAILROAD CROSSING in black lettering. As a minimum, one Crossbuck sign shall be used on each highway approach to every highway-rail grade crossing, alone or in combination with other traffic control devices. If automatic gates are not present and if there are two or more tracks at the highway-rail grade crossing, the number of tracks shall be indicated on a supplemental Number of Tracks (R15-2) sign of inverted T shape mounted below the Crossbuck sign in the manner and at the height indicated in the MUTCD.”

STOP and YIELD SIGNS

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) (Public Law 102-240; 105 Stat 1914; December 18, 1991) required that the FHWA revise the MUTCD to enable State or local governments to install STOP or YIELD signs at any passive highway-rail grade crossing where two or more trains operated daily. In response, the FHWA published a final rule in the Federal Register (57 FR 53029), which incorporated the new standards into the MUTCD. This final rule, published in March 1992, was effective immediately.

The FHWA and the FRA published a memorandum containing guidelines for when the use of STOP or YIELD signs is appropriate. According to the jointly-developed document, "it is recommended that the following considerations be met in every case where a STOP sign is installed: [1]"

1. Local and/or State police and judicial officials commit to a program of enforcement no less vigorous than would apply at a highway intersection equipped with STOP signs.
2. Installation of a STOP sign would not occasion a more dangerous situation (taking into consideration both the likelihood and severity of highway-rail collisions and other highway traffic risks) than would exist with a YIELD sign.

According to this memorandum, any of the following conditions indicate that the use of a STOP sign might reduce risk at a crossing:

1. Maximum train speeds equal, or exceed, 48 km/h (30 mph).
2. Highway traffic mix includes buses, hazardous materials carriers and/or large (trash or earth moving) equipment.
3. Train movements are 10 or more per day, five or more days per week.
4. The rail line is used by passenger trains.
5. The rail line is regularly used to transport a significant quantity of hazardous materials.
6. The highway crosses two or more tracks, particularly where both tracks are main tracks or one track is a passing siding that is frequently used.
7. The angle of approach to the crossing is skewed.

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[1] U.S. Department of Transportation; Federal Highway Administration; Federal Railroad Administration. 1993. Recommended Guidance for Stop and Yield Sign at Highway-rail Grade Crossings. Washington, DC. 3 p. [Attachment 2 to a July 8, 1993 memorandum from the Associate Administrator for Safety and Systems Applications, FHWA, and the Associate Administrator for Safety, FRA, to the FHWA Regional Administrators and the FRA Regional Directors of Railroad Safety.]

8. The line of sight from an approaching highway vehicle to an approaching train is restricted such that approaching traffic is required to substantially reduce speed.

The memorandum also states, however, that the above conditions should be weighed against the possible existence of the following factors:

1. The highway is other than secondary in character. Recommended maximum of 400 ADT in rural areas, and 1,500 ADT in urban areas.
2. The roadway is a steep ascending grade to or through the crossing, sight distance in both directions is unrestricted in relation to maximum closing speed, and heavy vehicles use the crossing.

A footnote in this joint document also states that "a crossing where there is insufficient time for any vehicle, proceeding from a complete stop, to safely traverse the crossing within the time allowed by maximum train speed, is an inherently unsafe crossing that should be closed."

ACTIVE DEVICES

An active highway-rail grade crossing is described as follows:

> **All highway-rail grade crossings equipped with warning and/or traffic control devices that gives warning of the approach or presence of a train.**

Due to the variables which should be considered, an engineering and traffic investigation is required to determine the specific application of active devices at any given highway-rail grade crossing. Guidance is provided in the following sections for the application of the many active traffic control system devices available for grade crossing design, in addition to various median treatments that can supplement these devices. The following is a list of active devices that can be considered for use at a highway-rail grade crossing. The first four commonly found at many grade crossings are designated as "standard devices."

STANDARD ACTIVE DEVICES

Flashing-Light Signal

A standard flashing-light signal consists of two red lights in a horizontal line flashing alternately at approaching highway traffic. At a crossing with highway traffic approaching in both directions, flashing-lights are installed facing oncoming traffic in a back-to-back configuration in accordance with the MUTCD. The support used for the lights should also include a standard crossbuck sign and, where there is more that one track, an auxiliary "multiple tracks" R15-2 sign. Back lights may be eliminated with one-way highway traffic, based on engineering judgment. An audible control device may be included.

