Preempting Traffic Signals near Railroad Crossings in Utah

A UDOT Manual

January 2017

Keeping Utah Moving

The Utah Department of Transportation (UDOT), per Title 54 of the Utah State Code and Administrative Rule R930-5, is the governing agency that oversees all public highway-rail at-grade crossings (Crossings) in the State of Utah. As defined in R930-5-1, UDOT's goals are to enhance user safety for all Crossings and provide for the efficient operation of trains, vehicles, and pedestrians through each Crossing. Traffic signal preemption near a Crossing is one of the enhancements that UDOT considers to achieve its most critical of goals, Zero Fatalities®, for Crossings throughout the State.

The planning and management of preemption is a "living" process that ensures decision making relates to current regulations and best practices for evaluation and implementation of preemption for at-grade crossings. As such, stakeholders, decision makers, technical committees, and the UDOT Chief Railroad Engineer should reassess the Manual on a periodic basis to verify it reflects the latest developments in the overall process, lessons learned, and any changes to stakeholder relationships and responsibilities to maintain proper and efficient at-grade railroad crossing preemption. The table below lists the revisions of this Manual since its initial publication.

Revision History

Rev. No.	Rev. Date	Sections Affected	Comments
0	October 2016	N/A	Initial version of the Manual
1	January 2017	Sections 3.3.9 and 4.3	Added language regarding pedestrian and bike trail crossings (see Section 3.3.9) and Table 11 that lists out the review documents for interconnected crossing projects (see Section 4.3).

Acknowledgements

The Utah Department of Transportation would like to recognize the Utah Transit Authority (UTA), Union Pacific Railroad (UPRR), and team consultants (Avenue Consultants, RailPros, and PineTop Engineering) for their assistance in the development of this Manual. This work would have also not been possible without the information collected from the Texas and City of Los Angeles Departments of Transportation. Through a series of Guideline Technical Committee (GTC) meetings, UDOT reviewed and discussed industry practices and lessons learned from other transportation agencies with regards to the development and implementation of this Manual and the Utah Preemption Form. This Manual and related reference documents represent the work and decisions of the GTC consisting of representatives from UDOT, UTA, UPRR, and others, including the following decisions that have been mutually agreed to by all listed parties.

The parties have reviewed the content of this Manual and agree to the adoption of the provisions, including the following specific technical details:

- Preemption timing calculation methodology, as detailed in this Manual and the Utah Preemption Form, is based on the Texas Department of Transportation Preemption Form (Version 03/2009), with enhancements based on the City of Los Angeles Department of Transportation Preemption Form (06/23/2008).
- The parties agree to adhere to the process for joint inspections of preempted highway-rail at-grade crossings (Crossings) to be performed at regular intervals as detailed in Chapter 5, *Inspecting and Maintaining Preempted Crossings*, of this Manual.

The parties agree to the guidelines and consistent processes established in this Manual 1) for identifying the need for preemption at a Crossing, 2) for calculating preemption time, 3) for implementing preemption changes, and 4) for inspecting and maintaining preempted Crossings. The parties agree to participate in reviews and inspections, provide preemption-relevant data in a timely manner given the nature of the request to enhance safety at a Crossing, and document and communicate changes to other impacted parties as necessary.

The collaborative effort and dedication of the team members are hereby recognized and appreciated.

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Chapter 1 Introduction

1.1 General

Preemption of a traffic signal at or near a highway-rail at-grade crossing (Crossing) occurs when traffic signal operations are modified 1) to clear roadway users from a railroad track before a train arrives at a Crossing, 2) to prevent roadway users from being directed onto an occupied Crossing, and/or 3) to provide for orderly movement of traffic while a Crossing is occupied by a train. The purpose of this Manual is to provide designers, engineers, and technicians the tools to identify, calculate, implement, and maintain traffic signal preemption near Crossings throughout the State of Utah. This Manual addresses the needs, roles, and responsibilities of a number of unique stakeholders (the Utah Department of Transportation [UDOT], Utah Transit Authority [UTA], Union Pacific Railroad [UPRR], and other local railroads, cities, and counties) in the context of operating heavy rail, light rail, streetcar, and commuter rail in conjunction with highway traffic.

Every Crossing is unique, and the physical and operational characteristics of each can vary significantly. As such, this Manual is not intended to present standards or a “one-size-fits-all” solution, but instead presents basic principles that govern the design and implementation of preemption for a Crossing. The tools described herein are to be applied with engineering judgment to arrive at the most appropriate solution on a location-by-location basis.

1.2 Manual Organization

This Manual is organized in line with the overall preemption process. *Figure 1* depicts an overview of this process, which is summarized by chapter below.

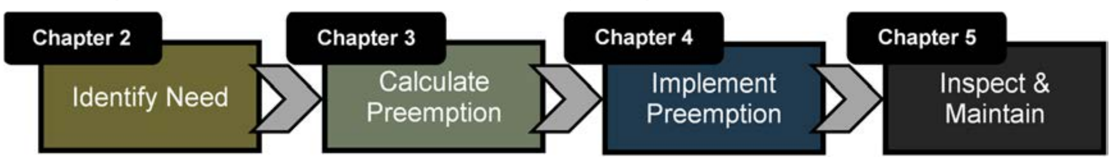


Figure 1: Overall Preemption Process

Chapter 1, *Introduction*, describes the purpose, existing documentation, definitions, and general roles applicable to this Manual.

Chapter 2, *Identifying the Need for Preemption*, details the process to identify preemption need at a traffic signal adjacent to a Crossing.

Chapter 3, *Calculating Preemption Time*, presents how to 1) measure and collect preemption-relevant data, 2) apply specific parameters when calculating preemption time, 3) contemplate unique scenarios, and 4) complete the Utah Preemption Form (Appendix A) to calculate preemption timing.

Chapter 4, *Implementation*, lists the actions that may prompt preemption changes, alongside the roles and responsibilities to calculate, review, and approve preemption.

Chapter 5, *Inspecting and Maintaining Preempted Crossings*, provides an overview of the traffic signal and railroad infrastructure maintenance procedures and re-evaluation factors for locations that presently operate under preemption.

1.3 Existing Documents

The information provided throughout this Manual references industry standards, recommendations, and practices from the resources listed in *Table 1*. If conflicts arise, the most recent versions of the noted references in *Table 1* should be referred to in the order listed.

Table 1: Standards and Guidance

Reference Title	Short Cite	Sponsoring Agency	Year Published
Utah Manual on Uniform Traffic Control Devices	UMUTCD	UDOT	2012
Utah Administrative Rules R920 and R930	Admin Rule R920 and Admin Rule R930	State of Utah	2013
AREMA Communications and Signals Manual	AREMA Manual	AREMA	2016
UDOT Railroad Coordination Manual of Instruction	UDOT Railroad Coordination MOI	UDOT	2015
FHWA Railroad-Highway Grade Crossing Handbook	FHWA Grade Crossing Handbook	FHWA	2007
ITE Traffic Control Devices Handbook	ITE TCD Handbook	ITE	2013
ITE Preemption of Traffic Signals Near Railroad Crossings	ITE Guideline	ITE	2006
TRB Highway Capacity Manual	HCM	TRB	2010

1.4 Abbreviations and Definitions

Table 2 lists the common abbreviations used throughout this Manual. This list is not exhaustive. The more technical abbreviations are defined in relevant chapters.

Table 2: Common Manual Abbreviations

Abbreviation	Term
AREMA	American Railway Engineering and Maintenance-of-Way Association
CFR	Code of Federal Regulations
Crossing	Highway-rail at-grade crossing
Manual	Manual for Preempting Traffic Signals near Railroad Crossings in Utah
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
ITE	Institute of Transportation Engineers
MOI	Manual of Instruction
UMUTCD	Utah Manual on Uniform Traffic Control Devices
TRB	Transportation Research Board
UDOT	Utah Department of Transportation
UPRR	Union Pacific Railroad
UTA	Utah Transit Authority

Table 3 lists common definitions used throughout this Manual. This list is not exhaustive. The more technical definitions are defined in relevant chapters.

Table 3: Common Manual Definitions

Term	Definition
Active Grade Crossing Warning System	The flashing-light signals with or without warning gates and audible devices, together with the necessary control equipment used to inform motorists of the approach or presence of a train at a Crossing. These are also considered Active Warning Devices.[a]
Company	Any local district (e.g., school district or water district) or utility company.[b]
Diagnostic Team	A team, led by the UDOT Chief Railroad Engineer, consisting of representatives from UDOT, the Railroads, and other relevant stakeholders that review, analyze, and recommend proposed improvements or modifications to an intersection and related Crossing.[c]
Highway Authority	An agency, that could be UDOT or a local jurisdiction (a local county or city) that owns or has jurisdiction over a road or highway.[b]
Railroad	All rail carriers (whether publicly or privately owned) and common carriers, including line haul freight and passenger Railroads, public transit districts, switching and terminal Railroads, passenger carrying Railroads (such as rapid transit), and commuter and street Railroads.[b]

[a] Definition from the UMUTCD.

[b] Definition from Utah Administration Rule R930.

[c] The Diagnostic Team is more specifically defined in Section 3.2.1 of the UDOT Railroad Coordination MOI.

1.5 General Roles under this Manual

Table 4 provides a general overview of the roles for each primary stakeholder and/or its representative under this Manual. Specific responsibilities are detailed in subsequent chapters.

Table 4: Titles and General Roles

Title	Role
UDOT Chief Railroad Engineer	Regulates and promotes safety at all locations in the state where public roadways (i.e., state highways, county roads, city streets, and all other public accesses) cross railroad tracks.
Traffic Signal Operations Engineer	Working for UDOT's Traffic Management Division, oversees traffic signal maintenance, traffic signal timing and optimization, event/incident traffic signal operation, performance measures and reporting, and coordination with UDOT's Regions on signal operations.
Highway Authority Representative	Represents the entity that owns or has jurisdiction over a highway or road. The Highway Authority could be UDOT or a local jurisdiction (a local county or city).
Diagnostic Team	Reviews, analyzes, and recommends proposed improvements or modifications to a Crossing. Led by the UDOT Chief Railroad Engineer, this team consists of the Highway Authority, Railroads, and other relevant stakeholders.
Railroad Representative	Represents the railroad entity (including line haul freight and passenger railroads, public transit districts, switching and terminal railroads, passenger carrying railroads [such as rapid transit], and commuter and street railroads) that owns, maintains, and/or operates at a Crossing.

Chapter 2 Identifying the Need for Preemption

Chapter 2 presents a quantifiable step-by-step approach to identify a need for preemption at a signalized intersection adjacent to a Crossing.

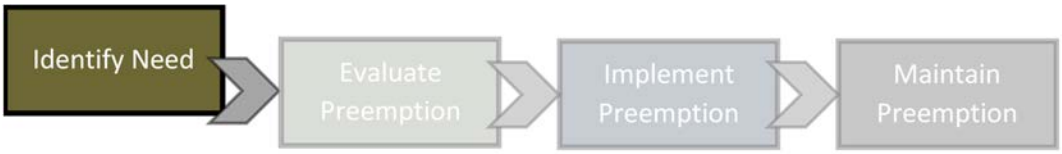


Table 5 summarizes the roles and responsibilities to initiate, recommend, and review a need for preemption at a signalized intersection adjacent to a Crossing. The listed actions are expanded upon in the subsequent sections.

Table 5: Preemption Need Identification Responsibilities

Action	Responsible Party	Comment
Initiate	UDOT Chief Railroad Engineer, Railroad, or Highway Authority Representative	Initiation occurs when Crossings are reviewed or requested for consideration on an as-needed basis (including new construction).
Measure, establish, analyze, and recommend	As assigned by the UDOT Chief Railroad Engineer or local Highway Authority equivalent	The measurement and calculations are conducted as described below to determine recommendations for preemption need.
Review	UDOT Chief Railroad Engineer and Diagnostic Team	Preemption results and recommendation are reviewed to determine a preemption need.
Inform	Depending on the jurisdiction of a Crossing and/or intersection	Any party (e.g., a Railroad, UDOT, or a local agency representative) impacted or associated with a Crossing and/or intersection should be informed of a preemption-eligible project.

2.1 Preemption Identification Process

The preemption need identification process begins, but would not be limited to, one of the following conditions that could potentially impact a new or existing Crossing:

- The Chief Railroad Engineer reviews all public Crossings that have a potential need for preemption,
- A Railroad or Highway Authority (whether initiated through UDOT or a local agency) identifies a concern through inspection or routine maintenance of a Crossing and/or intersection, or
- When road or railroad improvements impact the operations of a Crossing and/or intersection.

In order to substantiate a need for preemption, the following three steps must be completed by the applicable agency initiating the identification process (i.e., the Railroad, Highway Authority, or UDOT Chief Railroad Engineer).[1]

[1] *Table 12* in Chapter 5, *Inspecting and Maintaining Preempted Crossings*, lists the action and frequency for re-evaluating existing preempted Crossings.

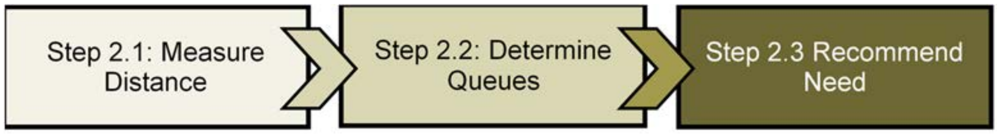
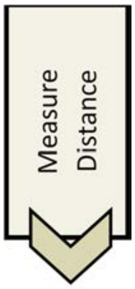


Figure 2: Preemption Need Identification Process Overview

Step 2.1: Measure Available Storage Distance



Measure the distance (otherwise known as the Available Storage Distance [D] depicted on *Figure 3*) from the railroad stop line (or where the vehicle stopping point would be) to the edge of the nearest curb return at the adjacent intersection or cross street. While the distance can be estimated via a desktop survey using reliable aerial imagery or design documents, it is a best practice to verify this initial estimate through field observation as described under Step 2.2.

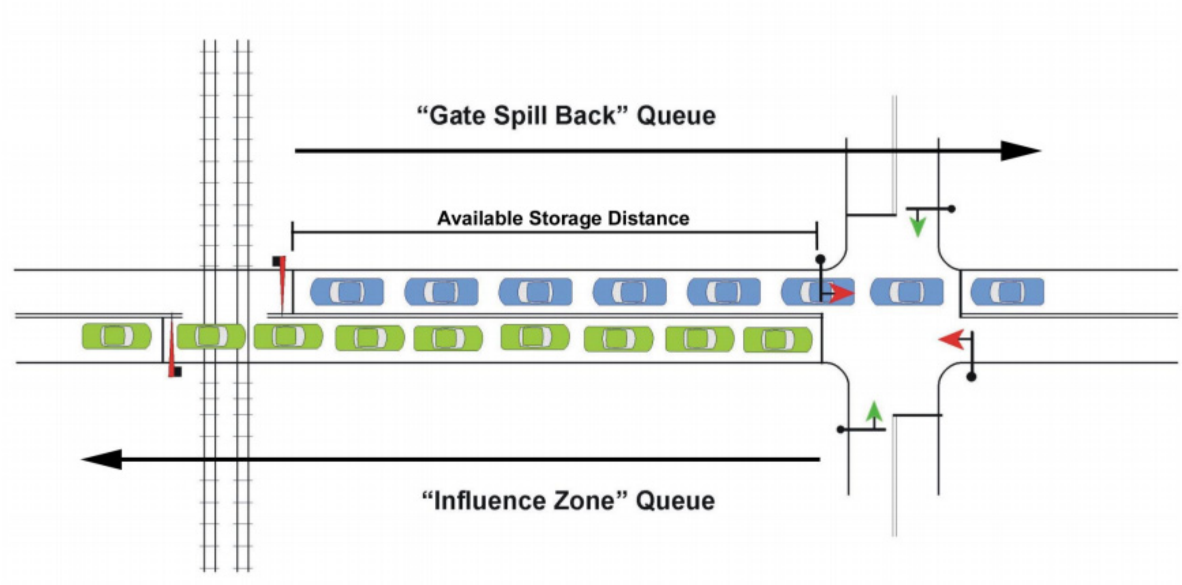


Figure 3: Potential Queue Lengths and Available Storage Distance

Step 2.2: Determine Queue Lengths

Apply one of following three methods to determine queue lengths: field observations, modeling, or calculating.

Conducting a Field Observation

Observing a Crossing or intersection in the field is the most desired and accurate method for measuring queue lengths. Conduct the field observation during peak vehicle traffic periods to study the worst-case scenarios.[2] Two types of queues typically occur that may warrant preemption. Depicted on *Figure 3* above, a Gate Spill Back Queue builds from a Crossing towards an adjacent intersection when the Active Warning Devices are activated. An Influence Zone Queue forms from an intersection and builds toward a nearby Crossing.

Modeling to Predict Queue Length

If a Crossing or intersection is not yet fully operational or modifications are proposed that would affect queuing (e.g., the signalization of a downstream intersection or the addition of a lane), intersection capacity software can provide queue length estimates that help determine whether the 95th percentile queue from a signalized intersection would lead to either a Gate Spill Back Queue or Influence Zone Queue.

Similar to other types of modeling, the output from the model is only as reliable as the input. Factors, such as back-to-back preemption events, train length, and overall time in preemption, can significantly affect the potential for on-track queuing. As such, carefully review the modeled data before making any recommendation.

Additional Considerations

When establishing a queue length, also consider the following variables that may affect queuing:

- *Upstream and downstream signals and platooning,*
- *Platooning from multiple preemption events (e.g., train frequency),*
- *Peak 15-minute flows,*
- *Nearby driveways and on-street parking,*
- *Overall pedestrian/bicyclist use/activities in the area,*
- *Special events or peak traffic seasons,*
- *Unique geometry, and*
- *Vehicle (e.g., design vehicle and longest vehicle) and operating characteristics of the vehicles (e.g., acceleration and stops before crossing) that routinely use the Crossing.*

Calculating to Predict Queue Length (if necessary)

When field observation or modeling is impractical, calculate the 95th percentile vehicle queue length using the following equations from the *ITE Guideline*, 2006 Edition. Although useful, the calculations are only an estimate, which is not always an accurate representation of a queue as it exists in the field. As such, only use these equations when field observation or modeling is not possible.

[2] Be aware that additional data must be collected for additional preemption evaluation. As described in Chapter 3, *Calculating Preemption Time*, collecting the necessary data during this step may streamline the overall data collection needs.

For an Influence Zone Queue:

- Equation 1: For signalized intersection volume to capacity ratio (v/c) less than 0.90:

  $$L = 2qr\ (1 + p)\ 25$$

  Where,
  L = length of 95th percentile queue (ft.)
  q = vehicle flow rate (veh./lane/sec.)
  r = effective red time (red + yellow) (sec.)
  p = proportion of heavy vehicles in traffic flow (as a decimal)
  The factor 25 represents the effective length of a passenger car (vehicle length plus space between vehicles) and the factor “2” is a random arrival factor.

