APPENDIX

PREEMPTION/INTERCONNECTION

The topic of highway traffic signal preemption and interconnection to active highway-rail grade crossings is very complex. It requires special traffic engineering evaluation, and close coordination between highway and railroad design and operation personnel. This appendix has been included to provide some guidance information on the subject, and provides detailed discussion on several elements. (Please refer to the main document for discussion on when to interconnect, agency coordination, accommodation of second train situations and references.)

PEDESTRIAN CLEARANCE PHASE

The MUTCD provides that the pedestrian clearance phase may be "abbreviated" during the railroad preemption of the traffic signals. Some agencies have elected to utilize the abbreviated interval, some eliminate entirely the pedestrian clearance phase during the preemption sequencing, while others provide full clearance intervals. Abbreviating the pedestrian "don't walk" phase may expedite the intended vehicular cycle, however, it may not expedite pedestrian or driver behavior. Drivers may yield to pedestrians and thereby prevent vehicles behind them from clearing off the tracks. To minimize this potential, full pedestrian clearance may be provided, but consequently, additional minimum preemption warning time will be required. The preemption interconnect may consist of simultaneous preemption (traffic signals are preempted simultaneously with the activation of the railroad control devices), or advance preemption (traffic signals are preempted prior to the activation of the railroad control devices), or possibly a special design which could consist of two separate closed loop normally energized circuits. The first, pedestrian clearance call should occur a predetermined length of time to be defined by a traffic engineering study and continue until the train has departed the crossing. The purpose of the first call is to safely clear the pedestrian. The second, vehicle clearance call, programmed with a higher priority in the traffic signal controller than the first call, should occur a predetermined length of time to be determined in a traffic engineering study, but not less than 20 seconds prior to the arrival of a train, and continue until the train departs the crossing. The purpose of the second call is to clear motor vehicle queues, which may extend into the limits of the crossing. While one preemption interconnect circuit can be used to initially clear-out the pedestrian traffic and then a time delay used for the second vehicular clearance, a system with two separate circuits provides a more uniform timing if the train speed varies once preemption occurred. This is especially important if the train accelerates after the pedestrian clearance is initiated. A timing circuit may not provide adequate warning time.

If the pedestrian clearance phase is abbreviated (or eliminated), additional signing alerting pedestrians of a shortened pedestrian cycle should be considered.

TRAFFIC SIGNAL CONTROLLER RE-SERVICE CONSIDERATIONS

Traffic signal controller re-service is the ability of the traffic signal controller to be able to accept and respond to a second demand for preemption immediately after a first demand for preemption has been released, even if the programmed preemption routine/sequence is not complete. In other words, if a traffic signal controller receives an initial preempt activation and shortly thereafter it is deactivated, most traffic signal controllers will continue to time out the preemption sequence; if a second demand for preemption is placed during this period, the traffic signal controller must return to the track clearance green. At any point in the preemption sequence, even during the track clear green interval, the controller must return to the start of a full track clearance green interval with a second preemption demand. Until recently, most traffic signal controllers were unable to recognize a second preempt until the entire preemption sequence of the first activation timed out. If the second demand occurred during the initial preemption sequence, the traffic signal controllers continued the same sequence as if that was still the initial demand for preemption. The traffic signal controller re-service capability must be able to accept and respond to any number of demands for preemption.

The point in which preemption is released from the railroad active control devices to the traffic signals is critical to the proper operation of re-service. In order for the traffic signal controller to recognize a second demand, the first demand must be released, therefore the railroad active control devices must release the preempt activation just as the crossing gates begin to rise, not when they reach a fully vertical position. Otherwise, especially at locations with short storage areas between the crossing and the highway intersection, traffic may creep under the rising gates and with a second train, a second track clear green interval will not be provided if the gates never reach a fully vertical position.

PROGRAMMING SECURITY

Security of programmed parameters is critical to the proper operation of the highway-rail preemption system. As an absolute minimum, control equipment cabinets should be locked and secure to prevent tampering and controllers should be password protected. In addition to preventing malicious tampering of control devices, security should be considered to prevent accidental changes in timing parameters, especially in the traffic signal controller where a programming mistake can easily be made due to the large quantity of parameters even when just viewing the data. Some traffic signal controller manufacturers have designed systems where the critical railroad preemption parameters can not be changed without both proper software and physically making a hardwire change the traffic signal cabinet. Without proper data changes, the traffic signals will remain in a flashing red operation until the data is corrected. In addition, these systems prevent a different type of controller or even controller software from operating the traffic signals. It is important to preserve the integrity of the system once it is tested and proven to operate properly. Another method of preserving the proper timing parameters is remote monitoring of the traffic signal controller. Routine uploads of traffic signal timings can be compared to a database to check for unapproved changes in any timing parameters.

