



Project Summary Report O-4265-S

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Project O-4265: Improved Traffic Signal Operation  
near Railroad Grade Crossings with Active Devices

Authors: Kevin N. Balke, Roelof J. Engelbrecht, Srinivasa R. Sunkari,  
and Steven P. Venglar

## Improving Safety and Operations of Traffic Signals near Railroad Grade Crossings with Active Warning Devices

PROJECT SUMMARY REPORT

While the number of collisions at railroad crossings declined between 2000 and 2004, the proportion of these collisions occurring at crossings protected by automatic gates has remained relatively constant. During 2000 alone, 93 incidents occurred at grade crossings protected by gates, resulting in 4 fatalities and 37 injuries. In 2004, these numbers had increased to 120 accidents, 9 fatalities, and 51 injuries. A significant portion of the collisions and fatalities occurred where a highway intersection was located within 150 feet of the crossing.

Figure 1 shows a common example of railroad-highway grade crossings adjacent to signalized intersections in Texas.

The objective of this research project was to increase safety and reduce disruption in coordinated operations along arterials with railroad preemption by improving the operation of traffic signal controllers near highway-railroad grade crossings. Significant safety concerns and operational problems exist at railroad-highway grade crossings adjacent to signalized intersections. Current TxDOT procedures, in particular the *Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings*



Figure 1. Typical Highway-Rail Grade Crossing in Texas.

worksheet, do not specifically address all these problems. This research project:

- determined safety, human factors, and operational problems at traffic signals near grade crossings;
- identified and evaluated potential solutions to these problems with regard to their effectiveness and applicability in Texas; and
- combined applicable solutions into a guideline document that will help TxDOT staff recognize and address the special circumstances associated with signals near grade crossings.

### What We Did...

As part of this project, Texas Transportation Institute (TTI) researchers conducted a survey of operations engineers and practitioners in Texas and in key locations across the United States to determine the paramount safety and operational issues relating to highway railroad grading crossings. TTI researchers then identified and evaluated potential operational and human factor solutions to the safety problems identified through the survey. TTI completely revised the Texas Department of Transportation's (TxDOT's) *Guide for Determining Time Requirements for Traffic*



*Signal Preemption at Highway-Rail Grade Crossings* to more accurately assess the required advanced warning time needed to address many of the safety issues at grade crossings. Guidelines were also developed for operating traffic signals near highway-railroad grade crossings.

## What We Found...

The results of the survey as well as past research identified a number of safety concerns at traffic signals near highway-rail grade crossings with active grade crossing warning systems. As shown in Figure 2, these included the following:

- abbreviating normal pedestrian clearance and minimum vehicle green times,
- gates descending on stationary vehicles or trapping those vehicles in queues on the tracks that could not go elsewhere,
- failure to consider the longer length and slower acceleration of heavy vehicles,
- not providing sufficient time between the last vehicle leaving the crossing and the train arriving at the crossing,
- non-supervised interconnect circuits and fail-unsafe traffic signal controller preempt inputs, and
- preemption over long distances.

Using hardware-in-the-loop simulation and other evaluation tools, researchers developed and evaluated numerous operational strategies to address these issues. In conducting these evaluations, TTI researchers found that TxDOT's current procedures of computing train warning time requirements needed to be upgraded to address many of these concerns. The updated guide contains a number of improvements over the guide currently in use. The updated guide:

- provides a more detailed calculation of the right-of-way transfer time,
- bases queue clearance time calculation on the design vehicle concept,

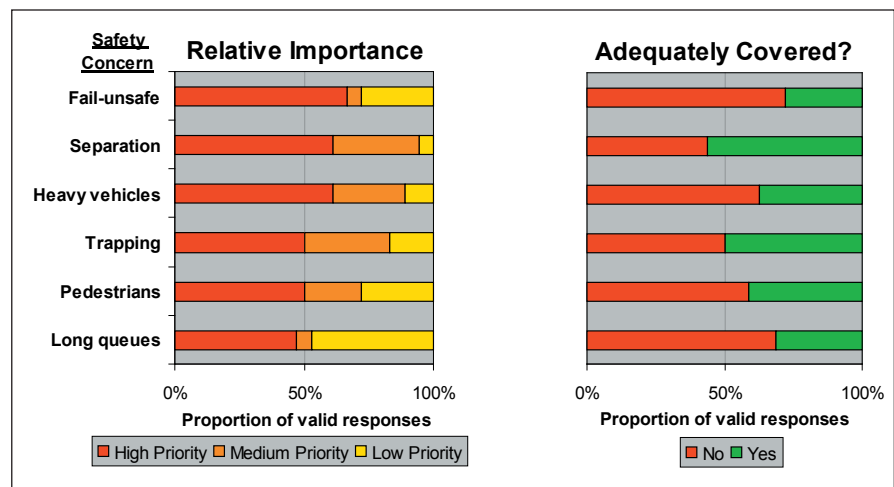


Figure 2. Summary of Critical Issues Associated with Traffic Signal Operations near Highway-Railroad Grade Crossings.

- places greater focus on the effects of heavy-vehicle characteristics (length, acceleration, effect of grade),
- categorizes minimum separation time as a design input,
- includes a method for track clearance green time calculation, and
- includes a method to calculate the advance preemption time required to avoid gates descending on heavy vehicles.

The updated guide is available both as a regular, printable document and as a fillable form. The fillable form can be completed on the computer screen and printed, with calculations done automatically.

## The Researchers Recommend...

The following recommendations were developed by TTI researchers to address the safety concerns at traffic near highway-rail grade crossings with active grade crossing warning systems.