- Equation 2: For signalized intersection volume to capacity ratio (v/c) between 0.90 and 1.0:

  $$L = (2qr + \Delta x)\ (1 + p)\ (25)$$

  Where,
  L = length of 95th percentile queue (ft.)
  q = vehicle flow rate (veh./lane/sec.)
  r = effective red time (red + yellow) (sec.)
  p = proportion of heavy vehicles in traffic flow (as a decimal)
  The factor 25 represents the effective length of a passenger car (vehicle length plus space between vehicles) and the factor “2” is a random arrival factor.
  $\Delta x = 100\ (v/c\ ratio - 0.90)$; e.g., v/c = 0.95, Δx = 5

Equations 1 and 2 cannot reliably be used when v/c > 1.0 (i.e., when the signalized intersection is oversaturated). Under these conditions a traffic analysis based on Highway Capacity Manual methodology or traffic simulation should be used.

For a Gate Spill Back Queue:

- Equation 3: To estimate Gate Spill Back Queue, equations 1 and 2 can be used with a modified factor r, which in this case represents the effective time that a Crossing would be blocked. The factor r in this case is estimated as:

  $$r = 35 + \left(\frac{L}{1.47S}\right)$$

  Where,
  r = modified factor r for equations 1 and 2
  L = train length (ft.)
  S = train speed (mph)

  The factor 35 assumes the Crossing will be blocked by the railroad warning system for 25 seconds before the train enters the Crossing and for 10 seconds after the train clears the Crossing.

Step 2.3 Recommend the Need for Preemption

Recommend Need

Based on measured distances (Step 2.1) and the established queue lengths (Step 2.2), *Figure 4* illustrates the workflow for recommending when preemption is needed.

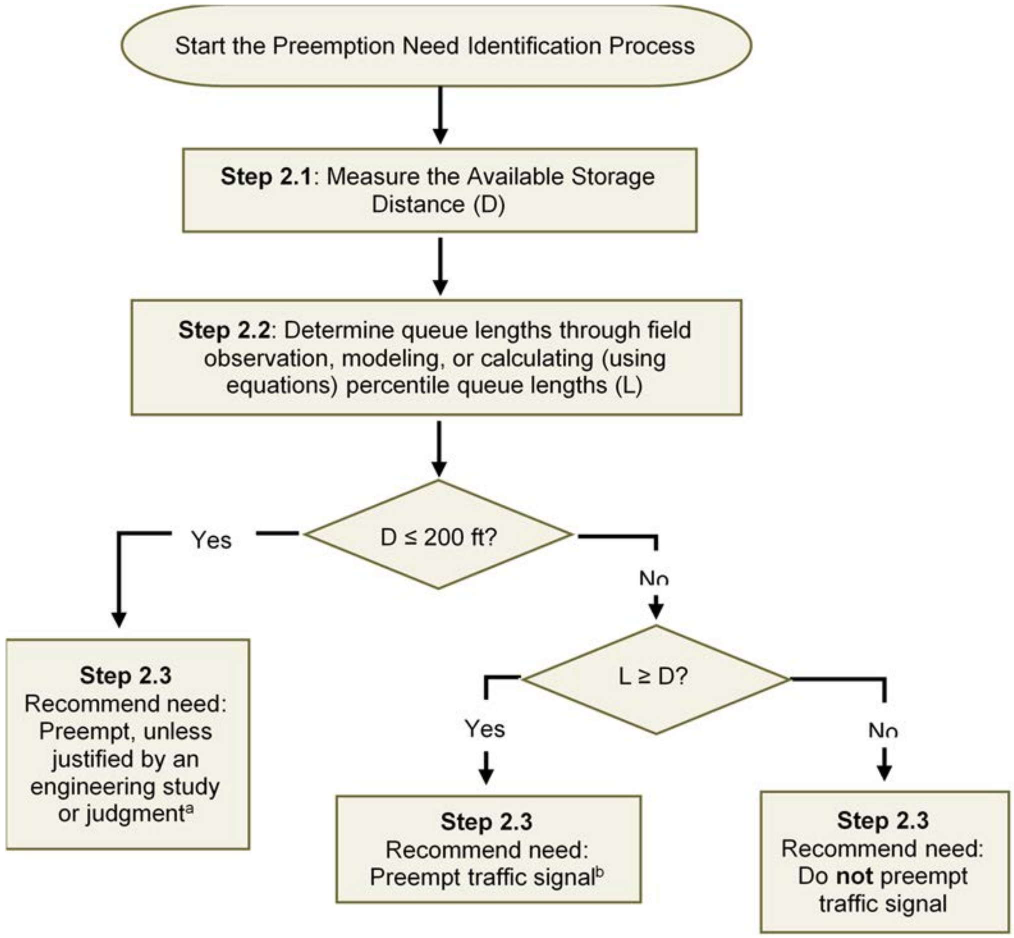


Figure 4: Workflow for Recommending Preemption Need

[a] If an existing or planned Crossing is less than or equal to 200 feet from a signalized intersection, preemption should be provided at the intersection (see Section 8C.09 of the UMUTCD).

[b] Also consider other queue mitigation strategies (e.g., a queue cutter or pre-signal), which are further described in Section 3.3.8, *Pre-signal and Queue Cutter Traffic Signals*.

In the instance that a stop or yield-controlled intersection has observed or the calculation (Step 2.2) has projected queues that lead to a Gate Spill Back Queue or Influence Zone Queue, consider potential improvements (e.g., signalization of the unsignalized intersection) to reduce the queue length. If one of the signal warrants from the UMUTCD (Chapter 4C) is met (e.g., Warrant 9, Intersection near a Grade Crossing) and the Highway Authority elects to install a signal at the intersection, the need for preemption should be determined using the step-by-step approach described in this chapter. A Highway Authority should contact the UDOT Chief Railroad Engineer to schedule a Diagnostic Team review to discuss the safety implications of installing a traffic signal near a Crossing.

Reviewing the Recommendations

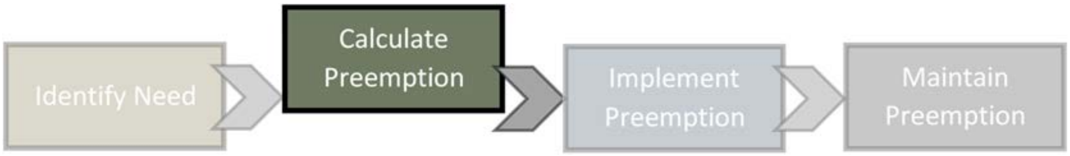
The need for preemption is determined when the following is completed.

- The Highway Authority or Railroad (that initiated the process) presents the results and preliminary recommendation/determination to the UDOT Chief Railroad Engineer.
- The UDOT Chief Railroad Engineer assembles a Diagnostic Team to review the results and preliminary determination.
- The Diagnostic Team reviews the request and the accompanying measurements, calculations, and preliminary determination and visits the Crossing for the preliminary assessment. The Diagnostic Team then provides a recommendation that will be documented and disseminated as an information item to the Railroad and Highway Authority (including any local agencies) overseeing the Crossing and its adjacent intersections, respectively.

The process to identify a preemption need is complete, and the recommendation may become an eligible preemption project. The project should then progress to a more detailed analysis as described in Chapter 3, *Calculating Preemption Time* and Chapter 4, *Implementation*.

Chapter 3 Calculating Preemption Time

Chapter 3 presents a four-step process for calculating intersection preemption and completing the Utah Preemption Form.



From collecting relevant data to contemplating locations with unique operational and geometric configurations, every Crossing and associated intersection are unique. As such, the tools and methodology described herein are to be applied with engineering judgment to arrive at the most appropriate solution.

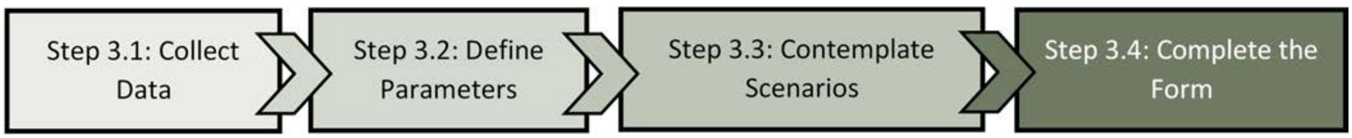
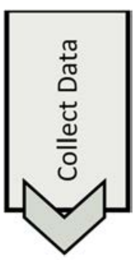


Figure 5: Preemption Calculation Process Overview

3.1 Step 3.1: Collecting Preemption-Relevant Data



The first step involves data measurement and collection from a variety of sources in order to complete the Utah Preemption Form (Step 3.4). By becoming familiar with the process described in this Manual, the individual collecting the data can streamline this step. The subsequent sections generally follow and define what is needed for the data input cells (i.e., the highlighted yellow cells) on the Utah Preemption Form (Appendix A [*Utah Preemption Form*]).

3.1.1 Determining Distances Critical for Preemption Timing

Defined and illustrated in *Table 6*, there are six critical distances used to calculate preemption timing.

Table 6: Distances Necessary for Preemption Timing

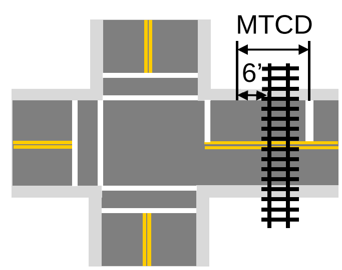
Term	Definition	Diagram
Minimum track clearance distance (MTCD)	The distance from the gate, Crossing stop line (if no gates are used), or 12 feet from track centerline (if no stop lines or gates are used) to 6 feet past the far rail. For four-quadrant gate systems, the distance is extended to the point where the rear of a vehicle would be clear of the exit arm.	

Table 6: Distances Necessary for Preemption Timing

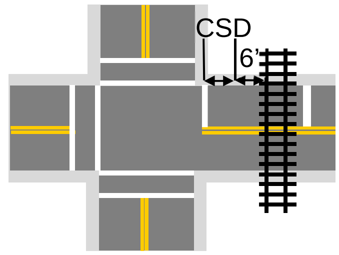
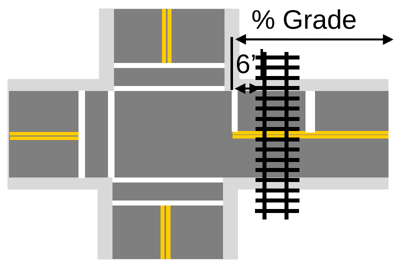
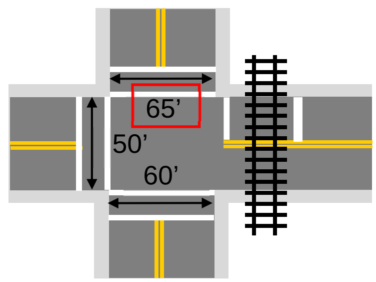
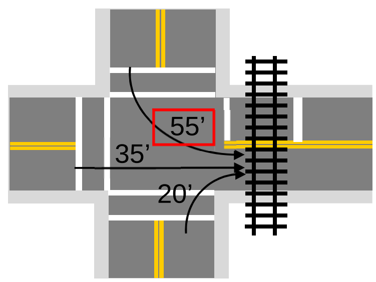
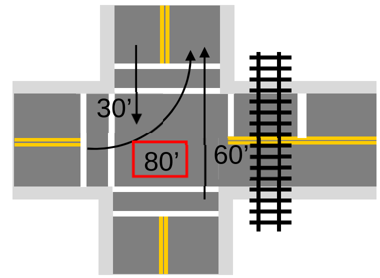
Term	Definition	Diagram
Clear storage distance (CSD)	The shortest distance from 6 feet past the near rail to the adjacent street intersection's stop line or the normal stopping point on a road.	
Grade	The average percent grade over a distance equal to the design vehicle clearance distance (defined in Section 3.1.2, *Determining Design Vehicle Length*), centered around the MTCD. When determining grade, note that uphill grades are positive, and downhill grades are negative.	
Longest crosswalk length	The length of the longest crosswalk at an intersection (in feet).	
Maximum approach move distance (MAMD)	The distance (in feet) from the farthest intersection stop line towards a Crossing. Depending on the proximity of the tracks to the intersection and the design vehicle, the MAMD is a possible measurement to consider when evaluating preemption. As such, this measurement is included as an optional tab in the Utah Preemption Form. Advance preemption time (APT) can be increased to include the amount of time it takes a design vehicle to travel from the far side of an intersection (any approach) to just past the front of the entrance gates. This allows the design vehicle to clear the intersection completely and progress through the Crossing without the risk of the vehicle stopping prior to the Crossing and blocking the intersection, in order to comply with the activation of the railroad warning equipment.	

Table 6: Distances Necessary for Preemption Timing

Term	Definition	Diagram
Maximum conflicting move distance (MCMD)	The longest distance (in feet) across the adjacent intersection that crosses the path of the track clearance phase. Depending on the proximity of the tracks to the intersection and the design vehicle, the MCMD is another possible measurement to consider when evaluating preemption. Similar to MAMD, this measurement is included as an optional tab in the Utah Preemption Form. APT can be increased to include the amount of time it takes a design vehicle to travel through an intersection. Paths of travel to consider are those that would potentially block a vehicle from exiting the Crossing area.	

Note: Refer to Section 3.3.3 for distance considerations at Skewed Crossings

3.1.2 Determining Design Vehicle Length

Determining the most appropriate design vehicle involves verifying the longest vehicle that typically uses a Crossing. *Table 7* (referenced from AASHTO's *Policy on Geometric Design of Highways and Streets*, 2011 Edition) lists the AASHTO designation for potential design vehicle types to be entered into the Utah Preemption Form. The Utah Preemption Form automatically populates the design vehicle length and height based on the vehicle type selected.

Table 7: Design Vehicle Type and Designations

Design Vehicle Type	AASHTO Designation	Design Vehicle Type	AASHTO Designation
Passenger Car	P	Intermediate Semitrailer	WB-40
Single-Unit Truck	SU-30	Intermediate Semitrailer	WB-50
Single Unit Truck (3 Axle)	SU-40	Interstate Semitrailer	WB-62
Intercity Bus-40	BUS-40	Interstate Semitrailer	WB-67
Intercity Bus-45	BUS-45	Double-Bottom Semitrailer/Trailer	WB-67D
City Transit Bus	CITY-BUS	Rocky Mountain Double-Semitrailer/Trailer	WB-92D
Conventional School Bus (65 Pass.)	S-BUS 36	Triple Semitrailer/Trailer	WB-100T
Large School Bus (85 Pass.)	S-BUS 40	Turnpike Double Semitrailer/Trailer	WB-109D
Articulated Bus	A-BUS		

Source: AASHTO *Policy on Geometric Design of Highways and Streets*, 2011 Edition.

The data collector should be aware that while a particular vehicle may be allowed to use a certain street, this does not mean that this vehicle should be selected as the design vehicle for study. Engineering judgment should be applied to determine the most appropriate vehicle type for a Crossing.

3.1.3 Collecting Traffic Signal Timing Information

The Highway Authority (whether UDOT or the relevant local agency) should have documentation of the traffic signal timing information necessary to complete the Utah Preemption Form. The data collector should request all information related to traffic signal timing and should confirm receiving data that includes, but is not limited to, the overall cycle length, track clearance green (TCG) times, signal phasing, and transitions during a preemption event, which would include the following traffic signal times:

- Minimum green time,
- Yellow change time,
- Red clearance time,
- Pedestrian walk time, and
- Pedestrian clearance time.

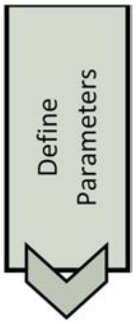
The data collector should understand the traffic signal timing practices of the Highway Authority (whether UDOT or the relevant local agency) that has the jurisdiction over the traffic signal under analysis (e.g., how does the agency calculate pedestrian clearance time, does the pedestrian clearance time include vehicle yellow and all-red, etc.).

3.1.4 Collecting Railroad-specific Data

The applicable Railroad representative provides the required Railroad timing information to complete the Utah Preemption Form. Generally, the data collector should obtain applicable Railroad warning times, advance preemption time, train speed, light flashing time before gate descent, gate descent time, buffer time, and (Railroad) equipment response times. The data collector should also document any Crossing concerns noted by the Railroad representative. Local Railroad representatives can provide valuable information regarding a Crossing that should be considered. Discussions can include vehicle types at the Crossing, unsafe motorist reports, and equipment issues (e.g., broken gate and near miss reports).

At any particular crossing, train operations can play a significant part of how the crossing operates. Near rail yards, for instance, switching moves are common and should be expected, depending on the operations at the yard. These types of factors need to be considered when determining the preemption time parameters that should be provided at a Crossing.

3.2 Step 3.2: Defining the Preemption Parameters



This section discusses the rail and highway signal timing parameters and factors to consider for calculating preemption timing. The understanding of these concepts will help designers, engineers, and technicians (the "practitioners") effectively communicate and correctly calculate preemption for site-specific conditions.

3.2.1 Railroad Parameters

Parameters described in this section are defined by the American Railway Engineering and Maintenance of Way Association (AREMA), which are used by a Railroad to provide sufficient warning time before a train arrives at a Crossing. Highway practitioners should understand the following parameters to correctly calculate preemption timing and communicate preemption timing needs to the applicable Highway Authority and Railroad.

Minimum time (MT), as defined by the UMUTCD and AREMA, is the minimum time of active warning device operation <u>prior</u> to the train's arrival at a Crossing. The MT must not be less than **20 seconds** as per the UMUTCD and AREMA. Additional warning time may be added as described below.

Clearance time (CT) must be added if the MTCD exceeds 35 feet. Under this condition, one second of CT is added for each additional 10 feet, or portion thereof. The equation is (MTCD - 35 feet)*0.1 sec/feet and should be rounded up to the nearest whole number. For example, if the MTCD is 48 feet, 2 seconds of CT should be used. *Table 8* provides CT seconds based on the various ranges of MTCDs.

Table 8: Example of How Clearance Time Should be Applied

MTCD (feet)	CT (seconds)
0 – 35	0
36 – 45	1
46 – 55	2
56 – 65	3

Notes: Practitioners should use integers for distance and time measurement. Rounding procedure should be determined based on engineering judgement. This *Table 8* provides examples of how to apply the CT equation. Practitioners should perform the CT calculation for MTCD > 65 feet.

Minimum warning time (MWT) is the summation of the MT and CT.

MWT = MT + CT

Train detection should be designed to provide at the least the MWT required for the fastest train expected to travel through a Crossing. However, factors such as train handling and type of rail detection can cause variability in warning times, which is typically handled by the Railroad's buffer time (BT).

Buffer time (BT) is the additional discretionary time provided by a Railroad to account for variability in train handling. As shown in AREMA Figure 3310-1, BT shall not be considered part of the MWT. Railroads often include a BT to increase the total warning time (TWT) to ensure the gates are down 5 seconds before a train arrives at a Crossing.