SUPERVISED INTERCONNECT CIRCUITRY

The interconnection circuit between the highway traffic signal control cabinet and the railroad signal cabinet should be designed as a system. Frequently, the interconnect cable circuit is designed so that the preemption relay can be falsely de-energized, thereby causing a preempt call, without the railroad signals being activated. The traffic signals will then cycle through their clearance phase and remain at “stop” until the false preempt call is terminated. If a train approaches the crossing during the false preemption, the railroad signals will activate, but the traffic signals will not provide track clearance phases because they are still receiving the first false call. Even worse, a short between the wires in this type of circuit will virtually disable preemption and will only be recognizable once the railroad active control devices are activated with an approaching train. To address this potential problem supervised preemption circuits may be used. In its simplest form, the supervised circuit is formed by having two control relays in the traffic control cabinet each of which is energized by the railroad crossing relay. One relay, the Preemption Relay, is energized only when the railroad active control devices are off. The second relay, the Supervision Relay, is energized only when the railroad active control devices are operating. When circuited in this manner, only one control relay is energized at a time. If both relays are simultaneously energized or de-energized, the supervision logic determines that there is a problem and can implement action. This action may include initiating a clearance cycle and upon completion of the clearout, the traffic signals can go into an all-way flashing red instead of stop. The all-way flashing red will allow traffic to advance off the tracks instead of being held by the red signal. An engineering study may determine that the all-way flashing red is undesirable due to high highway traffic volumes compared to rail traffic. In all cases remote-monitoring devices that send alarm messages to the railroad and highway authority should be installed. Law enforcement traffic control should be used until repairs can be performed. More information on supervised circuits can be found in an article, *Supervised Interconnection Circuits at Highway-Rail Grade Crossings,* by Mansel, Waight, and Sharkey, ITE Journal, March 1999, Institute of Transportation Engineers available at www.ite.org

ADVANCE PREEMPTION AND USE OF TIMERS

When advance preemption is used the traffic signal preemption occurs prior to the active control devices being activated. This allows preemption to begin behind the scene and the active control time of the railroad signals is not necessarily increased. Railroads frequently use two detection times in their system. The first detection time is designed to initiate traffic signal preemption.

The second detection time is used to activate the active control devices. If the train is decelerating as it approaches the crossing, the time difference between initiation of preemption and activation of the active control devices will increase. It is imperative that the time difference does not increase to the point where the traffic signal clear out cycle ends (i.e. traffic signal turns red) before the active control devices turn on. To prevent re-queuing traffic on the tracks, a "not-to-exceed" timer should be installed to force the activation of the active control devices prior to the appropriate time in the clear out cycle. If the train accelerates toward the crossing the second detection time will activate the active control devices prior to expiration of the timing cycle. Another issue when designing advance preemption circuitry is multiple consecutive train movements can cause the traffic signals to remain in preemption due to a second approaching train, but the railroad active control devices deactivate after the first train just clears the crossing. In this case, the traffic signals will not provide a second track clearance indication since the first call is still present, therefore the railroad circuitry should be designed to prevent this from occurring. Also, when the traffic signals experience a loss of power or a malfunction which causes an all way red flash, the advance preemption time becomes ineffective in helping clear vehicles from the crossing and effectively, vehicles will have less time to clear the crossing. An additional interconnection circuit should be utilized between the railroad and the traffic signal controls, so that the railroad active control devices would activate at the same time as the advance preempt circuit would normally activate the traffic signals in the event of all-way-red flash or loss of power to the traffic signals.

If railroad gates are used, another method of minimizing the potential of the clearout cycle from ending while traffic is on the tracks is to continue the clearout cycle until the gates are in the lowered position. This requires an additional circuit between the railroad cabinet and the highway traffic control cabinet and special logic in the traffic signal control cabinet. The above mentioned techniques for the supervised circuit may be employed.

STANDBY POWER SOURCES

Railroad active control devices are normally off when no train is approaching; therefore, railroads install backup power systems to provide power to the signals during commercial power failures. This is different from traffic signals that generally are dark if the commercial power is off. When traffic signals are dark, motorists in most jurisdictions are expected to know that traffic signals are ahead, stop their vehicle at the stop bar, and proceed through the intersection as if the dark signal was a stop sign. Since dark traffic signals cannot display a clear out aspect to a motorist, backup power systems should be considered at interconnected locations. When considering power back up systems for traffic signals, it should be considered on a system wide basis rather than just at individual interconnected locations since other adjacent signalized intersections may just as well also stall traffic. The fail-safe mode of operation in the event of a traffic signal malfunction is an all way red flash, in which case power back up systems will have no effect. The use of remote monitoring and law enforcement traffic control can be used to minimize the requirements and cost of the backup power system.