Use of Pre-Signals in Advance of a Highway-Rail Grade Crossing: A Specialized Tool with Specific Applications

THE U.S. HIGHWAY SYSTEM FREQUENTLY SHADOWS THE EXISTING RAILROAD NETWORK, RESULTING IN NUMEROUS HIGHWAY-RAIL GRADE CROSSINGS CLOSE TO HIGHWAY INTERSECTIONS. HIGHWAY TRAFFIC SIGNALS ARE USED WITH ACTIVE WARNING DEVICES AT SOME OF THESE CROSSINGS. IN SOME CASES, THE HIGHWAY SIGNAL HAS BEEN INSTALLED IN FRONT OF THE RAILROAD WARNING DEVICES. THIS IS KNOWN AS A PRE-SIGNAL.

BACKGROUND
As the U.S. highway network has grown in response to residential and commercial land development patterns, much of this network growth has occurred along existing railroad corridors. These railroad corridors were constructed between population centers; in some cases, railroad junctions themselves were the impetus behind the establishment of industrial facilities and the necessary worker communities that followed commercial enterprise.

This tendency for the expanding highway system to shadow the existing railroad network has resulted in the creation of numerous high-way-rail grade crossings that are close to highway intersections. As highway traffic volumes have increased over many years, certain configurations of grade crossings in proximity to highway intersections have emerged. This has resulted in the use of highway traffic signals in conjunction with active warning devices at some of these grade crossings.

Interconnected, Preempted Signals
The most typical installation places highway traffic signals near the downstream highway intersection and beyond the active warning devices, usually on separate structures. This practice normally requires special traffic signal preemption sequences and interconnection with railroad active controls to ensure that vehicles are not stopped within the crossing when the railroad warning devices are activated.

Pre-Signals
In some cases, highway signals have been installed in front of railroad warning devices. This type of installation, which serves to stop traffic before it crosses the railroad, now is commonly known as a pre-signal. The purpose of installing highway traffic signals in this manner at a crossing is to prevent vehicles from queuing across the grade crossing and finding themselves stopped on the tracks in the area now known as the minimum track clearance distance.

Other Supplemental Active Warning Devices
Other types of supplemental active warning devices include active advance warning signs with flashers, which often are used in advance of a crossing that cannot readily be seen by drivers on approach to the crossing until after the driver has passed the decision point where a “stop or go” decision must be made. In urban or arterial situations, a blank-out turn restriction sign may be used.

DEVELOPMENT OF PRE-SIGNALS
Differing names or descriptions were given to early pre-signal installations, such as double clearance signals; signals before the tracks; and overlap signals, among others. Previously, there were no broadly accepted guidelines for the use of these specialized signals.

In June 1997, a U.S. Department of Transportation task force established industry-standard definitions relating to the interconnection of highway traffic signals with highway-rail grade crossing warning systems. In this report, the term “pre-signals” was defined as: “Supplemental highway traffic signal faces [that are] operated as a part of the highway intersection traffic signals, [and are] located in a position that controls [highway] traffic approaching the railroad crossing and intersection.”

Pre-signals control the movement of highway traffic as it approaches the grade crossing in the direction of the down-
stream highway intersection. The timing and displays of these highway traffic signals are integrated with the railroad's preemption program.

The Federal Highway Administration's (FHWA) Guidance on Traffic Control Devices at Highway-Rail Grade Crossings illustrates a typical installation of pre-signals at a gated crossing. The illustration depicts the elements common to the pre-signal installations that normally are encountered.²

**IMPLEMENTATION OF PRE-SIGNALS TO NOW**

In general, the installation and operation of pre-signals has been based upon established local practices for highway traffic signals and highway-rail grade crossing devices, without a national standard emerging over time. Several leading organizations have worked in this area. Their issuance of selected standards, guidance, or recommended practices has started to recognize the problems that pre-signals may be particularly effective in mitigating.

**CURRENT STANDARDS AND PREVAILING GUIDANCE FOR THE USE OF PRE-SIGNALS**

Through the publication of the Manual on Uniform Traffic Control Devices (MUTCD) Part 4 (Highway Traffic Signals); Part 8 (Traffic Controls for Highway-Rail Grade Crossings); and Part 10 (Traffic Controls for Highway-Light Rail Transit Grade Crossings), FHWA has taken crucial first steps in coalescing the fragmented national experience to date into some useful commonality of practice and theory for the use of pre-signals.³ MUTCD Section 4D.15 (Size, Number, and Location of Signal Faces by Approach) establishes the standards for traffic signal faces that shall be satisfied by any installation of pre-signals. Specifically, Section 4D.15 states as a standard that signal faces for the major movement on the approach shall be located not less than 12 meters (m), or 40 feet (ft.), beyond the stop line.

Table 4D-1 contains the required minimum sight distance for a range of 85th-percentage approach speeds. If these minimums cannot be met on an approach, a sign shall be installed to warn approaching traffic of the traffic control signal.