Total warning time (TWT), as provided by the Railroad, accounts for variability in warning time and is calculated as:

TWT = MWT + BT

Advance preemption time (APT) is the additional time required by a traffic signal to transition from the normal (current) operating traffic signal phase to clear traffic from a Crossing (and, if necessary, from a CSD) before the railroad warning devices are activated. When APT is provided, the notification of an approaching train is forwarded to the highway traffic signal controller by the railroad equipment in advance of the activation of the railroad warning devices. APT is used when MWT is not enough to safely and adequately clear traffic from a Crossing. The Highway Authority needs to coordinate with the Railroad to provide the necessary APT.

Equipment response time (ERT) must be provided by the Railroad and will vary based on the railroad detection circuitry and equipment. ERT is the time it takes the railroad equipment to detect an approaching train, measure the train speed (if constant warning is available), and begin to predict the programmed warning times.

Total approach time (TAT) (also known as system design time in AREMA) is the Railroad design time, and it is calculated as:

TAT = TWT + APT + ERT

Figure 6 illustrates how each of these parameters relate to a Crossing.

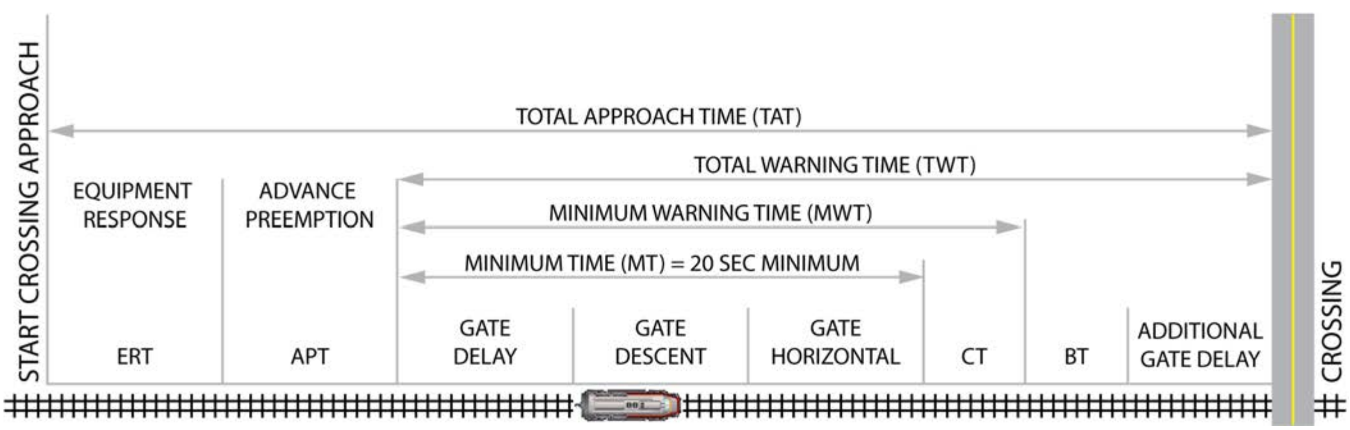


Figure 6: Railroad Warning Times

3.2.2 Traffic Signal Parameters

Most traffic signal controllers used in Utah have the ability to receive and manage several preemption and priority inputs. The order in which preemption and priority inputs are processed by the traffic signal controller is determined based on the priority level assigned to the input by the programmer and the relative hazard that each source represents to the motorists. Per Section 4D.27, P16 of the UMUTCD, where traffic signals are designed to respond under preemption to more than one type of rail or class of emergency vehicle, a Highway Authority *shall confirm that the following preemption precedence is never over-ridden by any other preemption or priority input*:

1. Freight/commuter/light rail preemption (where active warning devices are used)

Beyond this, a Highway Authority should apply the following order of precedence to process preemption and priority inputs:

2. Emergency vehicles (fire department vehicles, ambulances, etc. as per Utah Code 41-6a-102)
3. Transit vehicle preemption (light rail and streetcar for in-street running applications where active warning devices are not used)
4. Transit vehicle priority requests (light rail, streetcar, bus rapid transit [BRT], and bus)

A typical preemption sequence is:

- Entry into preemption (includes traffic signal equipment response time),
- Termination of the interval in operation (right-of-way transfer time [RWTT]),
- Track clear intervals,
- Preemption limited service/cycle intervals (green for phases not conflicting with train movement), and
- Return to normal operations after preemption.

Prioritizing Preemption Inputs

In the early part of 2015, a commuter train heading north out of New York City struck a vehicle that was stopped on the tracks of a Crossing. The National Transportation Safety Board conducted a thorough investigation of the crash and determined that the traffic control signal adjacent to the Crossing had two forms of preemption: one to clear the tracks when an approaching train was detected and another to keep the signalized intersection clear if a queue leaving the intersection in the direction of the Crossing was detected. The investigation revealed that if the preemption to keep the signalized intersection clear was active, then the preemption to clear the tracks was not implemented because it is not given top priority.

This manual recognizes the importance of ensuring at all times that freight/commuter/light rail preemption (where active warning devices are used) receives first priority when multiple or successive preemptions occur (Section 8C.09, P10 of the UMUTCD).

The following parameters are defined by AREMA and are used to provide sufficient preemption time at a preempted traffic signal before a train arrives at a Crossing. Highway practitioners should understand these parameters to correctly calculate preemption timing or the effect of signal timing on preemption in order to communicate preemption timing needs to a Railroad.

Right-of-way transfer time (RWTT) is the maximum amount of time needed for the worst case condition, prior to display of the TCG interval. This includes traffic signal control equipment time to react to a preemption call, in addition to any traffic control signal minimum green, pedestrian walk and change, yellow change, and red clearance intervals for conflicting traffic. Pedestrian clearance includes the change (flashing Don't Walk), yellow, and all-red intervals (solid Don't Walk).

Since preemption can occur at any point in a traffic signal's normal cycle of operation, enough time must be provided to safely terminate any active phase or combination of active phases at any point in the cycle. In order to terminate the active phase safely, minimum green, yellow change and red clearance times, and pedestrian clearance times must all be considered. This is the design (worst case) condition. It is important to remember that in actual operation, this time may be zero.

It is recommended that 1) there is a minimum through green time of four (4) seconds during RWTT, 2) vehicle yellow change and red clearance times remain consistent with normal operations, and 3) the pedestrian "walk" time is eliminated. The decision on whether to truncate pedestrian flashing "Don't Walk" interval (pedestrian change interval) should be site specific and based on engineering judgement. The preference for Utah's Crossings is to maintain the pedestrian change interval.

The decision on whether or not to truncate the flashing "Don't Walk" interval should be made on a case-by-case basis, with approval from the UDOT Traffic Signal Operations Engineer or local agency equivalent, and should consider the following:

- Train frequency
- Pedestrian frequency
- Train operations (e.g., ability to stop at a Crossing)
- Presence of flashing lights/bells to increase pedestrian awareness

Track clearance green (TCG) is the traffic signal time to clear stopped vehicles from the track area on the approach to the signalized highway intersection. As per the *ITE Guideline*, the TCG interval should equal or exceed the queue clearance time (QCT). The TCG interval must be long enough to prevent a premature display of a red traffic signal for traffic clearing the tracks. In the past in Utah, the sync point between the TCG and gate descent is typically programmed such that the TCG phase turns yellow as soon as the gate(s) begins its descent. (This applies only for advance preemption.) Alternatively, the use of a gate-down circuit provided by a Railroad can provide real-time operational information to use to terminate TCG. *It is not required that the TCG be long enough to clear all vehicles between a Crossing and a signalized intersection if there is sufficient CSD for the design vehicle. This time can also be determined by field observations.*

Queue clearance time (QCT) is the time required for the design vehicle of maximum length stopped just inside the MTCD to start up and move through and clear the entire MTCD.

Separation time (ST) is the component of maximum preemption time (MPT) during which the MTCD is clear of vehicular traffic prior to the arrival of a train.

Maximum preemption time (MPT) is the total amount of time required after the preempt sequence is initiated by the railroad warning equipment to complete the timing of the right-of-way transfer to the TCG interval, to initiate the track clearance phase(s), to move the design vehicle out of the Crossing's MTCD, and to provide an ST before a train arrives at a Crossing.

MPT = RWTT + QCT + ST

3.2.3 Simultaneous Preemption vs. Advance Preemption

Simultaneous preemption occurs when notification of an approaching train is forwarded to the highway traffic signal controller unit and the railroad active warning devices at the same time.

Figure 7 provides an example of a simultaneous preemption operational timeline for a traffic signal and active warning devices. Because of site-specific variables, the timeline is very rudimentary in nature, but shows the sequence of events that occur at a Crossing with simultaneous preemption, including the termination of pedestrian time and vehicle time on the parallel street and then the beginning of TCG time. These traffic signal activities occur at the same time the railroad lights begin flashing and the entrance gates start lowering. The timeline shows the entrance gates lowering and the transition of the traffic signal from track clearance to limited service operations for the duration of the preemption event.

Many locations equipped with simultaneous preemption do not have enough delay time between clearing vehicles through the MTCD and the lowering of the gates. This could result in a gate striking a vehicle stopped under the gate and could also result in a damaged gate. Furthermore, motorists can behave unpredictably in this situation.

For these reasons, this Manual *recommends that advance preemption be used instead of simultaneous preemption.*

Advance preemption occurs when notification of an approaching train is forwarded to the traffic signal controller unit by railroad equipment for a period of time prior to the activation of the railroad active warning devices.

Because of variables that must be determined in an engineering study, *Figure 8* provides a rudimentary example of an advance preemption operational timeline for traffic signal and active warning devices.

For advance preemption time: APT = MPT – MWT

There are several benefits that are realized under advance preemption. One of the benefits of using advance preemption, as compared to simultaneous preemption, is the reduced amount of railroad warning system activation time at locations where a large amount of MPT is necessary to adequately clear the crossing of vehicles. Advance preemption may be beneficial at these locations since long activation of warning times could contribute to lack of respect for the control device, resulting in undesirable motorist behavior. Advance preemption must consider additional time required by a traffic signal to clear traffic from a Crossing before the active warning devices are activated.

Therefore, advance preemption is the preferred method of preemption in Utah, unless engineering judgment shows that simultaneous preemption is adequate.

The use of advance preemption requires close coordination between a Highway Authority and a Railroad to ensure that all parties have a basic understanding of the operation of each other's system.

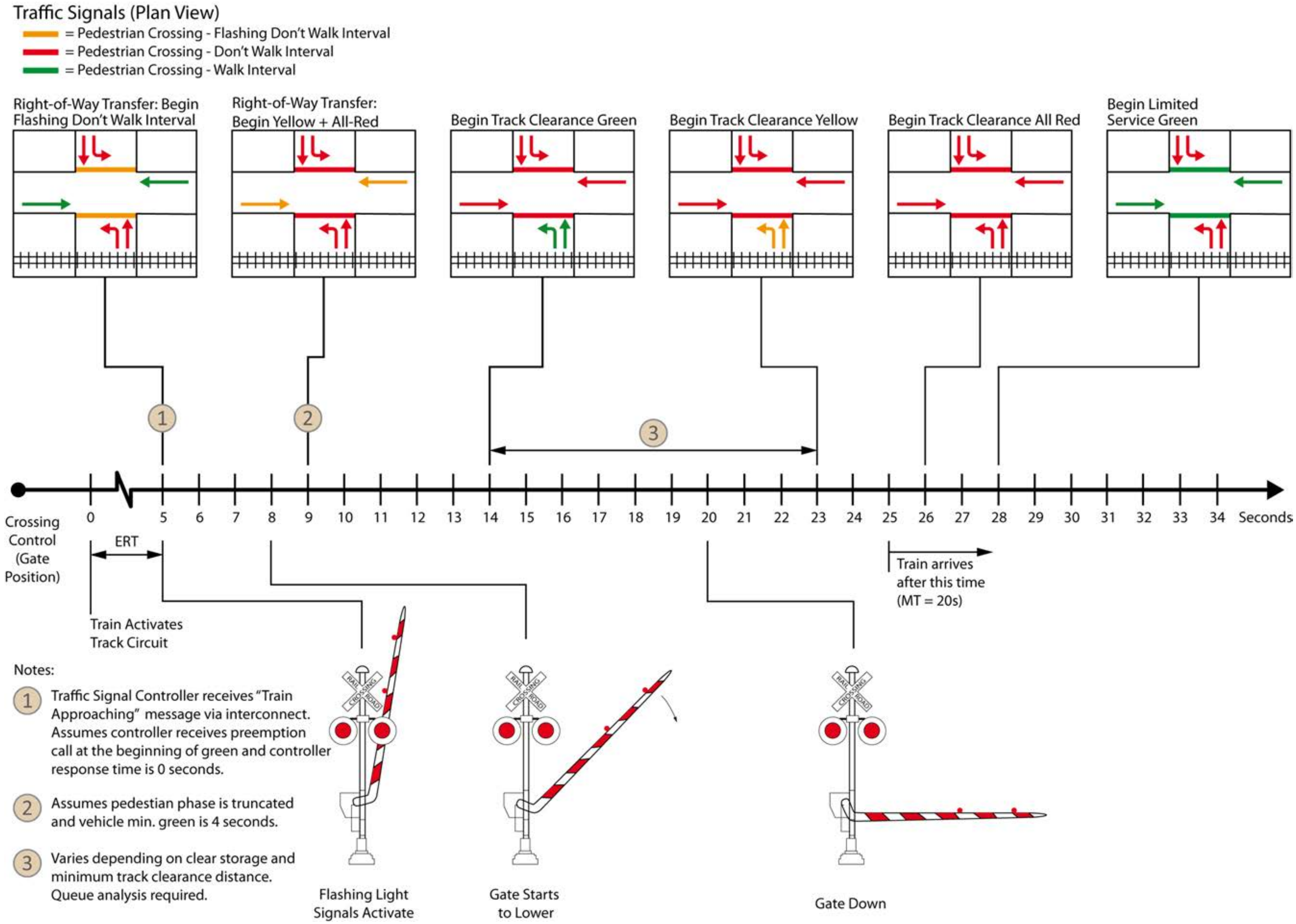


Figure 7: Example of Simultaneous Preemption

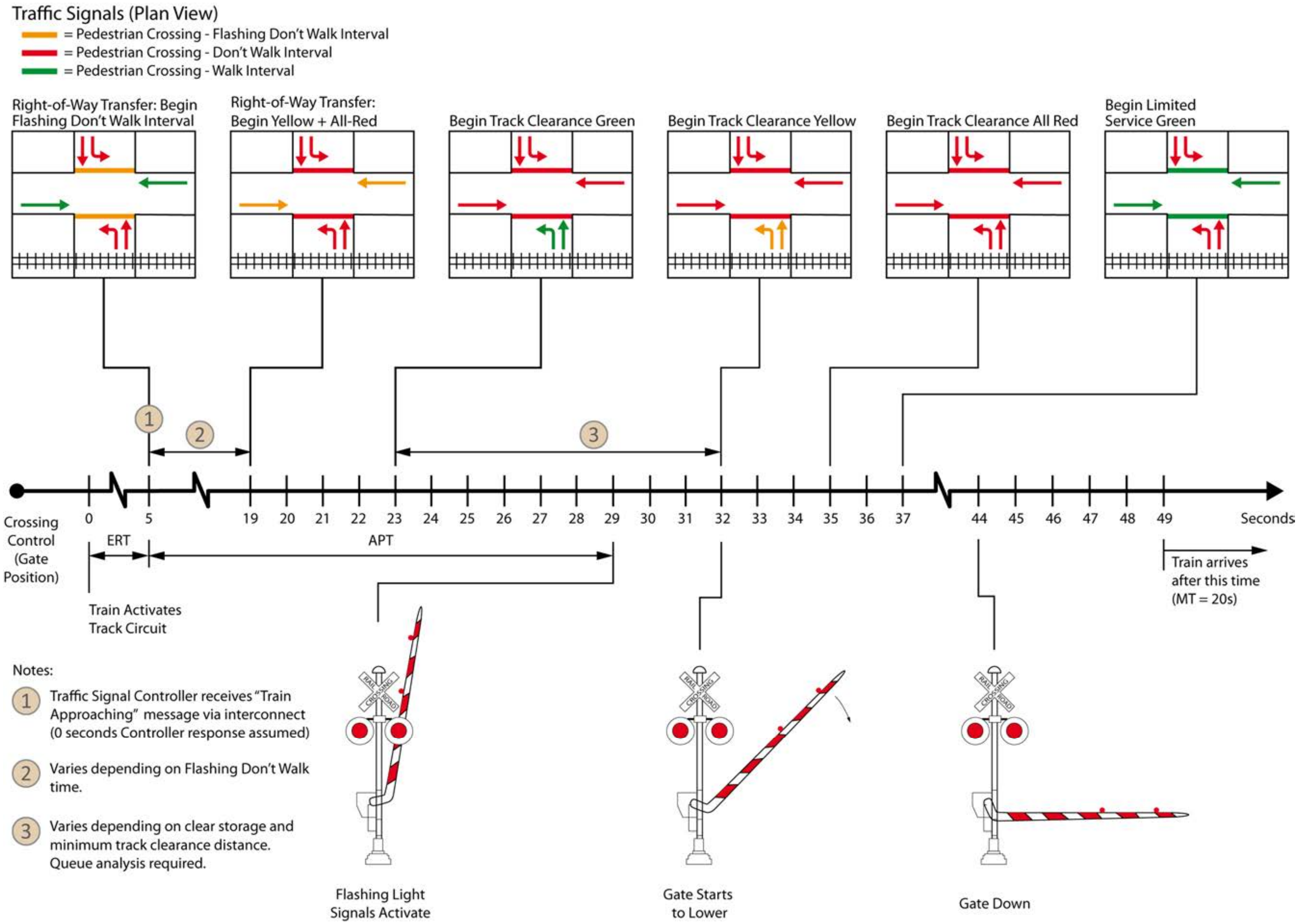


Figure 8: Example of Advance Preemption

3.3 Step 3.3: Contemplating Special Scenarios

There are certain scenarios that should be considered when making preemption calculations at certain Crossings. The following details some of these conditions.

3.3.1 Pedestrians

When evaluating preemption parameters, one special scenario that must be considered is the potential for truncation of pedestrian walk/change intervals. The UMUTCD allows for the truncation of pedestrian walk and/or change intervals when a railroad preemption call is received. Truncation allows for shorter RWTT, but it may not provide sufficient time for pedestrians to completely cross a street. Depending on the existing railroad infrastructure, providing full pedestrian time during preemption events may require significant improvements to a Railroad's infrastructure. If pedestrians typically do not use the intersection, then providing the full pedestrian time during preemption events might be considered over-designing.

Parameters to take into account when deciding whether or not to truncate pedestrian walk/change intervals are described in Section 3.2.2, *Traffic Signal Parameters*.

It is also important to consider that at signalized intersections that are preempted with a railroad, pedestrian calls should be activated through the use of a pedestrian push button whenever possible. If no pedestrians are being served when the preemption call is received, then the transfer to preemption operations can occur more quickly.