Cantilever Flashing-Light Signal

This device supplements the standard flashing-light signal. Cantilever flashing-lights consist of an additional one or two sets of lights mounted over the roadway on a cantilever arm and directed at approaching highway traffic. Cantilevered lights provide better visibility to approaching highway traffic, particularly on multi-lane approaches. This device is also useful on high-speed two-lane highways, where there is a high percentage of trucks, or where obstacles by the side of the highway could obstruct visibility of standard mast mounted flashing-lights. An example is where the terrain or topography of the approaching highway is such that the sight of a roadside mounted signal light could not be readily seen by an approaching driver due to vertical or horizontal curves.

Cantilever flashing-light signals may be mounted back-to-back and should also have an additional crossbuck added to the overhead structure, based on site conditions and engineering judgment.

Automatic Gate

The automatic gate provides supplemental visual display when used with both road side mounted flashing-lights and cantilever flashing-light signals. The device consists of a drive unit and a gate arm. The drive mechanism can be mounted on flashing-light posts or cantilever pole supports, or on a stand-alone support. The gate arm is fully reflectorized on both sides with 45 degree diagonal red and white stripes and has at least three lights; the tip light is continuously lit and the others alternately flash when the gate is activated and lowered. When lowered, the gate should extend across approaching highway traffic lanes. Special consideration should be given to clearances for movement of the counter weight arm portion of the gate drive unit in a median and adjacent to sidewalk locations with pedestrians, particularly with the requirements of the Americans with Disabilities Act (ADA) of 1990.

Additional Flashing-Light Signals

Additional approaches to active highway-rail grade crossings require additional flashing-light signals be directed at the approaching traffic. These lights can be mounted on existing flashing-light masts, extension arms, additional traffic signal masts, cantilever supports, in medians or other locations on the left side of the roadway.

SUPPLEMENTAL ACTIVE DEVICES

Active Advance Warning Signs with Flashers

A train activated advance warning sign (utilizing the W-10 sign) should be considered at locations where sight distance is restricted on the approach to a crossing, and the flashing-light signals cannot be seen until an approaching driver has passed the decision point (the distance to the track from which a safe stop can be made).[2] Two yellow lights can be placed on the sign to warn drivers in advance of a crossing where the control devices are activated. The continuously flashing yellow "caution" lights can influence driver speed and/or provide warning for stopped vehicles ahead. An Advisory Speed Plate sign indicating the safe approach speed also should be posted with the sign.

If the advance flashers are connected to the railroad control circuitry, and only flash upon the approach of a train, they should be activated prior to the control devices at the crossing so that a driver would not pass a dark flasher and then encounter an activated flashing-light at the crossing. (Track circuits may need to be revised to handle this.) A few States use a supplementary message such as TRAIN WHEN FLASHING. In order to allow the traffic queue at the crossing time to dissipate safely, the advance flashers should continue to operate for a period of time after the active control devices at the crossing deactivate, as determined by an engineering study.

If such an advance device fails, the driver would not be alerted to the activated crossing controls. If there is concern for such failure, some agencies use a passive, RAILROAD SIGNAL AHEAD sign to provide a full time warning message. The location of this supplemental advance warning sign is dependant on vehicle speed and geometric conditions of the roadway.

Active Turn Restriction Signs

An active turn restriction sign (blank-out sign with internal illumination) displaying "No Right Turn" or "No Left Turn" (or appropriate international symbol) should be used in the following instances; on a parallel street within 15 m (50 ft) of the tracks where a turning vehicle from that parallel street could proceed around lowered gates; at a signalized highway intersection, where traffic signals at a nearby highway intersection are interconnected and preempted by the approach of the train, and all existing turn movements toward the grade crossing should be prohibited. These signs shall be visible only when the restriction is in effect.

MEDIAN SEPARATION

Despite the dangers of crossing in front of oncoming trains, drivers continue to risk lives and property by driving around crossing gates. At many crossings a driver is able to cross the center line pavement marking and drive around a gate with little difficulty. The numbers of crossing gate violations can be reduced by restricting driver access to the opposing lanes. Highway authorities have implemented various median separation devices, which have shown a significant reduction in the number of vehicle violations at crossing gates.

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[2] *Manual on Uniform Traffic Control Devices For Streets and Highways* - 2000 Edition. FHWA. Sections 2C.26 and 4K.01. Official website is http://mutcd.fhwa.dot.gov or 202-289-0222

There are limitations common to the use of any form of traffic separation at highway-rail grade crossings. These include restricting access to intersecting streets, alleys and driveways within the limits of the median and possible adverse safety effects. The median should be designed to allow vehicles to make left turns or U-turns through the median where appropriate, based on engineering judgment and evaluation.