In Section 8D.07 (Traffic Control Signals at or Near Highway-Rail Grade Crossings), MUTCD lays out a framework of standards, guidance and options for the use of pre-signals. The standards for pre-signals found in Section 8 are as follows:

"If used, the pre-signals shall display a red signal indication during the track clearance portion of a signal preemption sequence to prohibit additional vehicles from crossing the railroad track.

"If a pre-signal is installed at an interconnected highway-rail grade crossing near a signalized intersection, a STOP HERE ON RED (R10-6) sign shall be installed near the pre-signal or at the stop line if used. If there is a nearby signalized intersection with insufficient clear storage distance for a device, or the highway-rail grade crossing does not have gates, a NO TURN ON RED (R10-11) sign shall be installed for the approach that crosses the railroad track."⁴

Current guidance states that pre-signals may be used at a highway-rail grade crossing that is within 50 ft. of a signalized intersection. In the event that multi-unit vehicles regularly use the grade crossing, that 50-ft. separation distance may be increased to 75 ft. If, however, a grade crossing is more than 75 ft. away, pre-signals still may be used if an engineering study or a diagnostic team review determines a need.

The use of visibility-limited signal faces (faces that are shielded, hooded, louvered, or otherwise restricted in angle of visibility to approaching road users) should be considered for the downstream signal faces at the intersection that controls the approach to be equipped with pre-signals.

The option is offered to time the pre-signals with an offset from the signalized intersection; this would keep vehicles from occupying either the roadway area between the gates or the area between the grade crossing and the downstream signalized intersection. This option should be explored during a field review by the diagnostic team prior to the design and installation of the pre-signals.

In 2004, the Institute of Transportation Engineers (ITE) issued a Recommended Practice prepared by Traffic Engineering Council Committee TENC-99-06, “Preemption of Traffic Signals Near Railroad Crossings.” Under Section II (Design Elements), the following discussion of pre-signals and their design and implementation is included: "Pre-signals can be located to stop vehicular traffic before the railroad crossing where the clear storage distance (measured between 6 ft. (2 m) from the rail nearest the intersection to the intersection stop line or the normal stopping point on the highway) is 50 ft. (15 m) or less. At approaches where high percentages of multi-unit vehicles are evident, the distance should be increased to 75 ft. (23 m). A vehicle classification study should be conducted to determine the types of vehicles using the crossing.

"Where the clear storage distance is greater than 50 ft. (15 m) or 75 ft. (23 m), depending on the roadway vehicle design length, but less than 120 ft. (37 m), pre-signals can be used only after an engineering study determines that the queue extends into the track area."
"If the clear storage distance is greater than 120 ft. (37 m), any traffic signal heads located at a railroad crossing should be considered to be a separate mid-block crossing (a "queue-cutter" signal), and not a pre-signal. However, coordination with the intersection signals may still be appropriate.

Pre-signals or queue-cutter signals should also be used wherever traffic could queue across the tracks and railroad warning devices consist only of flashing light signals. However, this can result in conflicting signal indications between the flashing red lights at the crossing and a display of track clearance green beyond the crossing. The installation of gates will eliminate this conflict.

1. Pre-Signal Location

Pre-signal mast arm poles can be located upstream or downstream from the railroad crossing. In all cases, pre-signal poles must be located to maintain visibility of the railroad flashing lights. If an existing railroad cantilever exists and upstream pre-signals are used, the heads may be mounted on the cantilever if permitted by the railroad or regulatory agency. If they are on a separate mount they must be located to avoid blockage or interference with the visibility of the railroad flashing lights. Railroad flashing lights should be located as specified in Chapter 8D of the MUTCD. Refer also to AREMA Communications and Signal Manual Parts 3.1.36 and 3.1.37 for additional guidance regarding the location of railroad warning devices.

To comply with the MUTCD, there should be a minimum of two pre-signal faces at the crossing. If the pre-signal faces are located upstream of the crossing, it may not be possible to have both signal faces located more than 40 ft. beyond the stop line unless the stop line is relocated. One of the pre-signal faces should be located on the right side of the road. A pre-signal located in the roadway median should be mounted at a minimum of 4 ft. 6 in. (1.4 m) above the median island grade, but below any railroad flashing lights.

2. Downstream Signal

The downstream traffic signal faces at the roadway intersection that control the same approach as the pre-signal may be equipped with programmable-visibility heads or louvers as appropriate based on an engineering study. The purpose of the signal programmable-visibility heads or louvers is to limit visibility of the downstream signal faces to the area from the intersection stop line to the location of the first vehicle behind the pre-signal stop line. This is to prevent vehicles stopped at the railroad crossing stop line from seeing the distant green signal indication during the clear track green. An engineering study should be conducted to review the specific site conditions, including the eye heights of drivers of vehicles likely to use the crossing, and establish the final design necessary to meet the visibility requirements.