Expanded upon in Section 3.3.6, *Preemption Traps*, the other element that must be considered if pedestrian timing is not truncated is the potential of creating a vehicle trap condition.

3.3.2 Train Operations near a Crossing

Other criterion to consider is the proximity of a Crossing to a rail yard operation.

The proximity of a Crossing to a rail yard should be considered because Crossings located near rail yards or switching operations have a tendency to have trains stopped near or sometimes on a Crossing for extended periods. Rail yards can have this effect at Crossings that may not be considered nearby because they often create long trains of rail cars while sorting that can extend back onto the Crossing. If advance preemption or long warning times in general are proposed at a Crossing, the train switching operations can cause the traffic signal to go into preemption even though the train may never reach the Crossing. This can be frustrating to motorists and can eventually lead to motorist non-compliance at a Crossing if the warning equipment continues to activate, but no train occupies the Crossing. If a similar condition is known to exist or is proposed, the Highway Authority should request the Railroad to determine if there are any design solutions to this type of preemption. Additionally, this type of configuration within close proximity to a rail yard is not a good location for long APT for these reasons.

The Highway Authority should talk to the Railroad about the options that can be considered to prevent multiple preemption events because of train operations in order to focus the preemption events to primarily those times that a train will be entering a Crossing.

3.3.3 Highway Geometry at a Crossing

Several scenarios must be considered related to highway geometry at a Crossing during preemption. The specific scenarios that should be considered are as follows.

Grades

As is discussed in Section 3.1.1, *Determining Distances Critical for Preemption Timing*, percent grades going over the MTCD must be measured at each Crossing. This measurement, when used in a preemption calculation, provides additional time to account for the effect of an uphill or positive grade on design vehicles 1) to start moving and 2) to accelerate through the MTCD before the train arrives. Grades are also important in determining the amount of time for the approach and conflicting vehicle movements. Grades are included accordingly in the calculations.

Skewed Crossings

Crossing skew is another special condition that must be considered during the calculation process. Skewed crossings are defined as a Crossing where the intersection between track and highway (Ø) is not equal to 90°.

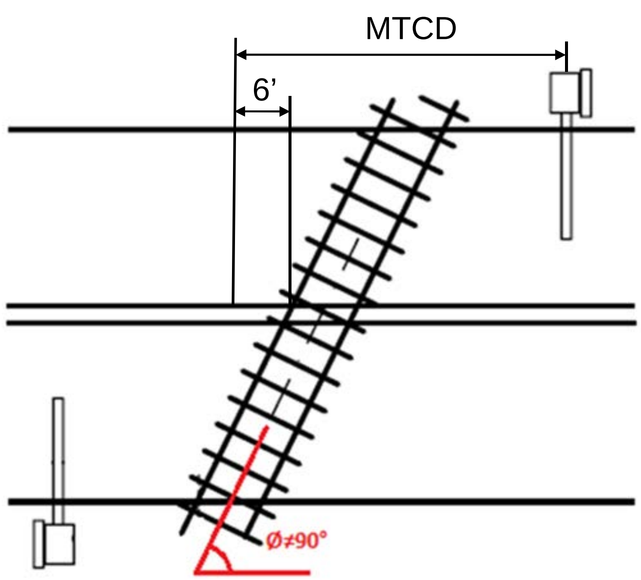


Figure 9: Skewed Crossing

Skewed Crossings also create a larger MTCD because of the angle of the tracks, which leads to an increased clearance time and total approach time. See Figure 9 for details.

3.3.4 Design Vehicle Percent of Trucks Crossing

As discussed in Section 3.1.2, *Determining Design Vehicle Length*, the design vehicle selection is based on the longest vehicle that typically uses a Crossing. The determination requires engineering judgment. Determining the design vehicle is an important and somewhat qualitative decision, therefore, evaluations should include a review of the types of vehicles that currently use a Crossing to determine if the average daily traffic (ADT) and truck percentages provided for a Crossing are accurate. Crossing users can change over time, so if field observations can determine the percent of trucks using a Crossing, that is beneficial.

The selection of the design vehicle has a direct effect on the preemption time calculation. Not only in the amount of time that is needed to clear the track area, but also in conflicting and approach vehicle times (should those calculations be included).

3.3.5 Multiple Preempt Calls

When evaluating a Crossing with two or more tracks, it is important to determine if there is the possibility for multiple trains to simultaneously use a Crossing. If a second train arrives when a traffic signal is already in railroad preemption mode, the traffic signal will continue in railroad preemption until both trains have cleared the Crossing. From a preemption calculation standpoint, there are no special adjustments that need to occur, as the preemption time for that Crossing (prior to the train's arrival) is not affected by the number of trains that arrive after the first preemption time is provided and before the first preempt sequence has terminated. However, discussions with the Railroad should implement "second train" logic in the railroad equipment per AREMA's *Communications and Signal Manual,* Parts 3.1.10, E.12.

3.3.6 Preemption Traps

Another scenario to be aware of is the preemption trap, which occurs when the track clearance phase ends before the gates and the warning devices are activated. Preemption traps can occur if the TCG time is not long enough or if it is not provided at the right time. For instance, if the actual RWTT during a specific preemption event is shorter than the maximum calculated RWTT, then the traffic signal controller will transition more quickly to TCG and then onto limited service over a shorter amount of time. If the traffic signal controller transitions to limited service (i.e., red signal indication for the approach, while green for non-conflicting phases) before the warning devices are activated, then a vehicle can foul the tracks during limited service. The preempt sequence will not provide TCG time again because TCG was already provided for the Crossing.

One way to prevent this is through the use of a gate down circuitry. The controller can be programmed to stay in TCG until the gate down relay information is received. This is an effective way to prevent preemption traps and allow for a transition to limited service operations as soon as the gate is down. Another option is to program a long TCG time that accounts for the maximum RWTT. *This option is not recommended because of the variables in RWTT*.

3.3.7 Advance Preemption Time to Avoid Gate Hitting Design Vehicle

Special consideration should be given to gate arm descent and the proximity of the gate to the travel path of the design vehicles when calculating preemption timing. This should be evaluated on a Crossing-by-Crossing basis and should be considered if the historical Crossing data indicate that there is an issue with broken gates. When this is deemed necessary, the Vehicle Gate Interaction tab of the Utah Preemption Form should be used.

3.3.8 Pre-signal and Queue Cutter Traffic Signals

Another specific scenario to consider is whether or not a pre-signal or queue cutter should be installed at a Crossing. The UMUTCD specifies that when a Crossing exists within 50 feet (*or within 75 feet for a highway that is regularly used by multi-unit highway vehicles*) of an intersection controlled by a traffic signal, a pre-signal should be considered. Queue cutter signals are used when the downstream signal is relatively far from the tracks, but vehicle queues tend to back up to the tracks (i.e., an Influence Zone Queue). Since the UMUTCD does not designate the consideration of pre-signals or queue cutters at distances greater than 50 feet from a downstream intersection, *Table 9* can be referenced for general distances, applications, and operational characteristics for both pre-signals and queue cutters. A sample pre-signal design is shown on *Figure 10*, and a sample queue cutter signal design is shown on *Figure 11*.

Table 9: Application and Operational Characteristics of Pre-signals and Queue Cutters at Specified Distances

Clear Storage Distance (CSD)	Application	Key Operational Characteristics
0 feet to 50 feet	Pre-signal	• Pre-signal operates continuously in coordination with downstream traffic signal and should include green offset where the downstream signal remains green longer than the pre-signal in order to clear all vehicles from the Crossing through the downstream intersection • Timing plan provides QCT sufficient to clear both the MTCD and CSD
50 feet to 120 feet	Pre-signal	• Pre-signal operates continuously in coordination with downstream traffic signal and should include green offset where the downstream signal remains green longer than the pre-signal in order to clear all vehicles from the Crossing through the downstream intersection • Timing plan provides QCT sufficient to clear the MTCD, but vehicles may remain in CSD
120 feet to 450 feet	Pre-signal or queue cutter	• Pre-signal or queue cutter signal can be chosen to best manage traffic at a Crossing • Pre-signal operates continuously in coordination with downstream traffic signal and should include green offset • Pre-signal may include queue detection to extend the duration of the green clearance interval • Queue cutter signal operates generally independently from downstream traffic signal for queue prevention at a Crossing • Queue cutter signal allows vehicles in CSD, but prevents vehicles in MTCD
Greater than 450 feet	Queue cutter	• Queue cutter operates when required to prevent queuing in MTCD • Activation and timing plan designed to prevent vehicles from queuing in the MTCD, but vehicles may queue in CSD

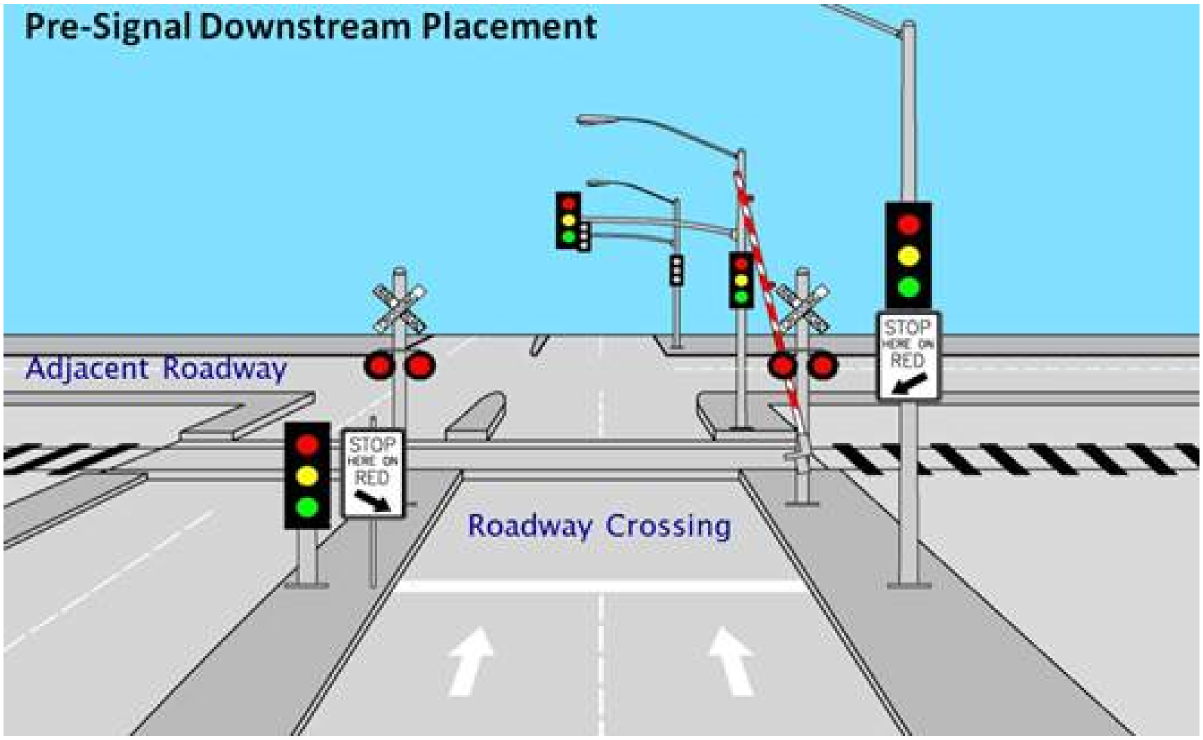


Figure 10: Sample Pre-Signal

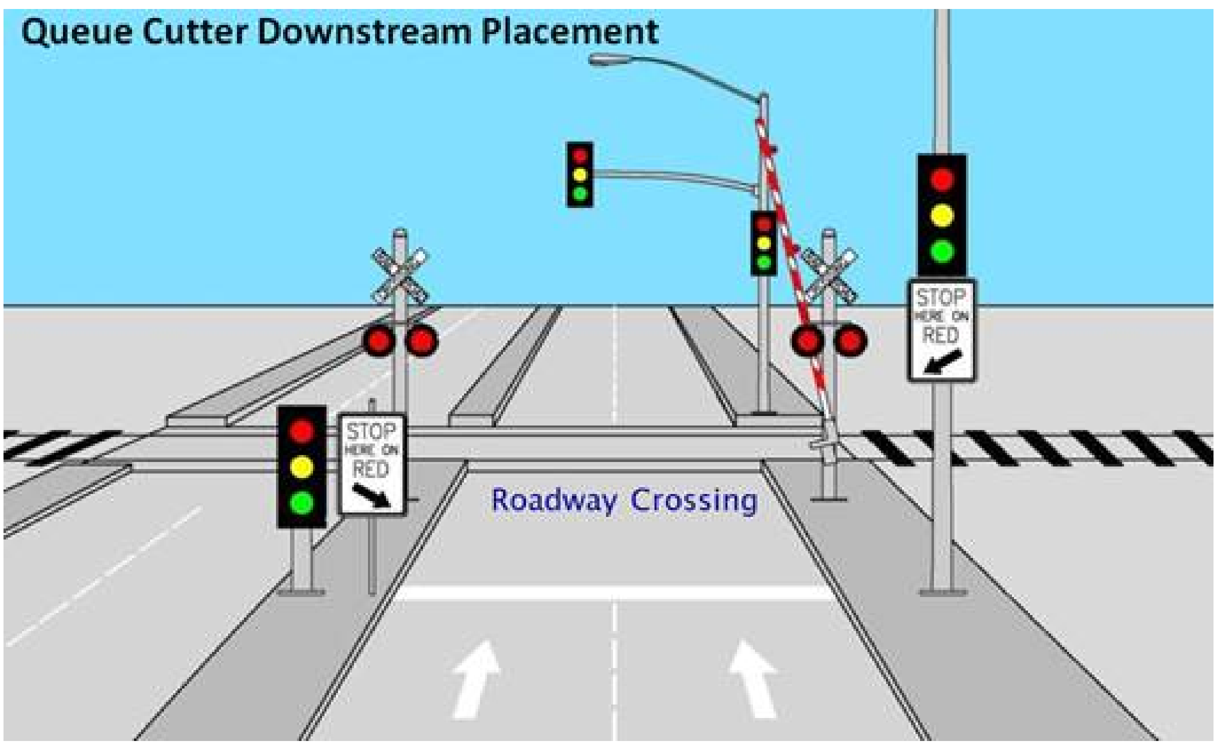


Figure 11: Sample Queue Cutter

While pre-signal and queue cutter signal distances are provided above, the main criteria to install a pre-signal or queue cutter is the observation of regular on-track queuing or the likely potential for on-track queuing under future conditions. If on-track queuing is known to occur and/or is observed during either the identification or calculation process, a pre-signal or queue cutter should be considered for the Crossing.

If a pre-signal or queue cutter is used, its design and operation should ensure that it does not obscure the railroad warning devices. Providing advance preemption at these Crossings allows the traffic signal to transition to TCG prior to the activation of the railroad warning device.

For preemption calculation purposes, modifications can be made to better account for these types of traffic signals, as follows.

Queue Cutter Signal Preemption Calculation Considerations

- The CSD may be set to zero. The queue cutter signal by design allows vehicles to store in the CSD (which could be extremely long, depending on where the next traffic signal is located). Thus, for calculation purposes, the CSD never needs to be fully cleared out.
- There are no maximum conflicting vehicles or maximum approach vehicles.
- There is no pedestrian clearance time for right-of-way transfer (i.e., no crosswalks).
- A mid-block queue cutter signal is typically interconnected for simultaneous preemption.
- APT is typically recommended to transition the queue cutter traffic signal from green to yellow to red, prior to the beginning of the railroad flasher activation.

See the Preemption Calculation Form for further instructions on how to calculate.

Pre-signal Preemption Calculation Considerations

- CSD, or a portion thereof, may be included in the calculation, depending on the distance to the downstream intersection and the proposed traffic operations. For example, the QCT is calculated based on the design vehicle clearing only the MTCD. However, the TCG should be sufficient to clear the MTCD and the CSD, or based on an engineering study, the MTCD and a portion of the CSD so some vehicles may remain in the CSD. This is especially important to consider when CSDs are longer.

3.3.9 Pedestrian/Bike Trail near a Crossing

Another specific scenario to consider is when a pedestrian/bike trail and pedestrian/bike trail traffic signal is installed near a Crossing. These traffic signals operate by transitioning to red and then providing time for pedestrians to cross from one side of a trail to the next.

For preemption calculation purposes, modifications can be made to better account for these types of traffic signals, as follows.

Pedestrian/Bike Trail Signal Preemption Calculation Considerations

- The CSD may be set to zero if there is significant distance between the Crossing traffic signal and the nearest signalized intersection. See Table 9 for typical distances where queue cutters can be applied.

See the Preemption Calculation Form for further instructions on how to calculate.

3.3.10 Street Running Gated Operations

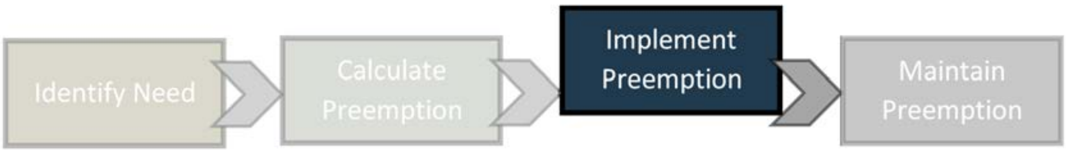
Street running train operations offer their own unique considerations. These types of Crossings need to be assessed on a Crossing-by-Crossing basis, considering type, speed, and frequency of trains, as well as highway user information. The preemption of a traffic signal under street running gated operations, will need to be fully integrated into the traffic signal operation. Certain elements of the Utah Preemption Form (e.g., the use of MAMD) may not be applicable to this type of crossing configuration.

3.4 Step 3.4: Completing the Preemption Form

Building upon Steps 3.1 through 3.3, the process ends by completing the Utah Preemption Calculation Form, attached as Appendix A (*Utah Preemption Form*). Appendix A includes line-by-line instructions, which details how a user can complete the form. A Highway Authority may also need to complete a traffic signal preemption request form, such as UPRR’s *Highway Rail Grade Crossing Traffic Signal Preemption Request Form* (Appendix C) when requesting preemption changes from a Railroad.

Chapter 4 Implementation

The results from Chapter 3, *Calculating Preemption Time* are now incorporated into potential project actions initiated by a Highway Authority or Railroad. This chapter describes three specific "Actions" (i.e., 1) traffic signal maintenance/timing adjustments, 2) railroad changes, and 3) roadway infrastructure improvements) that may require calculating preemption timing. This chapter also summarizes necessary responsibilities for completing a preemption assessment under each of these three Actions.



Referenced throughout the chapter, three key concepts represent the routine activities required to complete the preemption evaluation process.[3] These concepts are:

- **Calculate:** Chapter 3, *Calculating Preemption Time*, describes the process for collecting data, assessing preemption, and calculating preemption timing.