BARRIER WALLS SYSTEMS

Concrete barrier walls and guardrails generally prevent drivers from crossing into opposing lanes throughout the length of the installation. In this sense they are the most effective deterrent to crossing gate violations. But, the road must be wide enough to accept the width of the barrier and the appropriate end treatment.[3] Sight restrictions for vehicles with low driver eye heights and any special need for emergency vehicles to make a U-turn maneuver should be considered (but not for the purpose of circumventing the traffic control devices at the crossing). Installation lengths can be more effective if they extend beyond a minimum length of 46 m (150 ft).

WIDE RAISED MEDIANS

Curbed medians generally range in width from 1.2 to more than 30 m (4 - 100 ft). While not presenting a true barrier, wide medians can be nearly as effective since a driver would have significant difficulty attempting to drive across to the opposing lanes. The impediment becomes more formidable as the width of the median increases. A wide median, if attractively landscaped, is often the most aesthetically pleasing separation method.

Drawbacks to implementing wide raised medians include availability of sufficient right-of-way, and maintenance of surface and/or landscape. Additions such as trees, flowers and other vegetation higher than .9 m (3 ft) above the roadway can restrict the drivers' view of approaching trains. Maintenance can be expensive depending on the treatment of the median. Limitation of access can cause property owner complaints, particularly for businesses. Non-mountable curbs can increase total crash rate and severity of accidents when struck by higher speed vehicles (>64 km/h [40 mph]).[4]

NON-MOUNTABLE CURB ISLANDS

Non-mountable curb islands are typically six to nine inches in height and at least .6m (2 ft) wide, and may have reboundable, reflectorized vertical markers.

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3 *Roadside Design Guide*. American Association of State Highway and Transportation Officials (AASHTO). Washington D.C.; 1996, www.aashto.org, 202-624-5801

4 Ibid.

Drivers have significant difficulty attempting to violate these types of islands because the six to nine inch heights cannot be easily mounted and crossed.

There are some disadvantages to be considered. The road must be wide enough to accommodate a two foot median. The increased crash potential should be evaluated. AASHTO recommends special attention be given to high visibility if such a narrow device is used in higher speed (>64 km/h [40 mph]) environments. [5] Care should be taken to assure that an errant vehicle cannot bottom-out and protrude into the oncoming traffic lane. Sight restrictions for low driver eye heights should be considered if vertical markers are installed. Access requirements should be fully evaluated, particularly allowing emergency vehicles to cross opposing lanes (but not for the purpose of circumventing the traffic control devices at the crossing). Paint and reflective beads should be applied to the curb for night visibility.

MOUNTABLE RAISED CURB SYSTEMS

Mountable raised curb systems with reboundable vertical markers present drivers with a visual impediment to crossing to the opposing traffic lane. The curbs are no more than six inches in height, less than twelve inches in width, and built with a rounded design to create minimal deflection upon impact. When used together, the mountable raised median and vertical delineators discourage passage. These systems are designed to allow emergency vehicles to cross-opposing lanes (but not for the purpose of circumventing the traffic control devices at the crossing). Usually such a system can be placed on existing roads without the need to widen them.

Because mountable curbs are made to allow emergency vehicles to cross, and are designed to deflect errant vehicles, they also are the easiest of all the barriers and separators to violate. Large, formidable vertical markers will inhibit most drivers. Care should be taken to assure that the system maintains its stability on the roadway with design traffic conditions, and that retro-reflective devices or glass beads on the top and sides of the curb are maintained for night visibility. Curb colors should be consistent with location and direction of traffic adjacent to the device.

OTHER BARRIER DEVICES

FOUR-QUADRANT TRAFFIC GATE SYSTEMS

Four-quadrant gate systems consist of a series of automatic flashing-light signals and gates where the gates extend across both the approach and

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[5] *A Policy on Geometric Design of Highways and Streets*. American Association of State Highway Transportation Officials (AASHTO). 2001 Edition., available at www.ite.org, or 202-289-0222 or www.aashto.org, 202-624-5801

departure side of roadway lanes. Unlike two-quadrant gate systems, four-quadrant gates provide additional visual constraint and inhibit nearly all traffic movements over the crossing after the gates have been lowered. At this time, only a small number of four-quadrant gate systems have been installed in the U.S., and incorporate different types of designs to prevent vehicles from being trapped between the gates.