3. Pre-Signal and Downstream Signal Operation

The pre-signal intervals should be progressively timed with the downstream signal intervals to provide adequate time to clear vehicles from the track area and the downstream intersection. Vehicles that are required to make a mandatory stop such as school buses, vehicles hauling hazardous materials, etc., should be considered when determining the progressive timing to ensure that they will not be stopped within the minimum track clearance distance (see Appendix C). Where the clear storage distance is inadequate to store a design vehicle clear of the minimum track clearance distance and crossing gates are present, consideration should be given to installation of vehicle detection within the clear storage distance to prevent vehicles from being trapped within the minimum track clearance distance by extending the clear track green interval."

**PRE-SIGNAL OR QUEUE CUTTER?**

It is valuable to remember that although a queue cutter signal may in many ways resemble a pre-signal, it differs in certain ways. A signal should be used as a queue cutter when the clear storage distance exceeds 120 ft. and the traffic signal uses downstream vehicle detection to change the signals to red when the standing queue from the downstream signal is about to extend into the minimum track clearance distance.

Such a queue cutter signal will be interconnected for simultaneous preemption and may or may not function as a part of the downstream intersection signal system. A field analysis and review should be conducted sufficient to determine whether to pursue coordination of the queue cutter with the downstream intersection signals.

**OVERCOMING RESISTANCE TO PRE-SIGNALS**

Some traffic engineers may be reluctant to use pre-signals because they believe that vehicles stopped upstream from the crossing at the pre-signal will be prevented from being able to advance to the highway intersection and turn right on red. The temporary loss of flow due to right turn on red being precluded during the presence of a train is outweighed by the reduction in the potential for a severe collision between a stopped vehicle and a train.

Unfortunately, the opportunity for this type of accident is frequent when
viewed on a national basis. In addition, the capacity lost from right turns on red often can be recaptured by more precise timing of the traffic signal preemption sequence based upon site conditions, especially when the railroad crossing is frequently used by train traffic.

AVOIDING COMMON PITFALLS

Traffic engineers should bear in mind several important principles when considering the use of a pre-signal system at a highway-rail grade crossing:

• A pre-signal is not a substitute for a proper track clearance green interval.
• Employing pre-signals requires that engineers consider the use of “No Turn On Red” signage at the pre-signal to deter drivers wishing to turn right on red at the downstream intersection from passing the pre-signals and crossing the tracks.
• A pre-signal face located less than 40 ft. from the stop line will not be effective for motorists at the stop line. In the case of a shorter separation distance between pre-signal and stop line, motorists may be tempted to pull out onto the track when the track clearance green interval is displayed.
• A pre-signal is not an alternative to use of advance preemption. Advance preemption is necessary where the right-of-way transfer time, queue clearance time and separation time exceed the railroad warning time and the clear storage distance exceeds approximately 80 ft. (adequate storage distance for a 65-ft. tractor-trailer combination). Advance preemption also may be required where this distance is less than 80 ft. to prevent vehicle-gate interaction (striking the vehicle with the descending gate arm) or to prevent turning vehicles approaching the crossing from the intersection side from blocking the exit path of vehicles attempting to vacate the crossing during track clearance green.
• If a pre-signal is expected to keep vehicles off the tracks and function as a part of the preemption sequence, it must be provided with battery backup equivalent to that provided for the railroad warning devices.
• Unless it is carefully laid out, mounting of pre-signal faces may obstruct the view of railroad flashing light signals.
• If motorist compliance with pre-signal faces is expected, training and enforcement programs must be implemented with law enforcement agencies responsible for traffic enforcement at the crossing. Public information outreach for road users also is desirable, as this will increase the likelihood that road users will be able to recognize the new devices and correctly interpret their meaning.
• If the traffic signal control equipment experiences a malfunction and goes into flashing operation, consideration must be given to the pre-signal faces, including their flash color, as well as what the intended road user actions would be in the event of an approaching train. In addition, engineers must account for the situation at the grade crossing that would result from the loss of pre-signal function (road users might well pull onto the tracks). Real-time condition monitoring of the traffic signal control equipment may be a necessity to minimize down time in the event of failure.

CONCLUSION

There are many locations on the highway system where the use of pre-signals may be effective in reducing problems associated with vehicles queuing and stopping within railroad grade crossing track areas. Unfortunately, vehicles that stop within the track area all too often are involved in collisions with trains. The careful consideration and use of pre-signals can help alleviate these conditions. Guidelines for their proper use are available to traffic engineers in MUTCD and in ITE’s Recommended Practice entitled “Preemption of Traffic Signals Near Railroad Crossings.”

By using pre-signals as discussed in this feature, the number of incidences in which vehicles stop on the tracks can be greatly reduced. Properly implemented pre-signal installation will help keep the grade crossing clear under foreseeable conditions.

Traffic engineers will find pre-signals beneficial where their use is appropriate—in locations where the downstream intersection configuration relative to the grade crossing may require a very long track clearance green interval. Situations plagued with long traffic queues that may approach or obstruct the grade crossing also can be successfully addressed by an effective pre-signal design.

References