  Typically, if UDOT initiates an Action, the UDOT Traffic Signal Operations Engineer (or other resource as assigned by the UDOT Chief Railroad Engineer) would complete the preemption timing calculations. When a local Highway Authority initiates an Action, the local Highway Authority would assign the preemption timing calculations to an appropriate individual knowledgeable in calculating preemption timing.

  If a Railroad initiates an Action that could impact a state highway, the Railroad would contact the UDOT Chief Railroad Engineer, who would assign a resource (typically the UDOT Traffic Signal Operations Engineer) to complete the preemption timing calculations. If a Railroad initiates an Action that could impact a local roadway, the Railroad would contact the local Highway Authority and the UDOT Chief Railroad Engineer. The local Highway Authority would then assign the preemption timing calculations to an appropriate individual knowledgeable in calculating preemption timing.
- **Review:** Once preemption timing is calculated, the UDOT Chief Railroad Engineer, Railroad, and Highway Authority review the preemption timing changes to concur on the proposed changes. A Railroad may provide concurrence through approving a traffic signal preemption request form, such as UPRR's *Highway Rail Grade Crossing Traffic Signal Preemption Request Form* (Appendix C).
- **Approve:** The UDOT Chief Railroad Engineer approves the preemption timing changes. These changes are then implemented in the field by the responsible agency(ies) in coordination with the Railroad and the UDOT Chief Railroad Engineer.

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[3] If a signal does not currently operate with preemption, follow the process outlined in Chapter 2, *Identifying the Need for Preemption*, to identify whether the Action should consider preemption at the Crossing's adjacent intersection.

4.1 Action 1: Traffic Signal Maintenance/Timing Adjustments

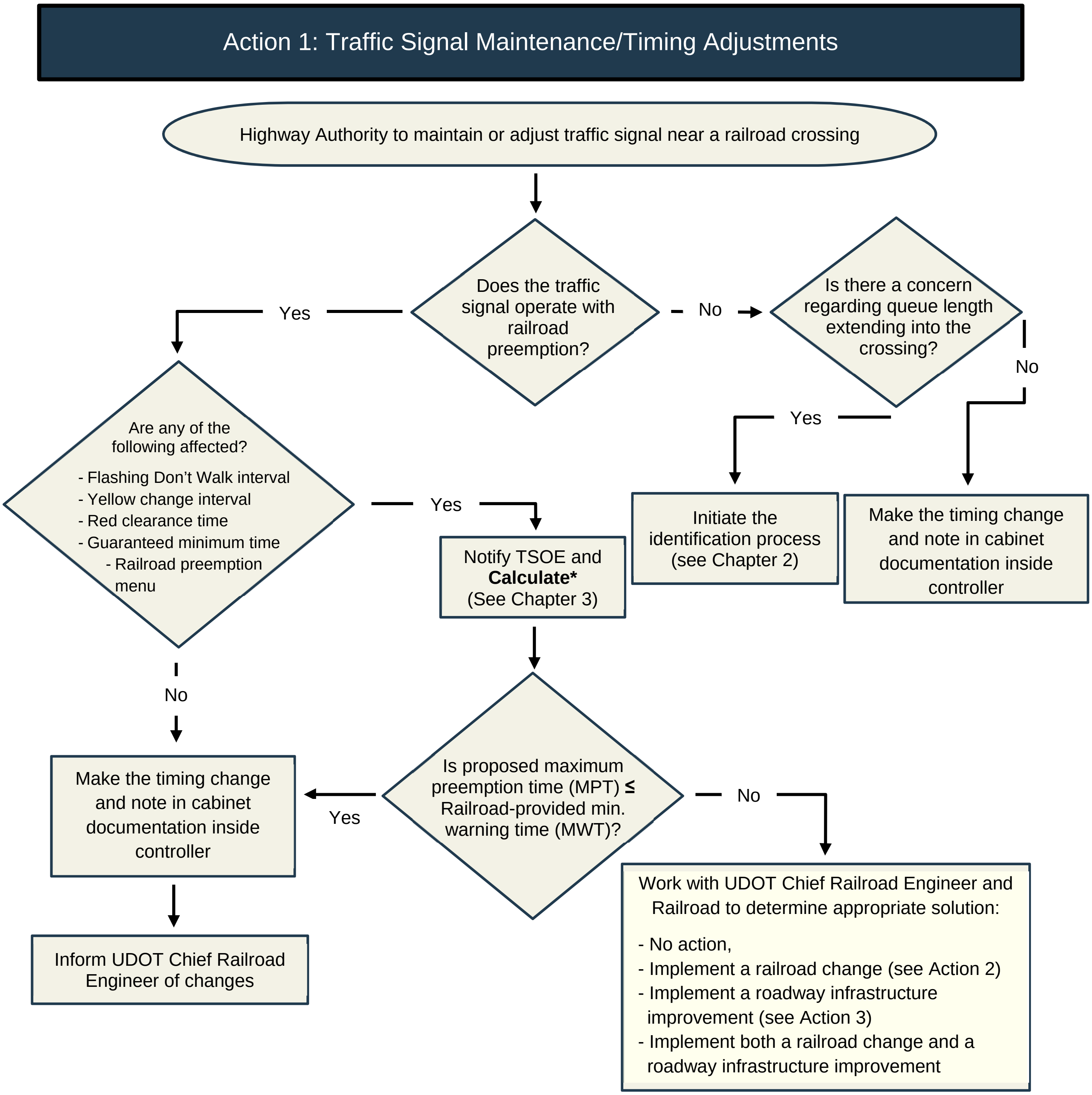
Action 1 is the most common of the three Actions and generally entails projects initiated by a Highway Authority to modify traffic signal timing, optimize a corridor, change equipment, or conduct maintenance by UDOT's Traffic Management Division or an equivalent local Highway Authority. Action 1 may or may not affect preemption timing or lead to the identification of a preemption need. For instances that impact preemption timing, the process on *Figure 12* would commence, and the UDOT Chief Railroad Engineer, with the support from the Traffic Signals Operations Engineer, would approve all proposed changes to preemption timing (including if preemption is required at an intersection).

Table 10 lists specific traffic signal timing adjustments that may affect preemption timing. Prior to making any adjustments, the UDOT Traffic Signal Operations Engineer or local agency equivalent must confirm that the traffic signal change does not affect preemption timing.

Table 10: Traffic Signal Timing Parameters that May Affect Preemption Timing

Preemption Calculation Parameter	Traffic Signal Timing Adjustment	Notes/Considerations
Right-of-way transfer time (RWTT) and track clearance green (TCG)	Flashing Don't Walk interval	This includes changes to the pedestrian Flashing Don't Walk interval.
	Yellow change interval	This includes increasing or decreasing the yellow change interval.
	Red clearance time	This includes increasing or decreasing the red clearance time.
	Guaranteed minimum time	The guaranteed minimum times will override preemption timing if the values violate the programmed guaranteed times.
	Railroad preemption menu	This includes all changes within the railroad preemption menu.

As a best practice to ensure these parameters are not inadvertently changed without prior approval, the Highway Authority should specify in each controller that these parameters **<u>should not</u>** be changed without first contacting the UDOT Traffic Signal Operations Engineer or local agency equivalent.



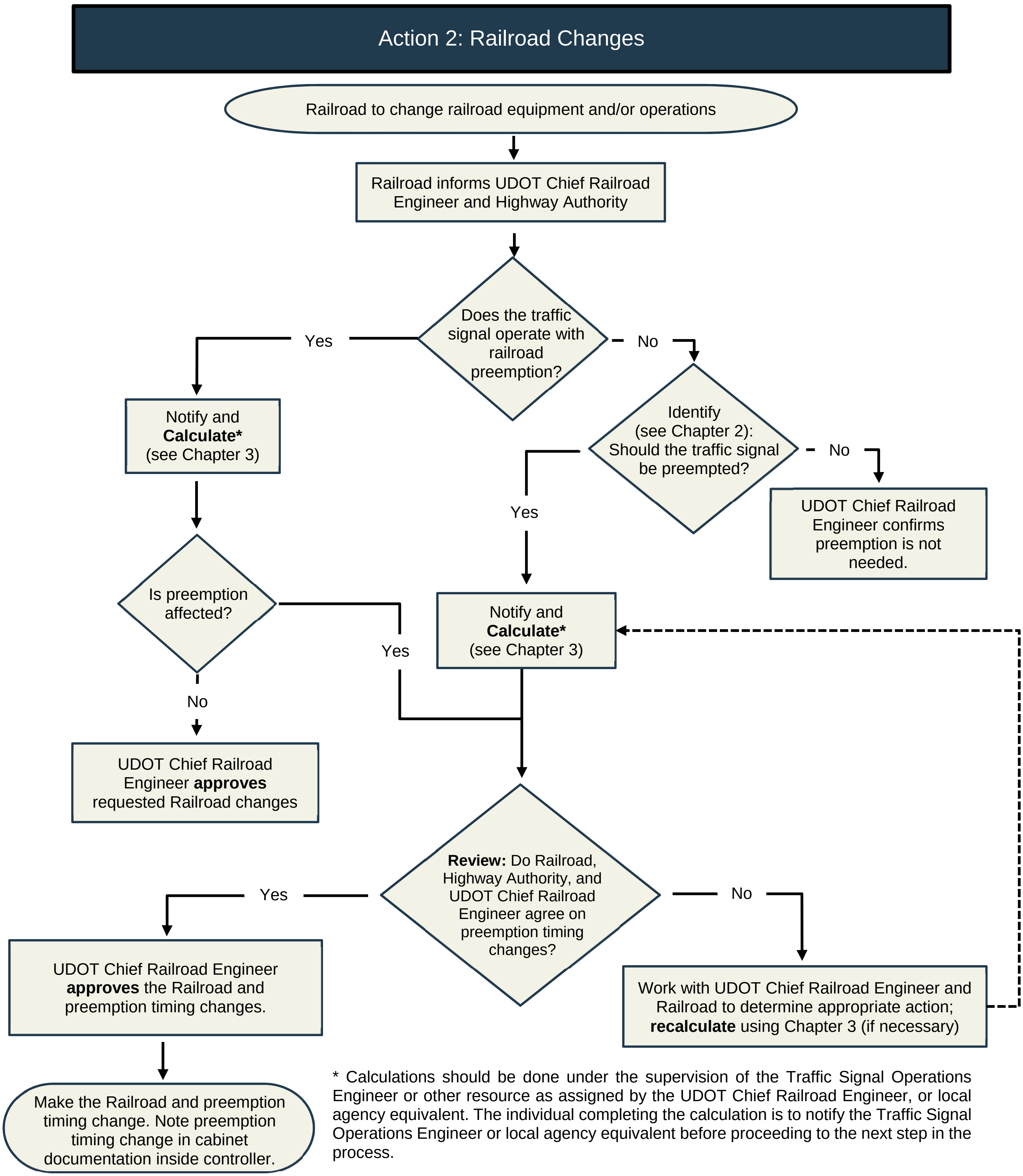
* Calculations should be done under the supervision of the Traffic Signal Operations Engineer or other resource as assigned by the UDOT Chief Railroad Engineer, or local agency equivalent. The individual completing the calculation is to notify the Traffic Signal Operations Engineer or local agency equivalent before proceeding to the next step in the process.

Figure 12: Signal Timing or Maintenance Workflow

4.2 Action 2: Railroad Changes

Action 2 generally consists of either 1) changes to a Railroad's equipment, timing, or train speed, or 2) Railroad-initiated projects that modify a Crossing's geometry, train detection, active warning devices, or the interconnect circuit. A Railroad starts the Action by informing the UDOT Chief Railroad Engineer and appropriate Highway Authority of a change that might affect preemption timing parameters at an adjacent signalized intersection.

As represented on *Figure 13*, the Action may affect preemption timing or lead to the identification of a preemption need at a Crossing and its adjacent intersection(s). In either case, the noted process would commence, and the UDOT Chief Railroad Engineer would approve all proposed changes to preemption timing with support from the Traffic Signal Operations Engineer (or equivalent for a local Highway Authority) before implementation.



* Calculations should be done under the supervision of the Traffic Signal Operations Engineer or other resource as assigned by the UDOT Chief Railroad Engineer, or local agency equivalent. The individual completing the calculation is to notify the Traffic Signal Operations Engineer or local agency equivalent before proceeding to the next step in the process.

Figure 13: Railroad Changes Workflow

4.3 Action 3: Roadway Infrastructure Improvements

Action 3 is the design and construction of roadway infrastructure improvements that could create a preemption-eligible Crossing or affect an existing preempted intersection. Initiated by a Highway Authority, this Action fits within one of two categories: railroad crossing safety improvement projects (funded by Railroad Safety funds) or highway improvement projects (funded by UDOT or a local agency).

Being that these types of projects entail both design and construction, the delivery workflow outlined in the UDOT Railroad Coordination MOI and in UDOT's Project Delivery Network would govern for UDOT-initiated projects. *Figure 14* and *Figure 15* represent the staff organization for these types of projects.

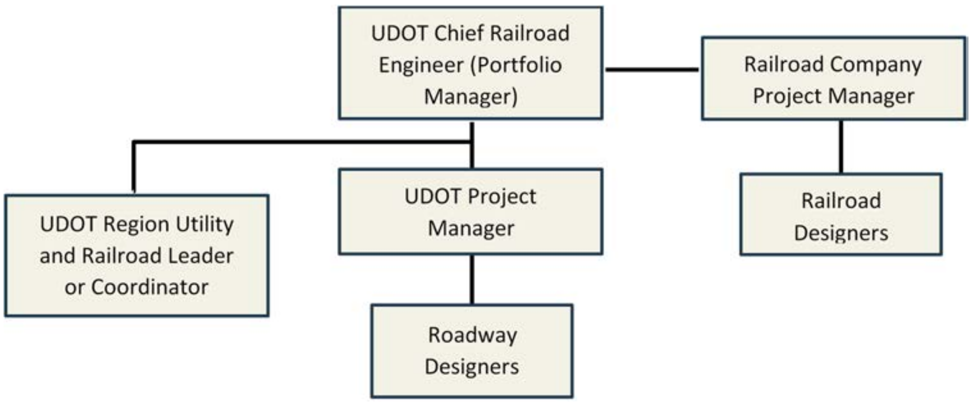


Figure 14: Railroad Crossing Safety Improvement Project Staff Organization

Source: UDOT Railroad Coordination MOI.

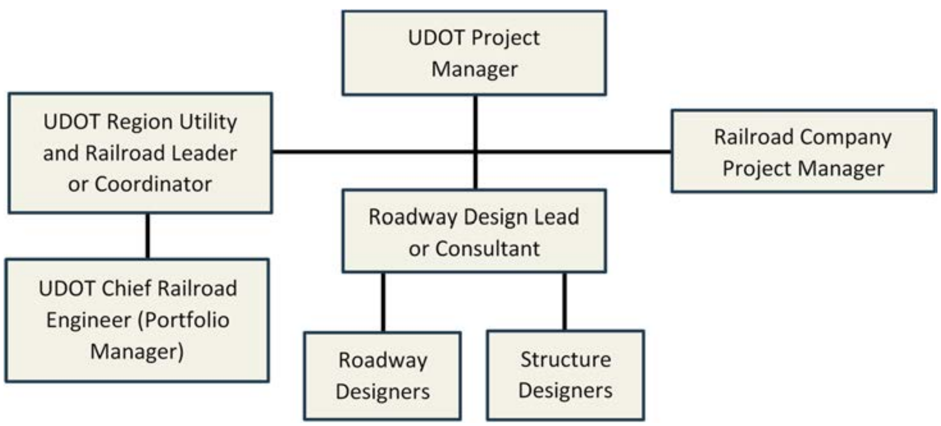


Figure 15: Highway Improvement Project Staff Organization (UDOT-initiated)

Source: UDOT Railroad Coordination MOI.

The local Highway Authority may organize its staff differently and follow a different delivery workflow than UDOT's Project Delivery Network. *Figure 16* illustrates staff organization that a local Highway Authority may follow. A local Highway Authority should then apply the workflow presented on *Figure 17* to calculate preemption timing.

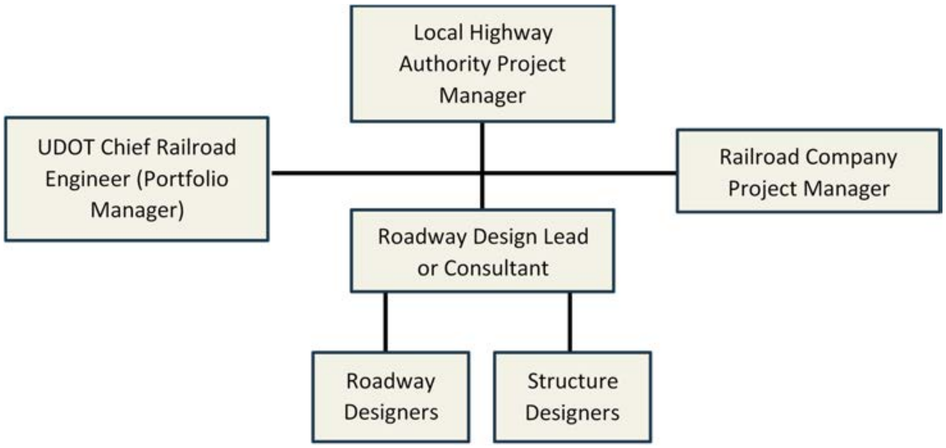


Figure 16: Highway Improvement Project Staff Organization (Local Highway Authority-initiated)

Action 3: Highway Improvement Project (Local Highway Authority-initiated)

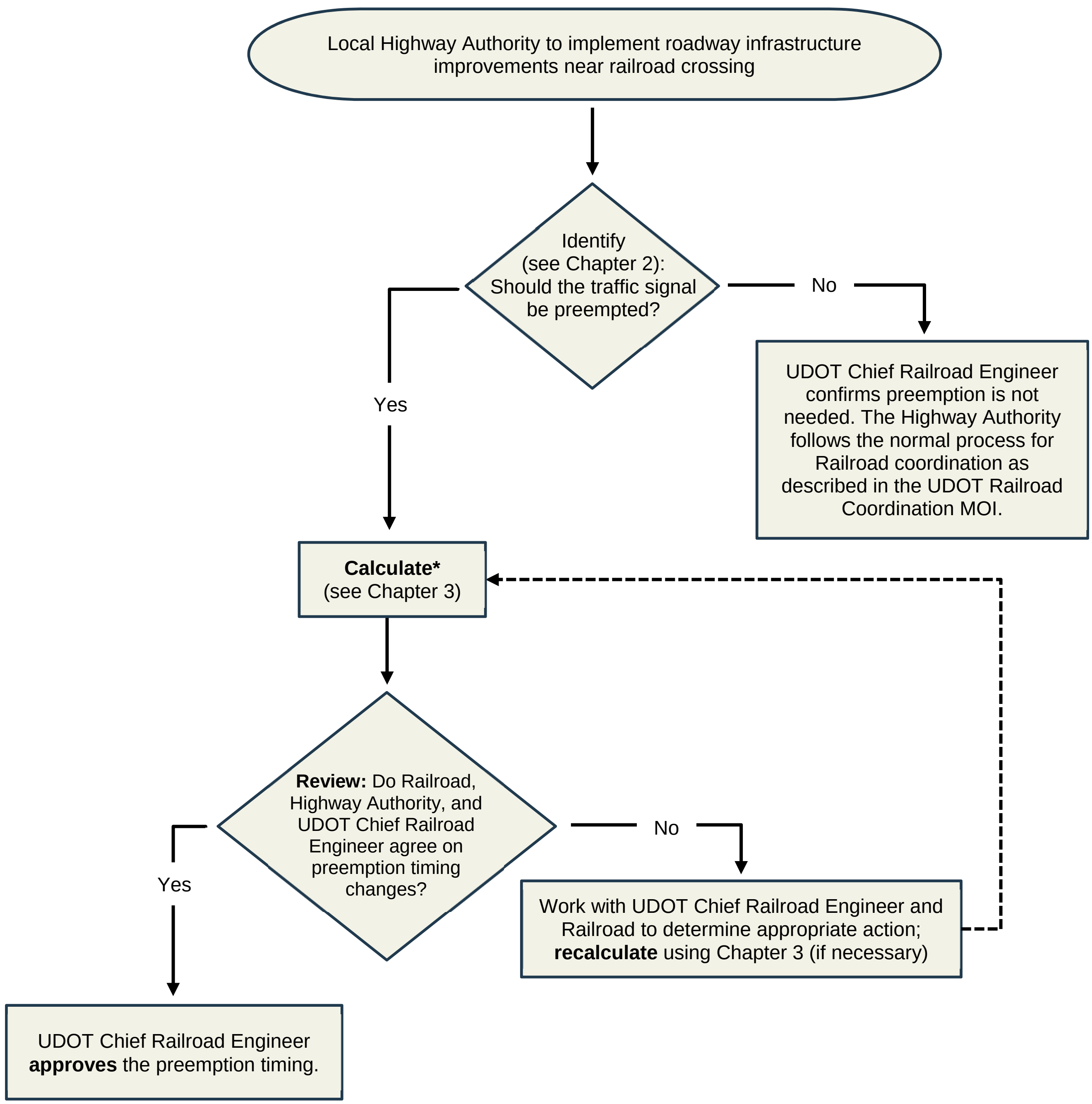


Figure 17: Highway Improvement Project (Local Highway Authority-initiated) Workflow

* Calculations should be done by the local agency.