VEHICLE ARRESTING BARRIER SYSTEM - BARRIER GATE

A moveable barrier system is designed to prevent the intrusion of vehicles onto the railroad tracks at highway-rail grade crossings. The barrier devices should at least meet the evaluation criteria for a NCHRP Report 350 (Test Level 2) attenuator; [6] stopping an empty: 4500-pound pickup truck traveling at 70 km/h (43 mph). However, it could injure occupants of small vehicles during higher speed impacts, and may not be effective for heavy vehicles at lower speeds.

Two types of barrier devices have been tested and used in the U.S.; vehicle arresting barriers and safety barrier gates.

The vehicle arresting barrier (VAB) is raised and lowered by a tower lifting mechanism. The VAB in the down position consists of a flexible netting across the highway approaches that is attached to an energy absorption system. When the netting is struck, the energy absorption system dissipates the vehicle=s kinetic energy and allows it to come to a gradual stop. This device was tested at three locations in the high-speed rail corridor between Chicago, IL and St. Louis, MO.

The safety barrier gate is a movable gate designed to close a roadway temporarily at a highway-rail crossing. A housing contains electro-mechanical components that lower and raise the gate arm. The gate arm consists of three steel cables, the top and bottom of which are enclosed aluminum tubes. When the gate is in the down position the end of the gate fits into a locking assembly that is bolted to a concrete foundation. This device has been tested to safely stop a pickup truck traveling at 72 km/h (45 mph) and has been installed in Madison, WI and Santa Clara County, CA.

A barrier gate could also be applied in those situations requiring a positive barrier e.g., in a down position, closing off road traffic and opening only on demand.

[6] National Cooperative Highway Research Program NCHRP Report 350. *Recommended Procedures for the Safety Performance Evaluation of Highway Features.* Transportation Research Board. National Research Council. Washington, DC: 1993, contact TRB at www.trb.org.

TRAIN DETECTION SYSTEMS

WARNING TIME AND SYSTEM CREDIBILITY

Reasonable and consistent warning times re-enforce system credibility. Unreasonable or inconsistent warning times may encourage undesirable driver behavior. Research has shown when warning times exceed 40-50 seconds, drivers will accept shorter clearance times at flashing lights, and a significant number will attempt to drive around gates.[7] Although mandated maximum warning times do not yet exist, efforts should be made to ensure traffic interruptions are reasonable and consistent without compromising the intended safety function of an active control device system's design. Excessive warning times are generally associated with a permanent reduction in the class of track and/or train speeds without a concomitant change in the track circuitry and without constant warning time equipment. When not using constant warning train detection systems, track approach circuits should be adjusted accordingly when train speeds are permanently reduced. Another frequent cause of excessive warning times at crossings without constant warning time equipment is variable speed trains, e.g., inter-city passenger trains or fast commuter trains interspersed with slower freight trains.

A major factor affecting system credibility is an unusual number of false activations at active crossings. Every effort should be made to minimize false activations through improvements in track circuitry, train detection equipment, and maintenance practices. A timely response to a system malfunction coupled with repairs made without undue delay can reduce credibility issues. Remote monitoring devices are an important tool.

Joint study and evaluation is needed between the highway agency and railroad to make a proper selection of the appropriate train detection system.

Train detection systems are designed to provide the minimum warning time for a crossing. In general, the MUTCD states that the system should provide for a minimum of 20 seconds warning time. When determining if the minimum 20 seconds warning time should be increased, the following factors should be considered:

- track clearance distances due to multiple tracks and/or angled crossings; (add one second for each 3 m [10 ft] of added crossing length in excess of 10.7 m [35 ft]);
- the crossing is located within close proximity of a highway intersection controlled by STOP signs where vehicles have a tendency of stopping on the crossing;

[7] *Warning Time Requirements at Railroad-Highway Grade Crossings with Active Traffic Control*. Report No. FHWA SA-91-007, Federal Highway Administration. Washington, DC: February 1991, www.fhwa.dot.gov.

- the crossing is regularly used by long tractor-trailer vehicles;
- the crossing is regularly used by vehicles required to make mandatory stops before proceeding over the crossing (e.g. school buses and hazardous materials vehicles);
- the crossing's active traffic control devices are interconnected with other highway traffic signal systems;
- provide at least 5 seconds between the time the approach lane gates to the crossing are fully lowered and when the train reaches the crossing, per 49 CFR Part 234;
- the crossing is regularly used by pedestrians and non-motorized components;
- where the crossing and approaches are not level and ;
- where additional warning time is needed to accommodate a four-quadrant gate system.