### Abbreviating normal pedestrian clearance and minimum green times

*The Texas Manual on Uniform Traffic Control Devices for Streets and Highways (TxMUTCD)* allows for the shortening of minimum durations of the green and pedestrian clearance intervals

at traffic signals that are interconnected with railroad grade crossing equipment (i.e., signals operating under preemption). Very little guidance is provided, however, as to when and how much these intervals can be shortened. TTI researchers recommend using 2 seconds of minimum green time during the transition into preemption. To quantify the need for full pedestrian clearance times, TTI researchers developed a Truncation Exposure (TE) index that determines the impact of pedestrian clearance time truncations. The TE defines the time, in pedestrian-seconds per day, that normal pedestrian clearance is truncated due to preemption, and provides an indication of the number of seconds during the day in which pedestrians have to clear the intersection unprotected due to clearance time truncations.

### Gates descending on stationary vehicles or trapping vehicle in a queue on the tracks with nowhere to go

One cause of gates descending on stationary vehicles or trapping a vehicle in a queue on the tracks is a maximum normal preemption time that is more than the total warning time available from the railroad. The other cause of gates descending on stationary or trapped vehicles is the ending of the track clearance phase before the active grade crossing warning lights start



to flash or the gates start to descend, blocking access to the crossing. At a minimum, TTI researchers recommend that duration of the track clearance green phase be no less than 15 seconds. A more accurate approach is to consider the observed or expected variation in advance preemption time together with the actual gate descent characteristics. Other strategies to ensure that vehicles are not trapped or the gates do not descend on stationary vehicles include minimizing the variation in the right-of-way transfer time, minimizing the variation in the advance preemption time, using a gate-down signal, and avoiding using the advance preemption.

### **Failure to consider longer lengths and slower acceleration of heavy vehicles**

The queue clearance time has to be determined on the worst-case vehicle mix, which may include one or more design vehicles. As shown in [Figure 3](#), trucks should be considered as the design vehicle at many grade crossings. The previous version of the guide used only a single design vehicle (usually a passenger car) for calculating warning time requirements. However, at many crossings, heavy vehicles or vehicles that are required by law to stop at the crossing (e.g., a school bus) should be the design vehicle. The updated guide provides a methodology for calculating the minimum queue clearance times based on the operating characteristics of different design vehicles.

### **Not providing sufficient time between the last vehicle leaving the crossing and the train arriving at the crossing**

The time difference between when the last vehicle clears the crossing and the arrival of the train at the crossing is referred to as separation time. Separation time is generally considered part of the preemption sequence. It typically represents the time at the end of the preemption sequence after the signal has transferred the right-of-way to the approaching train and queued vehicles have cleared the tracks. Previously, separation time was



Figure 3. Heavy Vehicles at Grade Crossings Have a Significant Impact on Operations.

considered a variable in the calculation of the required advance warning times. As a result, in the worst-case situation, separation time between vehicular traffic and the train arrival could be as low as zero seconds. Under the revised guide, a minimum separation time (fixed interval) is entered to increase the likelihood that at least a few seconds separate the last vehicle leaving the crossing and the train's arrival under all circumstances.

### **Non-supervised interconnect circuits and fail-unsafe traffic signal controller preempt inputs**

Under the current state-of-the-practice design of traffic signal and railroad interconnects, if the interconnect circuit is disrupted or disconnected, the traffic signal will not be alerted to the train continuing to approach the crossing once an initial preemption has occurred. This creates a “fail-unsafe” condition. What needs to occur is that when the interconnect circuit between the railroad warning equipment and traffic signal equipment breaks, the controller should automatically transition into preemption and remain in preemption even when a train is not present. This represents a “fail-safe” condition

because the system fails in its most restrictive state (i.e., preemption).

### **Preemption over long distances**

Preemption over long distances is especially difficult because of the need for long minimum preemption warning times and the time required to clear traffic off the tracks. The best strategy providing preemption over long distances is the use of a traffic signal timing plan at the intersection to ensure that queues at the traffic signal never back up far enough to block the grade crossing. In those situations where this cannot occur, the use of pre-signals (i.e., installing a separate traffic signal upstream of the railroad tracks) and the use of queue cutter signals (e.g., flashing beacons installed upstream of the grade crossing to alert vehicles that a train is approaching and to not stop on the tracks) are two strategies recommended for helping keep the track area free of queued traffic. TTI researchers recommend that the operations of both pre-signals and queue cutter signals be closely coordinated with the operations of the intersection traffic signal to ensure that the queue does not build over the crossing.



## For More Details...

The research is documented in:

Report 0-4265-1, *Engineering Solutions to Improving Operations and Safety at Signalized Intersections near Railroad Grade Crossings with Active Devices*

**Research Supervisor:** Roelof J. Engelbrecht, TTI

**Researchers:**

Steven P. Venglar, TTI, s-venglar@tamu.edu, (210) 979-9411  
Srinivasa R. Sunkari, TTI, s-sunkari@tamu.edu, (979) 845-7472  
Kevin N. Balke, TTI, k-balke@tamu.edu, (979) 845-9899

**TxDOT Project Director:** David Valdez, TxDOT, dvaldez@dot.state.tx.us, (512) 416-2642

**TxDOT Research Engineer:** Wade Odell, TxDOT, wodell@dot.state.tx.us, (512) 465-7403

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This report is not intended for construction, bidding, or permit purposes. The engineers in charge of the project were Roelof J. Engelbrecht, P.E. #91766, and Kevin N. Balke, P.E. #66529.

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Texas Transportation Institute/TTI Communications  
The Texas A&M University System  
3135 TAMU  
College Station, TX 77843-3135