The Highway Authority completing Actions 2 and 3 needs to submit the documentation listed in *Table 11* to the Railroad and UDOT Chief Railroad Engineer in order for them to complete their review.

Table 11: Review Documents for Interconnected Crossing Projects

Documents	Description
Preemption Calculations	UDOT Preemption Calculation Form
Traffic Signal Plan Sheets	Traffic Signal Layout, Signal Circuit, Signal Schedule, Detailed Phase Diagram, any other applicable traffic signal details.
Signing and Striping Plan Sheets	Signing and Striping Sheets for all approaches to the crossing (at least to W10 series signs), any other applicable signing and striping details.
Civil/Roadway Plan Sheets	Roadway Plan Layout Sheets, Roadway Profile Sheets, any other applicable roadway details/sheets.
Preemption Request Form	Provide UPRR/UTA Preemption Request Form (use form for the railroad that owns/maintains track) filled out by the highway authority, that details the type of preemption requested, circuits, etc.
Other Related Documents	Provide any other relevant related documents as necessary (i.e. diagnostic meeting minutes, traffic impact studies, etc.)

4.4 Responsibilities

Table 12 summarizes the responsibilities by activity and party that would be necessary to complete the preemption evaluation and implement a specific Action.

Table 12: Implementation Responsibility Matrix

Action	Responsible Party				
	UDOT Chief Railroad Engineer	Traffic Signal Operations Engineer[a]	Highway Authority Representative	Diagnostic Team[b]	Railroad Representative
Action 1: Signal maintenance/timing adjustments (Figure 12)	□ ●	○ Δ	○ Δ □		□
Action 2: Railroad changes (Figure 13)	□ ●	Δ	□	□	○ □
Action 3a: Railroad crossing safety improvement projects (Railroad Safety funds)	○ □ ●	Δ	□	□	□
Action 3b: Highway improvement projects (Highway Authority funds) (Figure 17)[c]	□ ●	Δ	○ Δ □	□	□

Key: ○ = initiate; Δ = calculate; □ = review; ● = approve.

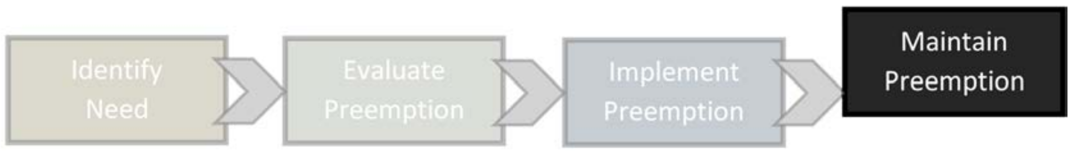
[a] Or other resource as assigned by the UDOT Chief Railroad Engineer or local agency equivalent.

[b] If a Diagnostic Team is formed, refer to the roles and responsibilities outlined in Administrative Rule R930-5.

[c] The Highway Authority could either be UDOT or a local agency requesting the UDOT Chief Railroad Engineer to evaluate a Crossing/intersection or series of Crossings/intersections.

Chapter 5 Inspecting and Maintaining Preempted Crossings

The final step within the overall preemption process involves the routine inspection and maintenance of all Crossings and railroad preempted intersections. While the primary intent of Chapter 5 is a focus on typical inspection and maintenance responsibilities, frequency, and follow-up actions. The chapter also discusses what to do when the characteristics of a Crossing/intersection change and the general procedures related to communication, documentation, and ranking preemption eligible Crossings.



5.1 Typical Inspection and Maintenance Procedures

5.1.1 Equipment

Appendix B (*UDOT Safety Audit Checklist*) lists the standard equipment that should be inspected and maintained in accordance with details listed in *Table 13*.

5.1.2 Inspection Frequency and Responsibilities

Table 13 lists the type, frequency, and responsibilities of typical inspection and maintenance activities related to a Crossing and preempted intersection.

Table 13: Maintenance Inspection Type, Frequency, and Responsibilities

Type of Inspection	Frequency	Responsibilities	
		Lead	Participants
Active Warning System Device operation	Monthly	Railroad	-
Warning time	Annually	Railroad	Highway Authority
Traffic signal preemption interconnection	Monthly	Railroad	Highway Authority
Interconnected crossing safety audit (see Appendix B: UDOT Safety Audit Checklist)	Every 3 years[a]	UDOT Chief Railroad Engineer	Highway Authority and Railroad Owner and Maintainer

[a] The interconnected crossing safety audit should be completed every 3 years for all existing preempted Crossings as funding and resources are available.

The FRA has developed further information related to inspection procedures that is outlined in the Electronic Code of Federal Regulations found at the link: [49 Code of Federal Regulations (CFR) 234](#) that designers, engineers, and technicians should consider and review accordingly.

5.1.3 Interconnected Crossing Safety Audit

During the Interconnected Crossing Safety Audit, the Diagnostic Team should perform a review and use the Safety Audit Checklist (included as Appendix B). The Railroad and Highway Authority should discuss any changes since the last joint inspection, such as:

- Changes in traffic patterns,
- Changes in Railroad traffic,
- Complaints about a Crossing or intersection,
- Safety concerns (e.g., vehicles stopped on a Crossing, vehicles driving around a Crossing, or near misses), or
- Closure requests to Highway Authority.

The primary goal of the Diagnostic Team in its review is to recommend solutions that could include the:

- Elimination of a Crossing;
- Installation of additional safety enhancements, if appropriate (This may include passive warning devices, active warning devices, traffic signal, the type of Crossing material, improvements to Highway approaches, removal of foliage and brush, pedestrian facility improvements, and improvements to street lighting.);
- Request of an engineering study to evaluate the need for an overpass or other grade separation structure(s); or
- The installation of other safety-related changes (which may include implementation of/change to preemption) to improve vehicle and pedestrian safety based on specific concerns related to a Crossing or intersection.

A complete description of the Diagnostic Team's roles and responsibilities are defined in Administrative Rule R930-5-5.

5.2 Changes Requiring Reevaluation at Interconnected Crossings

A Crossing or preempted intersection's context (i.e., the location and environment surrounding a Crossing or intersection) will inevitably change over time from changes in traffic patterns, construction, operations, and other variables. When evaluating preemption parameters, the highway practitioner should consider any change that may compromise safety at a particular preemption location. The highway practitioner should assess an intersection and Crossing at the time a change occurs or at a minimum during the review process. Changes of note may include those identified in *Table 14*.

Table 14: Potential Changes that May Affect Railroad Preemption

Context Change	Detail of the Change
Construction	Work performed on the Railroad or roadway at a Crossing or along the approach to a Crossing
Queue	Changes related to the increase or characteristic of use for one or more of the following modes: - Vehicle - Bicycle - Pedestrian - Train
Speed	A significant change in train or vehicle speeds going through a Crossing
Standards	Modifications to a standard leading to railroad or traffic signal timing changes (e.g., an increase in the standard pedestrian speed used to calculate pedestrian timing)
Operations	Alteration of operations at a Crossing (e.g., left-turn phasing)
Accidents	Accident occurring at a Crossing or other specific safety concerns based on field observations or unsafe motorist reports (e.g., vehicle stopped on a Crossing, vehicle driving around Crossing)
Other	Any other reason deemed necessary by the Railroad or Highway Authority

Note: Further information on the causes that may necessitate a review can be found in Administration Code R930-5-7.

In the event these changes are identified, it is the responsibility of the Highway Authority to inform the UDOT Chief Railroad Engineer, who will assess whether a Diagnostic Team review is required.

5.2.1 Communicating and Documenting Changes

All major changes should be documented with a signed agreement between the Railroad and Highway Authority, reviewed by the Diagnostic Team, and approved by the UDOT Chief Railroad Engineer. The agreement, construction plans, and any other related documents should be filed and stored with both the Railroad and Highway Authority and in the grade crossing railroad cabinets.

5.2.2 Ranking Preemption Eligible Crossings

Ranking of preemption-eligible projects may be required if resource constrints (e.g., funding and staffing) limit the UDOT Chief Railroad Engineer from implementing the projects in a given fiscal year. In such instance, the UDOT Chief Railroad Engineer may apply the process outlined in Appendix D to rank preemption-eligible locations.

Appendix A

Utah Preemption Form

Utah Preemption Form

Section 1: Grade Crossing Information

City: ______________________

County: ______________________

Highway Authority: ______________________

Cross Street: ______________________

Parallel Street: ______________________

UDOT Signal No.: ______________________

Date: ______________________

Completed By: ______________________

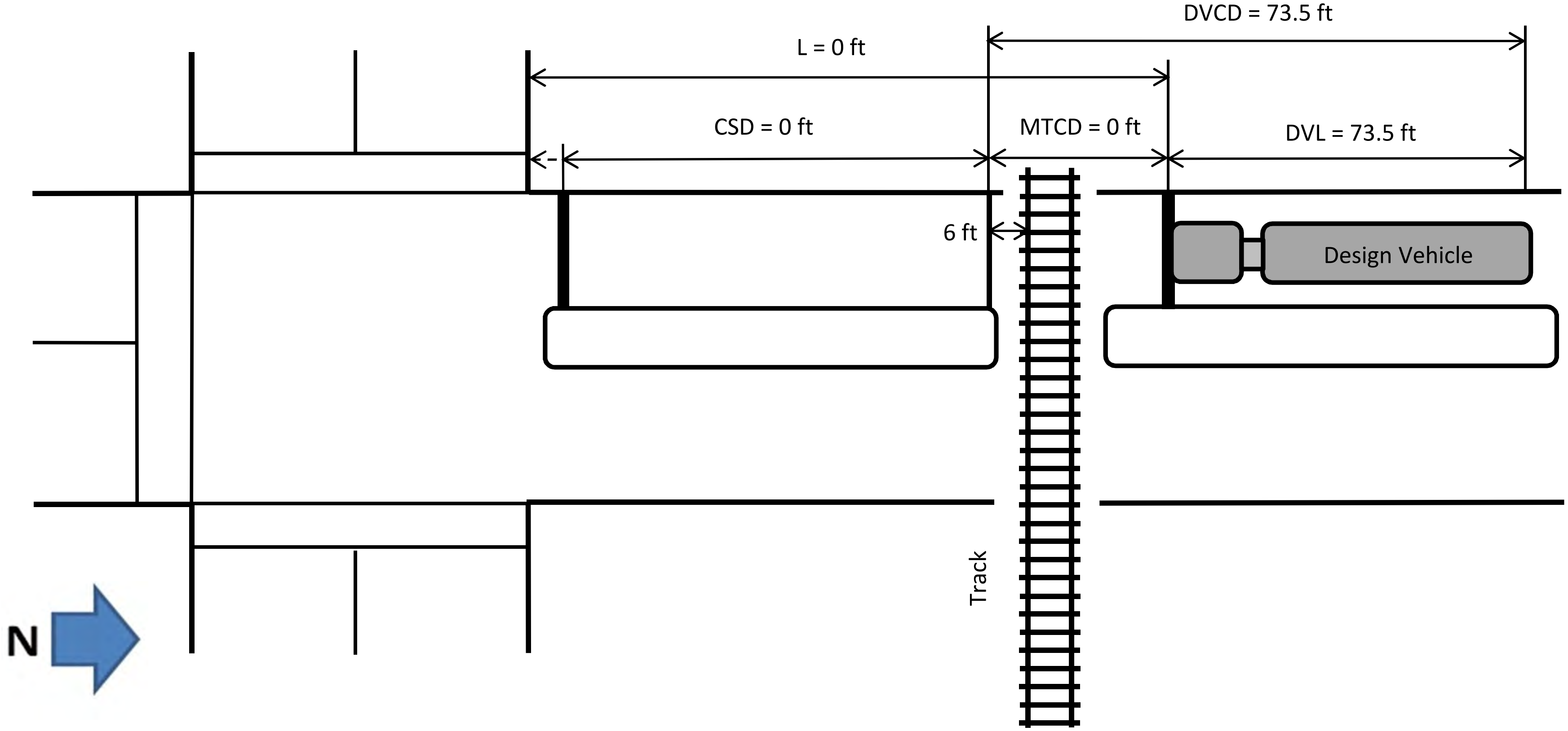
Highway Authority Contact: ______________________

Phone: ______________________

Railroad Owner/Operator: ______________________

DOT Crossing #: ______________________

http://safetydata.fra.dot.gov/officeofsafety/publicsite/crossing/xingqryloc.aspx



North Arrow : 0°

Number of Tracks:

*Yellow Cells Indicate inputtable data. Grey cells are automatically calculated.

** Some automatically calculated cells reference hidden tabs. To unhide right click any tab and select unhide.

Utah Preemption Form

Section 2: Crossing Distances and Grades

	Value	Unit	Grade		Remarks/Justification
1. CSD = Clear Storage Distance = Definition		ft			
2. MTCD = Minimum Track Clearance Distance = Definition		ft	Grade=	%	Grade estimated using Google Earth Street View
3. DVL = Design Vehicle Length (See Below For Inputtable Cell) = Definition	73.5	ft			*Value is programmed into Line 9*
4. L = Queue startup distance, (CSD+MTCD)= Definition	0	ft			*From graphic on page 1*
5. DVCD = Design Vehicle Clearance Distance = Definition	73.5	ft			*Measurement described in Calculation Summary tab.*
6. MAMD = Maximum Approach Move Distance (Optional) = Definition		ft	Grade =	%	Grade estimated using Google Earth Street View
7. MCMD = Maximum Conflicting Move Distance (Optional) = Definition		ft	Grade =	%	Grade estimated using Google Earth Street View

Section 3: Design Vehicle Length and Queue Clearance Time

	Car	SU Truck	Bus	Semi Truck	Remarks/Justification
8. AASHTO designation Definition	P	SU-30	BUS-40	WB-67	
9. Design Vehicle Length Definition	19	30	40.5	73.5	*Taken from AASHTO Designations Tab.*
10. Design Vehicle Height Definition	4.3	13.5	12	13.5	*Taken from AASHTO Designations Tab.*
11. Time required for design vehicle to start moving Definition	2.0	2.0	2.0	2.0	*Calc = 2+(line 4)/20.*
12. Time for design vehicle to accelerate through DVCD Definition	2.5	3.7	5.3	11.5	*Equations described in Calculation Summary tab.*
13. Queue Clearance Time Definition	**4.5**	**5.7**	**7.3**	**13.5**	*Add lines 11 & 12.*
14. Use as design vehicle? (Pick one)	no	no	no	yes	*Select category of vehicle to use for calculation*

Section 4: Traffic Signal Operations and Associated Times

	Value	Remarks/Justification
15. Preempt delay time (sec) Definition		
16. Controller response time to preempt (sec) Definition		*Controller Type:*
17. Preempt verification and response time (sec) Definition	0	*Add Lines 15 & 16.*

*Yellow Cells Indicate inputtable data. Grey cells are automatically calculated.

** Some automatically calculated cells reference hidden tabs. To unhide right click any tab and select unhide.

Worst-Case Conflicting Vehicle Time

	Value	Remarks/Justification
18. Worst case conflicting vehicle direction [Definition]	-	
19. Min. green service time (sec) [Definition]		
20. Yellow change time (sec) [Definition]		
21. Red clearance time(sec) [Definition]		
22. Worst-case conflicting vehicle time (sec) [Definition]	0	*Sum of Lines 19-21.*

Worst Case Conflicting Pedestrian Time

	Value	Remarks/Justification
23. Worst case conflicting pedestrian direction [Definition]	-	116' crosswalk length
24. Min. walk time during right-of-way transfer (sec) [Definition]		
25. Pedestrian change interval (sec) [Definition]		*Calc = (Maximum Crosswalk Length)/(4 ft per sec)*
26. Vehicle yellow change interval (if not included in line 25)(sec) [Definition]		
27. Vehicle red clearance interval (if not included in line 25)(sec) [Definition]		
28. Worst case conflicting pedestrian time (sec) [Definition]	0	*Sum of Lines 24-27.*
29. Worst case conflicting vehicle or pedestrian time (sec) [Definition]	0	*Greater of Lines 22 & 28.*

Section 5: Maximum Preemption Time Calculation

	Value	Remarks/Justification
30. Right of Way Transfer Time (sec) [Definition]	**0**	*Add lines 17 & 29.*
31. Queue clearance time (sec) [Definition]	**14**	*Line 13.*
32. Track Clearance Green Time [Definition]	**14**	*Equations described in Calculation Summary tab.*
33. Desired minimum separation time (sec) [Definition]		
34. Maximum Preemption Time (sec) [Definition]	**14**	*Add Lines 30, 32, 33, 51,70.*

*Yellow Cells Indicate inputtable data. Grey cells are automatically calculated.