INTERFERENCE / INTEGRITY OF ACTIVE TRAFFIC CONTROL DEVICE SYSTEMS

Interference with normal functioning of an active control device system diminishes the driver's perception of the integrity of the system. Interference can result from, but is not limited to, trains, locomotives or other railroad equipment standing within the system's approach circuit, and testing or performing work on the control device systems or on track and other railroad systems or structures. The integrity of the control device system may be adversely affected if proper measures are not taken to provide for safety of highway traffic when such work is underway. It is important that Railroad employees are familiar with Federal regulations and railroad procedures which detail measures to be taken prior to commencing activities, which might interfere with track circuitry.

TYPE OF DETECTION SYSTEM

DC, AC-DC or AFO Grade Crossing Island and Approach Circuits:

These basic train detection circuits use a battery or transmitter at one end of a section of track and a relay, receiver or diode at the other end. A train on the section of the affected track will shunt the circuit and de-energize the relay. This type of system will continue to operate until the train leaves the circuit.

Motion Sensitive Devices (MS)

A type of train detection (control) system for automatic traffic control devices that has the capability of detecting the presence and movement of a train within the approach circuit of a crossing. MS devices will activate the traffic control devices at the crossing for all trains located within the approach circuit that are moving toward the crossing, regardless of train speed. If a train stops within the approach circuit before reaching the crossing, the traffic control devices will deactivate until the train resumes motion toward the crossing, but will remain deactivated if the train retreats beyond the detection circuit.

Constant Warning Time (CWT) Systems

A constant warning time system has the capability of sensing a train as it approaches a crossing, measuring its speed and distance from the crossing, and activating the traffic control devices to provide the desired warning time. Traffic control systems equipped with CWT provide relatively uniform warning times where train speeds vary and trains do not accelerate or decelerate within the approach circuits once the devices have activated. Trains may perform low speed switching operations beyond 213 m (700 ft) from a crossing without causing the crossing devices to unnecessarily activate. This reduces or eliminates excess gate operation that in turn, causes unnecessary delays to highway traffic. Like motion sensitive systems, if a train stops within the approach circuit before reaching the crossing the traffic control devices will deactivate.

RAILROAD TRAIN DETECTION TIME AND APPROACH LENGTH CALCULATIONS

It should be noted that even when "constant warning devices" are used, the calculated arrival time of the train at the crossing is based on the instantaneous speed of the train as it enters the crossing circuit. Once the calculation is made, changes in train speed will change train arrival time at the crossing and correspondingly reduce (or increase) the elapsed warning time at the crossing. This factor must be considered at a crossing interconnected to a nearby highway traffic signal utilizing either a simultaneous or advance preemption sequence.

Design information about railroad interconnection circuits and approach length calculations can be found in the American Railway Engineering and Maintenance-of-Way Association (AREMA) Signal Manual[8], Manual Part 3.1.10, *Recommended Functional/Operating Guidelines for Interconnection Between Highway Traffic Signals and Highway - Rail Grade Crossing Warning Systems*; and Manual Part 3.3.10, *Recommended Instructions for Determining Warning Time and Calculating Minimum Approach Distance for Highway-Rail Grade Crossing Warning Systems*.

PREEMPTION/INTERCONNECTION:

WHEN TO INTERCONNECT

The guidance in the MUTCD states: "When a highway-rail grade is equipped with a flashing-light signal system and is located within 60 m (200 ft) of an intersection or mid-block location controlled by a traffic control signal, the traffic control signal should be provided with preemption in accordance with Section 4D.13." Recent studies indicate that when designing for the installation of a new traffic control signal substantially beyond 60 m (200 ft) (possibly 152-305m [500-

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8 American Railway Engineering and Maintenance-of-Way Association (AREMA) Signal Manual, Manual Part 3.1.10 is available at the following URL： http://www.arema.org/pubs/pubs.htm

1000 ft]) of a highway-rail grade crossing, an estimate of the expected queue length should be performed. For estimation purposes, a 95% probability level should be used. If the resulting expected queue length is equal to or greater than the available storage distance, consideration should be given to interconnecting the traffic control signal with the active control system of the railroad crossing and providing a preemption sequence. Guidance on estimating queue length is available in the article, “Design Guidelines for Railroad Preemption at Signalized Intersections,” *ITE Journal*, February 1997. Guidance on the design of preemption operation is available in *Preemption of Traffic Signals At or Near Railroad Grade Crossings with Active Warning Devices*, #RP-025A, Institute of Transportation Engineers, 1997 www.ite.org or 202-289-0222; and the *Implementation Report of the USDOT Grade Crossing Safety Task Force, June 1, 1997, U.S. Department of Transportation*, www.fhwa.dot.gov. The *Implementation Report* is an excellent source of definitions.

FACTORS TO CONSIDER

Joint Agency Coordination

Close coordination between the highway agency and the railroad company is required when interconnecting a traffic signal with active railroad traffic control devices. In order to properly design the highway-rail preemption system, both the railroad company and the highway agency should understand how each system operates. An engineering study should be conducted at each interconnected location to
determine the minimum preemption warning time necessary to adequately clear traffic from the crossing in the event of an approaching train. Factors that need to be considered when calculating this time are equipment response and programmed delay times, minimum traffic signal green times, traffic signal vehicular and pedestrian clearances, queue clearance times and train/vehicle separation time.

Extended Advance Warning Times

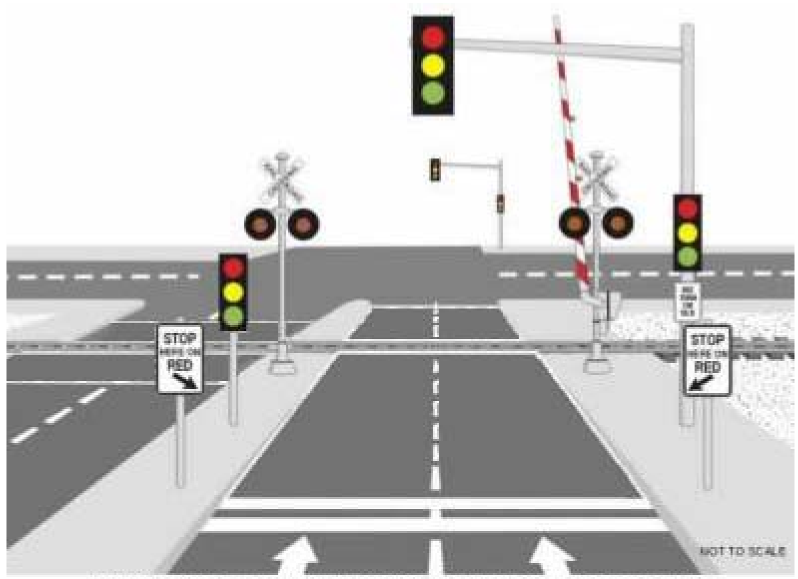
Whenever it becomes necessary at gated crossings to provide design advance warning times in excess of 45 seconds, whether for traffic signal preemption or other purposes, consideration should be given to including supplemental median treatments to discourage drivers from attempting to circumvent the gates.

Second Train Circuitry at Multiple Track Crossings

At multiple track crossings, “second train” circuitry can be considered as part of the control network. This circuitry is intended to detect a second train approaching the crossing, but outside the normal warning time approach circuit. For instance, the normal approach circuit may provide 25 seconds warning but the second-train circuit may look an additional 10 seconds. If a train activates a train activates the traffic control devices AND a second train is detected within the 35-second circuit, the gates will be held down for the second train and the traffic signals remain preempted. (Also see Traffic Signal Controller Re-Service Considerations in the Preemption/Interconnection Appendix.)

Diagonal Railroad Crossing Both Highway Approaches to the Intersection

Where the railroads run diagonally to the direction of the highway, it is probable that the railroad may cross two highway approaches to an interconnected intersection. When this situation occurs, it is normally necessary to clear out traffic on both roadways prior to the arrival of the train, requiring approximately twice the preemption time computed for one approach. It is also normally required to have both railroad active traffic control device systems designed to operate concurrently. This is needed to prevent the interconnected traffic signals and railroad active control devices from falling out of coordination with each other which otherwise can occur under certain types of train movements or when one of the two crossings experiences a false signal activation prior to an actual train movement. When the railroad control devices activate, traffic leaving the intersection and approaching either crossing may queue back into the intersection and block traffic if there is not adequate storage for those vehicles between the crossing and the intersection. Traffic turning at the intersection toward the other crossing may also be unable to proceed due to stopped traffic.



PRE-SIGNAL LOCATION AT AUTOMATIC GATE CROSSING
FIGURE 4

When this occurs, utilization of advance preemption together with a hybrid design may help alleviate this problem. The hybrid design could consist of delaying the activation of the railroad devices facing vehicles leaving the intersection and approaching both crossings to help vehicles clear out of the intersection during the preemption sequence.