** Some automatically calculated cells reference hidden tabs. To unhide right click any tab and select unhide.

Section 6: RR Warning Time

		Remarks/Justification
35. Duration of flashing lights before gate descent starts (sec) Definition		
36. Full gate descent time (sec) Definition		
37. Required minimum time, MT (seconds) Definition		
38. Clearance time, CT (sec) Definition	0	*CT = (MTCD - 35 ft)*0.1 sec/ft (Round the result to the nearest second).*
39. Minimum warning time, MWT (sec) Definition	0	*Add Lines 37 & 38.*
40. Buffer time, BT (sec) Definition		
41. Total warning time provided by the railroad (sec) Definition	**0**	*Sum of Lines 39-40.*

Section 11: Advance Preemption and Total Approach Time

Advance Preemption Time

		Remarks/Justification
42. Additional warning time required from railroad (sec) Definition	**14**	*Subtract Line 39 from Line 34.*

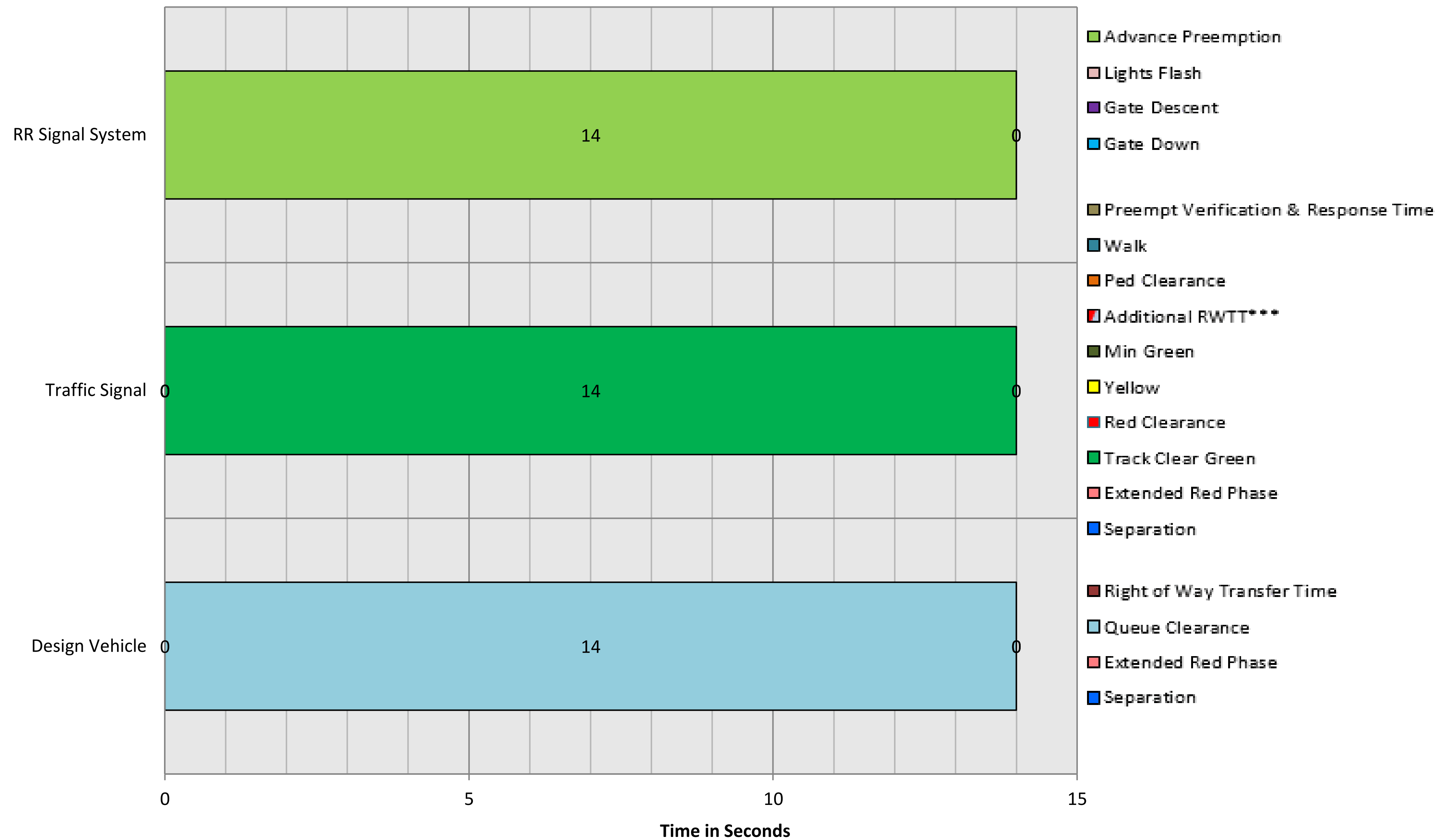
Total Approach Time

		Remarks/Justification
43. RR equipment response time (sec) Definition		
44. Total approach time (sec) Definition	**14**	*Sum of Lines 41-43.*

*Yellow Cells Indicate inputtable data. Grey cells are automatically calculated.

** Some automatically calculated cells reference hidden tabs. To unhide right click any tab and select unhide.

Preemption Timeline



***Additional RWTT is a special timeline addition that adds extra RWTT in the case that the approach move vehicle clearance time or conflicting move vehicle clearance time is larger than the pedestrian clearance time.

Utah Preemption Form

City: ____________________

County: ____________________

Highway Authority: ____________________

Parallel Street: ____________________

Cross Street: ____________________

UDOT Signal No.: ____________________

Date: ____________________

Completed By: ____________________

Highway Authority Contact: ____________________

Phone: ____________________

Railroad Owner/Operator: ____________________

DOT Crossing #: ____________________

http://safetydata.fra.dot.gov/officeofsafety/publicsite/crossing/xingqryloc.aspx

Section 7: Approach Vehicle Clearance Time and/or Conflicting Vehicle Clearance Time

Approach Vehicle Clearance Time

	Value	Remarks/Justification
45. Calculate Approach Vehicle Clearance Time?	no	
46. Max approach move distance (feet)	N/A	*Line 6*
47. Approach vehicle clearance time (sec) Definition	N/A	*Equations described in Calculation Summary tab.*

Conflicting Vehicle Clearance Time

	Value	Remarks/Justification
48. Calculate conflicting vehicle clearance time?	no	
49. Max conflicting move distance (feet)	N/A	*Line 7*
50. Conflicting vehicle clearance time (sec) Definition	N/A	*Equations described in Calculation Summary tab.*

Extra RWTT

	Value	Remarks/Justification
51. Additional RWTT due to Approach/Conflicting Vehicle clearance (sec) Definition	0	*Equations described in Calculation Summary tab.*

*Yellow Cells Indicate inputtable data. Grey cells are automatically calculated.

** Some automatically calculated cells reference hidden tabs. To unhide right click any tab and select unhide.

Utah Preemption Form

City: ______________________ Date: ______________________

County: ______________________ Completed By: ______________________

Highway Authority: ______________________ Highway Authority Contact: ______________________

Parallel Street: ______________________ Phone: ______________________

Cross Street: ______________________ Railroad Operator/Owner: ______________________

UDOT Signal No.: ______________________ DOT Crossing #: ______________________

http://safetydata.fra.dot.gov/officeofsafety/publicsite/crossing/xingqryloc.aspx

Section 8: Vehicle-Gate Interaction Time

		Remarks/Justification
52. Calculate vehicle-gate interaction time?	no	
53. Time required for design vehicle to start moving (sec) Definition	N/A	*Line 11.*
54. Time required for design vehicle to accelerate thru DVL (sec) Definition	N/A	*Equations described in Calculation Summary tab.*
55. Time required for design vehicle to clear descending gate (sec) Definition	N/A	*Add Lines 30, 53 & 54.*
56. Duration of flashing lights before gate descent starts (sec) Definition	0	*Line 35.*
57. Full gate descent time (sec) Definition	0	*Line 36.*
58. Distance from gate to nearest side of design vehicle (feet) Definition		*Value must be between 4 & 20.*
59. proportion of non-gate interaction descent time Definition	N/A	*Equations described in Calculation Summary tab.*
60. Non-interaction gate descent time (sec) Definition	N/A	*Line 57 (x) Line 59.*
61. Time available for design vehicle to clear descending gates (sec) Definition	N/A	*Sum of Lines 56 & 60.*
62. Advance preemption to avoid design vehicle-gate interaction (sec) Definition	N/A	*Subtract Line 61 from Line 55.*
63. Additional TCG time to account for design vehicle-gate interaction (sec) Definition	0	*Equations described in Calculation Summary tab.*

*Yellow Cells Indicate inputtable data. Grey cells are automatically calculated.

** Some automatically calculated cells reference hidden tabs. To unhide right click any tab and select unhide.

Utah Preemption Form

City:		Date:	
County:		Completed By:	
Highway Authority:		Highway Authority Contact:	
Parallel Street:		Phone:	
Cross Street:		Railroad Owner/Operator:	
Udot Signal No.:		DOT Crossing #:	

http://safetydata.fra.dot.gov/officeofsafety/publicsite/crossing/xingqryloc.aspx

Section 9: Time to move past Clear Storage Distance		**Remarks/Justification**
64. Add time to TCG to clear CSD	no	
65. Distance design vehicle must travel to clear DVL, MTCD, & CSD Definition	N/A	*Sum of Lines 1-3.*
66. Total time for design vehicle to clear DVL, MTCD, & CSD Definition	N/A	*Equations described in Calculation Summary tab.*
67. Total time for design vehicle to clear DVCD Definition	N/A	*Line 12.*
68. Additional TCG time needed for design vehicle to clear CSD Definition	0	*Subtract Line 67 from Line 66.*

*Yellow Cells Indicate inputtable data. Grey cells are automatically calculated.

** Some automatically calculated cells reference hidden tabs. To unhide right click any tab and select unhide.

Keeping Utah Moving

Utah Preemption Form

City: ______________________________ Date: ______________________________

County: ______________________________ Completed By: ______________________________

Highway Authority: ______________________________ Highway Authority Contact: ______________________________

Parallel Street: ______________________________ Phone: ______________________________

Cross Street: ______________________________ Railroad Owner/Operator: ______________________________

UDOT Signal No.: ______________________________ DOT Crossing #: ______________________________

http://safetydata.fra.dot.gov/officeofsafety/publicsite/crossing/xingqryloc.aspx

Section 10: Remove Track Clearance Green Phase

Approach Vehicle Clearance Time

Remarks/Justification

69. Remove Track Clearance Green Time?	no	
70. Track Clearance Green Time to be applied as extended red	N/A	*Equations described in Calculation Summary tab.*

Definition

*Yellow Cells Indicate inputtable data. Grey cells are automatically calculated.

** Some automatically calculated cells reference hidden tabs. To unhide right click any tab and select unhide.

UDOT Preemption Form Instructions

General Instructions: Preemption time should be calculated using the UDOT Preemption Form (Tab 1). The Form uses a modified TXDOT methodology to calculate advance preemption and total approach time. The following instructions provide additonal defintions and information related to each line on the UDOT Preemption Form. Lines that are auto calculated are colored grey within the following tables.

Section 1 Grade Crossing Information

Before performing any calculations, the following information must be filled out:

Line #	Term	Definition	
-	City	City where Crossing is located. If Crossing is not within a city, the nearest city should be located and the word “near” should be included in front of the city.	
-	County	County where Crossing is located.	
-	Highway Authority	The Highway Authority responsible for the Crossing. If the Crossing is located on a state highway, the Highway Authority is UDOT. If not, the Highway Authority is the local road authority (city or county).	
-	DOT Crossing Number	The DOT crossing number provided by the FRA. If the number has not already been provided, it can be attained by accessing the FRA database at: http://safetydata.fra.dot.gov/officeofsafety/publicsite/crossing/xingqryloc.aspx	
-	Date	Date that Crossing calculation is performed.	
-	Completed By	Name of person who performed the calculation.	
-	Highway Authority Contact	Name of person at the Highway Authority to contact regarding the Crossing.	
-	Phone	Highway Authority contact’s phone number.	
-	Number of Tracks	Number of tracks at the Crossing. This data can be obtained from field verification, aerial imaging, or FRA inventory reports (in order of preference).	
-	UDOT Signal No.	The traffic signal number provided by UDOT. If the number has not already been provided, it can be attained from the Highway Authority contact.	

Section 2 Crossing Distances and Grades

Relevant crossing distances and grades are inputted next on the Utah Preemtion Form (Tab 1).

Line #	Term	Definition	Link
1	Clear Storage Distance (CSD)	The shortest distance from 6 feet past the near rail to the adjacent street intersection.	Back to Form
2	Minimum Track Clearance Distance (MTCD)	The distance from the gate, distance from the limit line if no gates are used, or 12 feet from track centerline if no limit lines or gates are used to 6 feet past the far rail. For four-quadrant gate systems, the distance is extended to the point where the rear of a vehicle would be clear of the exit arm.	Back to Form
3	Design Vehicle Length (DVL) (auto-calc)	See Line # 9 for input information.	Back to Form
4	Queue Startup Distance (L) (auto-calc)	The maximum length in feet of queued vehicles downstream of the design vehicle. This is the sum of the MTCD and CSD.	Back to Form
5	Design Vehicle Clearance Distance (DVCD) (auto-calc)	The design vehicle clearance distance is the length in feet that the design vehicle travels to clear the crossing. This is the sum of the DVL and MTCD.	Back to Form
6	Maximum Approach Move Distance (MAMD)	The distance (in feet) from the farthest intersection limit line towards a Crossing. See Section 7 of these instructions for further information.	Back to Form
7	Maximum Conflicting Move Distance (MCMD)	The longest distance (in feet) across the adjacent intersection that crosses the path of the track clearance phase. See Section 7 of these instructions for further information.	Back to Form

Section 3 Design Vehicle Length and Queue Clearance Time

Once the relevant data of Section 2 is inputted, the design vehicle can be chosen next.

Line #	Term	Definition	Link
8	AASHTO Designation	AASHTO Designation is the abbreviation for design vehicles based on the 2011 AASHTO Policy on Geometric Design of Highways and Streets. This abbreviation is used to determine design vehicle length (DVL) and design vehicle height (DVH). Abbreviations are split into separate drop down lists based on whether the design vehicle can be categorized as a passenger car, SU truck, bus, or semi-truck. See AASHTO Designation tab.	Back to Form
9	Design Vehicle Length (DVL) (auto-calc)	Design Vehicle Length is the length of the design vehicle in feet. Once one decides which design vehicle to use, use the pulldown tabs under "use as design vehicle?" to select the desired type of vehicle. This selection will change the acceleration time based on the TXDOT vehicle acceleration graph using a WB-50 (Semi-truck), S-BUS40 (Bus), SU (Single-unit truck), and left turn passenger car (car) (see Figure 1). If the design vehicle chosen does not meet the exact vehicle used in the graph, the closest vehicle type's graph will be used and the length of design vehicle listed in Table 2 in Chapter 4 of the Guideline (for example, if one wants a WB-67, use the semi-truck column and in the dropdown select WB-67 as the design vehicle length. The form will automatically calculate line 13 using the WB-50).	Back to Form
10	Design Vehicle Height (auto-calc)	Design Vehicle Height is the height of the design vehicle in feet. This data is automatically filled in based on the height of the design vehicle selected and based on the value given for that design vehicle in the 2011 AASHTO Policy on Geometric Design of Highways and Streets.	Back to Form
11	Time required for design vehicle to start moving (auto-calc)	The time, in seconds, elapsed from the start of track clearance green interval until the design vehicle begins to move in seconds. This is calculated using the equation 2+(L/20). This allows 2 seconds for startup time plus a 20 ft/sec "shock wave" speed if the travel lane downstream of the crossing is full of vehicles.	Back to Form

Line #	Term	Definition	Link
12	Time for design vehicle to accelerate through DVCD (auto-calc)	The time, in seconds, required for the design vehicle to accelerate from a stop and travel the complete design vehicle clearance distance. This time is interpolated using the graph in Figure 1 or the equation in Figure 2. If the DVCD is less than 400 feet, start at the value of the DVCD on the x-axis of Figure 1, draw a vertical line to the intersection of the design vehicle acceleration time performance curve and then draw a horizontal line from the intersection of the vertical line and design vehicle line to the y-axis. The value where the horizontal line intersects the y-axis is the time for the design vehicle to accelerate through DVCD. If the value of the DVCD is greater than 400 feet, calculate the time for design vehicle to accelerate through DVCD using the equation from Figure 2 and values from Figure 3 to get the time for design vehicle to accelerate through the DVCD. When an uphill or positive grade exists for the MTCD, a multiplier must be applied to the value from the graph or equation to get the actual time for design vehicle to accelerate through the DVCD. See Figure 4 for the applicable multipliers. The correct multiplier is chosen by using the column under the correct design vehicle and percent grade (if the percent grade is between grade percentages, use the larger value) and then using the row that's value is closest to the DVCD (again, always use the larger value). For example, if an uphill grade of +3% exists, a WB-50 semi-truck is the design vehicle, and a DVCD of 160 feet exists, a multiplier of 1.34 should be used.	Back to Form
13	Queue Clearance Time (auto-calc)	The queue clearance time is the total amount of time required after the traffic signal for the approach displays a green, to begin moving a queue of vehicles through the queue startup distance and then move the design vehicle from a stopped position at the far side of the crossing completely through the minimum track clearance distance (MTCD). This value is computed by adding the time required for a design vehicle to start moving to the time for a design vehicle to accelerate through DVCD. It is computed for each type of design vehicle (car, SU truck, Bus, Semi-truck) in this part of the Utah Preemption Form and will be summarized later in the Form (Tab 1).	Back to Form

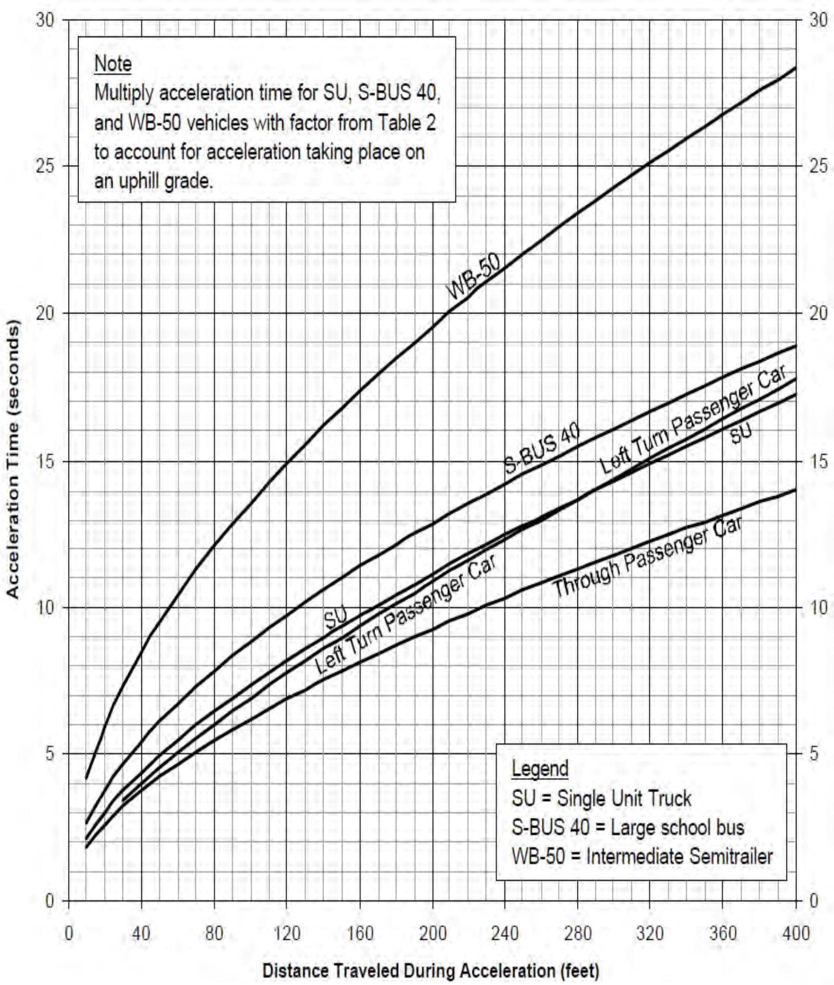


Figure 1: Acceleration over time over a fixed distance on level surface (TXDOT)

$$T = e^{\left[a - b\sqrt{c + \frac{2}{b}\ln\left(\frac{d}{X}\right)}\right]}$$

T = time to accelerate through distance X, in seconds;
X = distance over which acceleration takes place, in feet;
ln = natural logarithm function;
e = 2.17828, the base of natural logarithms; and
a, b, c, and d = calibration parameters from Table 3.