Pre-Signals

Pre-signals control traffic approaching the highway-rail grade crossing toward the nearby highway intersection, and are operated as part of the highway intersection traffic signal system. Their displays are integrated into the railroad preemption program. A diagram of a pre-signal is shown as Figure 4.

Figure 4
This figure depicts the location of a pre-signal at an automatic gate crossing. In the foreground of the figure is the away-going side of a divided highway. The road crosses a railroad track and a little further, intersects another road. At the intersection of the two roads, there is a traffic-control signal. The crossing is equipped with lights and an automated crossarm. Prior to the railroad crossing is another traffic-control signal and a double white line where vehicles are to stop. The signal and lines are designed to prevent a line of vehicles forming at the highway-highway intersection that would back up onto the railroad tracks. On either side of the road at the double white line is a sign that reads "STOP HERE ON RED," with and arrow pointing to the double white line.

An engineering study should be made to evaluate the various elements involved in a pre-signal. These are summarized as follows.

> Where the highway intersection is less than 15m (50 ft) from the highway-rail crossing (23m [75 ft] for a roadway regularly used by multi-unit vehicles), pre-signals should be considered. Where the clear storage distance is greater than 23 m (75 ft), pre-signals could be used, subject to an engineering study determining that the queue extends into the track area.
>
> Without pre-signals at highway-rail grade crossings, drivers may focus on the downstream highway traffic signal indications rather than the flashing-light signals located at the grade crossing. This type of driver behavior is especially undesirable during the beginning of the preemption sequence when the downstream traffic signals are typically green (in order to clear queued vehicles off the tracks) and the flashing-light signals are activated.
>
> Driver behavior at crossings equipped with pre-signals is modified because the driver stops at the railroad stop line even when a train is not approaching. By providing a consistent stopping location, with or without the presence of a train, the driver will not become confused as to a safe location to stop when a train is approaching.
>
> Where geometric considerations in advance of the crossing complicate the installation of a pre-signal on a separate support in front of the railroad signal, the placement of railroad flashing-light signals and traffic signals on the same support should be considered to reduce visual clutter and to increase driver visibility of the pre-signals. A written agreement between the highway agency and railroad may be required.
>
> The pre-signal phase sequencing should be progressively timed with an offset adequate to clear vehicles from the track area and downstream intersection. Vehicles that are required to make a mandatory stop (e.g.,

school buses, vehicles hauling hazardous materials, etc.) should be considered when determining the amount of time for the offset to ensure that they will not be forced to stop in the clear storage area.

For highway-rail grade crossings equipped with a pre-signal and clear storage distance less than 15 m (50 ft), (23 m [75 ft] for a roadway regularly used by multi-unit vehicles), a clear zone between the crossing and the downstream intersection may be diagonally striped to delineate the clear storage area.

The downstream traffic signal at the highway intersection controlling the same approach as the pre-signal should be equipped with programmable visibility indications or louvers. The downstream heads should only be visible from within the down stream intersection to the driver eye location of the first vehicle behind the pre-signal stop bar. Design of the visibility limited indications is quite complex and should consider a range of driver eye heights for the various vehicles expected on the roadway.

Long Distance between the Highway-Rail Crossing and the Highway Intersection

In cases where the crossing is located far from the highway intersection -- up to 305 m (1000 ft), the necessary minimum preemption warning time may be very high and in turn may require very long approach circuits along the tracks in order to provide such a time. Long track circuits can become extremely complex and expensive to implement, especially if located in an area where there are several adjacent crossings with overlapping track circuits, switching spurs, railroad junctions or commuter rail stations which could affect train operating speeds within the detection circuit. In addition, excessive preemption times may have detrimental effects on traffic flows within the vicinity of the crossing and may cause other problems such as traffic backing up along a route parallel to the crossing and backing up through another adjacent interconnected intersection. These are just a few factors to consider with a long distance interconnection.

Queue Cutter Flashing-light Beacon

An alternative to interconnecting the two traffic control devices may be the use of an automated Queue Cutter Flashing-light Beacon upstream of the highway-rail grade crossing. They may be utilized in conjunction with DO NOT STOP ON TRACKS (R8-8) as stated in the MUTCD signs. Such beacons can be activated by an induction loop on the departure side of the highway-rail grade crossing that detects a growing queue between the crossing and the distant highway intersection. If the beacons are activated only when the traffic signals on that approach are not green, they can be more effective as opposed to flashing all the time.

These are some of the many factors that should be considered when interconnecting an active traffic control device at a highway-rail grade crossing to a nearby highway traffic signal. A separate Preemption/Interconnection appendix is included with this report to provide further explanation of this very complex subject. However, it is not the intent of this document to serve as a primer for this very complicated topic. It cannot be emphasized enough that design, construction, operation and maintenance of this type of system requires expert knowledge and full cooperation between highway and railroad authorities. Other special conditions are discussed in the following section.

Also See Appendix for additional information

OTHER SPECIAL CONDITIONS

POTENTIAL QUEUING ACROSS TRACKS

Where queuing across a highway-rail grade crossing is occasioned by a nearby highway intersection that is not equipped with a traffic signal, the traffic engineer has a number of options including:

1) Install a DO NOT STOP ON TRACKS sign;
2) Install an automated Queue Cutter Flashing-light Beacon (see prior discussion in “Factors to Consider”); and/or;
3) Install a traffic signal with railroad preemption at the highway/highway intersection.

Queues extending over the highway-rail grade crossing could be considered a possible need for the installation of a traffic signal at the nearby highway intersection. However, the third option needs to be considered very carefully considering the harmful effects of an otherwise unwarranted traffic signal.

TRAIN AND LIGHT RAIL TRANSIT (LRT) ACTIVATED HIGHWAY TRAFFIC SIGNALS

Urban city streets often pose a special case for the application of active grade crossing traffic control devices. Slow speed switching moves and mixed-use light rail transit (LRT) operations are often controlled by traffic signals. In such cases, traffic signal heads must be clearly visible to the train operator. Trains must stop short before entering these intersections. Train detection can be accomplished by the use of island track circuits, key selector switches, inductive loops, train to way-side communications and other technologies.

Where LRT vehicles move within the street median or through the intersection of two or more city streets, and where train operating speeds and sight distances are consistent with safe stopping distances, the train may operate through these intersections controlled by traffic signal indications without stopping. In such cases, special transit signal aspects, which clearly indicate traffic signal controlled right-of-way, must govern train moves. Special transit indications may also provide information concerning track alignment to the transit operator. Automatic train stops and other train control devices may be used to enforce a train=s compliance with the signal indication. Where special train aspects are present and safe stopping distance is assured, transit vehicles may utilize train to way-side communications, inductive loops, cantenary detector switches or other forms of detection to activate the traffic signals. Great care should be exercised in the location of special train indicators to avoid confusion to drivers approaching the intersection. Programmed heads and special aspects are helpful in this regard.

(SECOND) TRAIN COMING ACTIVE WARNING SIGN

Train detection systems can also be used to activate a "2nd Train Coming" supplemental warning sign. This sign is used on a limited basis, normally near commuter stations where multiple tracks and high volumes of pedestrian traffic are present. The sign will activate when a train is located within the crossing's approach circuits and a 2nd train approaches the crossing. It is also being evaluated at multiple track highway-rail grade crossings as a supplement to automatic gates. (Since this sign is not currently in the MUTCD, any jurisdictions wishing to use symbols to convey any part of this message, must request permission to experiment from the FHWA.)

PEDESTRIAN AND BICYCLIST CONSIDERATIONS

Non-motorist-crossing safety should be considered at all highway-rail grade crossings, particularly at or near commuter stations and at non-motorist facilities, such as bicycle/walking trails, pedestrian only facilities, and pedestrian malls.[9]

Passive and active devices may be used to supplement highway related active control devices to improve non-motorist safety at highway-rail crossings. Passive devices include fencing, swing gates, pedestrian barriers, pavement markings and texturing, refuge areas and fixed message signs. Active devices include flashers, audible active control devices, automated pedestrian gates, pedestrian signals, variable message signs and blank out signs.

These devices should be considered at crossings with high pedestrian traffic volumes, high train speeds or frequency, extremely wide crossings, complex highway-rail grade crossing geometry with complex right-of-way assignment, school zones, inadequate sight distance, and/or multiple tracks. All pedestrian facilities should be designed to minimize pedestrian crossing time and devices should be designed to avoid trapping pedestrians between sets of tracks.

Guidelines for the use of active and passive devices for Non-motorist Signals and Crossings are found in section 10D of Part 10 of the MUTCD.

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9 *Traffic Control Devices Handbook*. Institute of Transportation Engineers. Washington, D.C.: 2001. Section 13.2.12, Railroad and Light Rail Transit Grad Crossings , www.ite.org or 202-289-0222.