Figure 2: Equation for acceleration over time over a fixed distance

Design Vehicle	Grade	a	b	c	d
Through Passenger Car	Level	7.75	3.252	5.679	2.153
Left Turning Passenger Car	Level	10.29	5.832	3.114	5.090
Single Unit Truck (SU)	Level to 2%	8.16	3.624	5.070	2.018
	4%	10.39	4.865	4.560	1.739
	6%	9.52	4.542	4.393	1.700
	8%	9.38	4.597	4.165	1.668
Large School Bus (S-BUS 40)	Level to 1%	10.02	4.108	5.95	0.885
	2%	11.51	5.254	4.801	1.300
	4%	10.79	5.042	4.577	1.266
	6%	10.61	5.101	4.329	1.253
	8%	11.84	6.198	3.652	1.554
Intermediate Semi-Trailer (WB-50)	Level	17.75	7.984	4.940	0.481
	2%	10.26	4.026	6.500	0.249
	4%	9.39	3.635	6.670	0.193
	6%	9.38	3.732	6.310	0.188
	8%	10.31	4.515	5.219	0.265

Figure 3: Parameter to estimate the acceleration times over distances greater than 400 ft using Figure 2 (TXDOT)

Acceleration Distance (ft)	Design Vehicle and Percentage Uphill Grade														
	Single Unit Truck (SU)				Large School Bus (S-BUS 40)					Intermediate Tractor-Trailer (WB-50)					
	0-2%	4%	6%	8%	0-1%	2%	4%	6%	8%	0%	2%	4%	6%	8%
25	1.00	1.06	1.13	1.19	1.00	1.01	1.10	1.19	1.28	1.00	1.09	1.27	1.42	1.55
50	1.00	1.09	1.17	1.25	1.00	1.01	1.12	1.21	1.30	1.00	1.10	1.28	1.44	1.58
75	1.00	1.10	1.19	1.29	1.00	1.02	1.13	1.23	1.33	1.00	1.11	1.30	1.47	1.61
100	1.00	1.11	1.21	1.32	1.00	1.02	1.14	1.25	1.35	1.00	1.11	1.31	1.48	1.64
125	1.00	1.12	1.23	1.34	1.00	1.03	1.15	1.26	1.37	1.00	1.12	1.32	1.50	1.66
150	1.00	1.12	1.24	1.37	1.00	1.03	1.16	1.28	1.40	1.00	1.12	1.33	1.52	1.68
175	1.00	1.13	1.25	1.38	1.00	1.03	1.17	1.29	1.42	1.00	1.12	1.34	1.53	1.70
200	1.00	1.13	1.26	1.40	1.00	1.04	1.17	1.30	1.43	1.00	1.13	1.35	1.54	1.72
225	1.00	1.14	1.27	1.42	1.00	1.04	1.18	1.32	1.45	1.00	1.13	1.35	1.56	1.74
250	1.00	1.14	1.28	1.43	1.00	1.04	1.19	1.33	1.47	1.00	1.13	1.36	1.57	1.76
275	1.00	1.14	1.29	1.44	1.00	1.05	1.20	1.34	1.49	1.00	1.14	1.37	1.58	1.77
300	1.00	1.14	1.30	1.46	1.00	1.05	1.20	1.35	1.50	1.00	1.14	1.37	1.59	1.79
325	1.00	1.15	1.30	1.47	1.00	1.05	1.21	1.36	1.52	1.00	1.14	1.38	1.60	1.81
350	1.00	1.15	1.31	1.48	1.00	1.05	1.22	1.37	1.54	1.00	1.15	1.39	1.61	1.82
375	1.00	1.15	1.31	1.49	1.00	1.06	1.22	1.38	1.55	1.00	1.15	1.39	1.62	1.84
400	1.00	1.15	1.32	1.50	1.00	1.06	1.23	1.40	1.57	1.00	1.15	1.40	1.63	1.85

Figure 4: Multipliers to account for slower acceleration on uphill grades (TXDOT)

Section 4 Traffic Signal Operations and Associated Times

Traffic signal operations and associated times and their definitions are listed below:

Line #	Term	Definition	Link
15	Preempt Delay Time	The amount of time, in seconds, that the traffic signal controller is programmed to delay before transition from normal operations to railroad preemption operations once the preempt call is received. The preempt delay time can be any value greater than or equal to 0 and may not be available for all controllers.	Back to Form
16	Controller Response Time	The time, in seconds, that elapses while the controller unit electronically registers a preempt call. The controller manufacturer should be contacted to determine this value and the controller type should be included in the remarks.	Back to Form
17	Preempt Verification and Response Time (auto-calc)	The time, in seconds, between the receipt of the preempt request and the time the controller software actually begins to respond to the preempt call. This is calculated by adding the preempt delay time and controller response time.	Back to Form

Line #	Term	Definition	Link
18	Worst Case Conflicting Vehicle Direction	The vehicle direction (i.e. northbound left) that creates the largest conflicting vehicle time at the intersection.	Back to Form
19	Minimum Green Time During Right-of-Way Transfer	The maximum number of seconds that any vehicle phase must display a green indication before the controller unit will terminate the phase through yellow change and red clearance. This can be any value greater than or equal to 0 and is usually determined by the highway authority.	Back to Form
20	Yellow Change Time	The maximum required yellow change time for any vehicle phase. This value is usually a standard time and can be obtained from the Highway Authority.	Back to Form
21	Red Clearance Time	The maximum required red clearance interval for any vehicle phase. This value is usually a standard time and can be obtained from the Highway Authority.	Back to Form
22	Worst case-conflicting vehicle time (auto-calc)	The time, in seconds, for the worst case conflicting vehicle to complete its movement through the intersection.	Back to Form
23	Worst Case Conflicting Pedestrian Crosswalk Location	The pedestrian crosswalk location (i.e. East Leg) that creates the largest conflicting pedestrian time at the intersection.	Back to Form
24	Minimum walk time during right-of-way transfer	Minimum pedestrian walk time, in seconds, for longest crosswalk. This time can be omitted or shortened and should be obtained from the Highway Authority.	Back to Form
25	Pedestrian Change Interval	The time, in seconds, for the worst case pedestrian phase. This is the flashing don't walk time before transitioning to vehicle yellow change time and red clearance time. This time can be omitted or shortened and should be obtained from the Highway Authority.	Back to Form
26	Vehicle yellow change interval	The maximum required yellow change time for any vehicle phase. This value is usually a standard time and can be obtained from the Highway Authority.	Back to

Line #	Term	Definition	Link
27	Vehicle red clearance interval	The maximum required red clearance interval for any vehicle phase. This value is usually a standard time and can be obtained from the Highway Authority.	Back to Form
28	Worst-case conflicting pedestrian time (auto-calc)	The total programmed phase time, in seconds, for the worst-case conflicting pedestrian before transitioning to track clearance green. This time is calculated by adding the minimum walk time during right-of-way transfer, pedestrian clearance time during right-of-way transfer, vehicle yellow change time, and vehicle red clearance time.	Back to Form
29	Worst-case conflicting vehicle or pedestrian time (auto-calc)	The maximum conflicting phase time, in seconds, for the intersection. This time is calculated by comparing the worst-case conflicting pedestrian time and worst-case conflicting vehicle time and picking the larger of the two.	Back to Form

Section 5 Maximum Preemption Time Calculation

The Maximum preemption calculation and corresponding calculations/inputs are listed below:

Line #	Term	Definition	Link
30	Right-of-way transfer time (auto-calc)	The maximum amount of time needed for the worst case condition before track clearance green. This is equal to the worst-case conflicting vehicle or pedestrian time.	Back to Form
31	Queue clearance time (auto-calc)	The queue clearance time is the total amount of time required after the traffic signal for the approach displays green, to begin moving a queue of vehicles through the queue startup distance and then move the design vehicle from a stopped position at the far side of a Crossing completely through the minimum track clearance distance (MTCD). It is the same queue clearance time as is defined in Section 3 of these Form Instructions.	Back to Form
32	Track Clearance Green Time (auto-calc)	The traffic signal time to clear stopped vehicles from the track area on the approach to the signalized highway intersection. The TCG interval should equal or exceed the queue clearance time. The TCG interval must be long enough to prevent a premature display of a red traffic signal for traffic clearing the tracks. This value is the combination of queue clearance time, additional TCG due to design vehicle gate interaction (optional addition), and additional TCG for design vehicle to clear CSD (optional addition). For further information see section 8 and section 9.	Back to Form

Line #	Term	Definition	Link
33	Desired minimum separation time	Additional time that can be provided between the time the traffic clears the track and the train arrival at a Crossing. This time can be set to 0 or more seconds and should be obtained from the Railroad. Values of 4 to 8 seconds are typically used.	Back to Form
34	Maximum preemption time (auto-calc)	The total amount of time required after the preempt call is initiated by the railroad warning equipment to complete right-of-way transfer to the track clearance interval, initiate track clearance phases, move the design vehicle out of the MTCD, and provide a separation time before the train arrives at a Crossing. This is calculated by adding right-of-way transfer time, queue clearance time, and desired minimum separation time.	Back to Form

Section 6 RR Warning Time

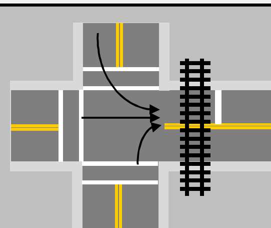
The RR Warning time and corresponding calculations/inputs are listed below:

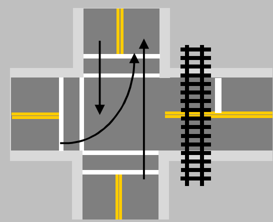
Line #	Term	Definition	Link
35	Duration of flashing lights before gate descent starts	The time the railroad warning lights flash before the gates start to descend. This value can be obtained from the Railroad or measured in the field and is usually between 3 to 5 seconds.	Back to Form
36	Full gate descent time	The time, in seconds, it takes for the gates to descend to a horizontal position after they start moving. This value can be obtained from the Railroad or measured in the field.	Back to Form
37	Required minimum time (MT)	The least amount of time active warning devices should be active before the arrival of the train at the grade crossing. The FRA and Utah MUTCD require that this time be at least 20 seconds.	Back to Form
38	Clearance Time (CT) (auto-calc)	The additional time, in seconds, that may be provided for wide or skewed-angle crossings. Clearance time is a calculation when the MTCD exceeds 35 feet. The AREMA manual requires that one second of additional CT be added for each additional 10 feet once the MTCD is greater than 35 feet. The equation is (MTCD-35 ft)*0.1 sec/ft and should be rounded up to the nearest whole number. For example, if the MTCD is 48 feet, 2 seconds of CT should be used.	Back to Form

Line #	Term	Definition	Link
39	Minimum warning time (MWT) (auto-calc)	This is the actual minimum time that active warning devices can be expected to operate at the crossing before the train approaches the grade crossing. The value is calculated by adding the required minimum time and the clearance time.	Back to Form
40	Buffer Time (BT)	Time, in seconds, added by the Railroad to account for train handling. This value should be obtained from the Railroad.	Back to Form
41	Warning time provided by the railroad (auto-calc)	The sum of the minimum warning time, buffer time, and railroad equipment response time. This value should be confirmed with the Railroad.	Back to Form

Section 7 Approach Vehicle Clearance Time and/or Conflicting Vehicle Clearance Time

Once all the values are input into the Utah Preemption Form (Tab 1), the decision can be made as to whether to include calculations for approach vehicle clearance time and/or conflicting vehicle clearance time. If it is decided that approach vehicle clearance time and/or conflicting vehicle clearance time should be considered in the calculation, the following should be used:

Line #	Term	Definition	Link
47	Approach vehicle clearance time	 It is calculated using different formulas for the different types of design vehicles. Passenger car = $2.46+(0.5483*MAMD^{0.5463})$ SU truck = $2.48+(0.6026*MAMD^{0.5474})$ S-BUS 40 = $2.72+(0.5333*MAMD^{0.5348})$ WB-50 = $3.99+(1.2559*MAMD^{0.5188})$ If the MAMD has a grade greater than 0%, multipliers should be used from Figure 3 and should be applied as is discussed in the definition for “Time for design vehicle to accelerate through DVCD.”	Back to Form

Line #	Term	Definition	Link
50	Conflicting Vehicle Clearance Time (auto-calc)	The conflicting vehicle clearance time is the time it takes the design vehicle to start up and accelerate through the maximum conflicting move distance. (See below for description)  It is calculated using different formulas for the different types of design vehicles. Passenger car = $2.46+(0.5483*MCMD^{0.5463})$ SU truck = $2.48+(0.6026*MCMD^{0.5474})$ S-BUS 40 = $2.72+(0.5333*MCMD^{0.5348})$ WB-50 = $3.99+(1.2559*MCMD^{0.5188})$ If the MCMD has a grade greater than 0%, multipliers should be used from Figure 3 and should be applied as is discussed in the definition for “Time for design vehicle to accelerate through DVCD.”	Back to Form
51	Additional RWTT due to Approach/Conflicting Vehicle clearance (auto-calc)	The additional RWTT that is added in case the approach move vehicle clearance time or conflicting move vehicle clearance time is larger than the pedestrian clearance time.	Back to Form

Section 8 Vehicle-Gate Interaction Time

Vehicle-gate interaction time is another optional calculation included in the Utah Preemption Form. If it is decided that vehicle-gate interaction time should be included in the calculation, the following definitions should be used:

Line #	Term	Definition	Link
53	Time Required for Design Vehicle to Start Moving (auto-calc)	The time, in seconds required for the design vehicle to accelerate from a stop and travel the complete design vehicle clearance distance. This is the same time calculated in Section 3 of these Form Instructions.	Back to Form
54	Time required for design vehicle to accelerate thru DVL (auto-calc)	The time required for the design vehicle to accelerate it's own length. This is calculated using the graph in Figure 1 or the equation in Figure 2, and the steps describing the calculation are the same as is described Section 3 of these Form Instructions under the definition of "Time for design vehicle to accelerate through DVCD." If a grade exists for the MTCD, use the multipliers from Figure 3 as described in Section 3 of these Form Instructions under the definition of "Time for design vehicle to accelerate through DVCD."	Back to Form
55	Time required for the design vehicle to clear the descending gates (auto-calc)	The total time once right-of-way transfer begins that is needed before the gates descend in order to not have vehicle-gate conflict. This is calculated by adding the right-of-way transfer time, the time required for design vehicle to start moving, and the time required for design vehicle to accelerate thru the design vehicle length.	Back to Form
56	Duration of flashing lights before gate descent starts (auto-calc)	The time the railroad warning lights flash before the gates start to descend. This value is generated from Tab 1 of the Utah Preemption Form, which is data obtained from the Railroad or measured in the field and is usually between 3 to 5 seconds. This data is described in Section 6 of these Form Instructions and is input from Form Line 34 on Tab 1.	Back to Form

Line #	Term	Definition	Link
57	Full gate descent time (auto-calc)	The time, in seconds, it takes for the gates to descend to a horizontal position after the gates start moving. This value is generated from Tab 1 of the Utah Preemption Form, which is data obtained from the Railroad or measured in the field. This data is described in Section 6 of these Form Instructions and is input from Form Line 35 on Tab 1.	Back to Form
58	Distance from gate to nearest side of design vehicle (feet)	Horizontal distance along the gate in feet from the center of the gate mechanism foundation to nearest side of design vehicle.	Back to Form
59	Proportion of non-gate interaction descent time (auto-calc)	The decimal proportion of the full gate descent time during which the gate will not interact with the design vehicle if it is located under the gate. This is calculated using Figure 5. Using the curve for the design vehicle chosen, draw a horizontal line from the y axis on Figure 5 using the value of distance from gate to nearest side of design vehicle until it hits the curve, and then draw a vertical line at the intersection of the horizontal line and design vehicle curve. Use the value that is intersected on the x-axis as the proportion of non-gate interaction descent time.	Back to Form
60	Non-interaction gate descent time (auto-calc)	The time, in seconds during gate descent that the gate will not interact with the design vehicle if it is located under the gate. This is calculated by taking the full gate descent time and multiplying it with the proportion of non-gate interaction descent time.	Back to Form
61	Time available for design vehicle to clear descending gates (auto-calc)	The time after railroad warning lights start to flash that is available for the design vehicle to clear the descending gate before the gate hits the vehicle. This is calculated by adding the duration of flashing lights before the gate descent starts to the non-interaction gate descent time.	Back to Form
62	Advance preemption to avoid design vehicle gate-interaction (auto-calc)	The amount of advance preemption time required to avoid the gates descending on a stationary or slow-moving design vehicle. This is calculated by subtracting the time available for design vehicle to clear descending gates from the time required for the design vehicle to clear the descending gates.	Back to Form

Line #	Term	Definition	Link
63	Additional TCG time to account for design vehicle-gate interaction (auto-calc)	The extra track clearance green time required to avoid the gates descending on a stationary or slow-moving design vehicle. This is calculated by subtracting the the minimum warning time and maximum preemption time from the advance preemption to avoid design vehicle-gate interaction.	[Back to Form]

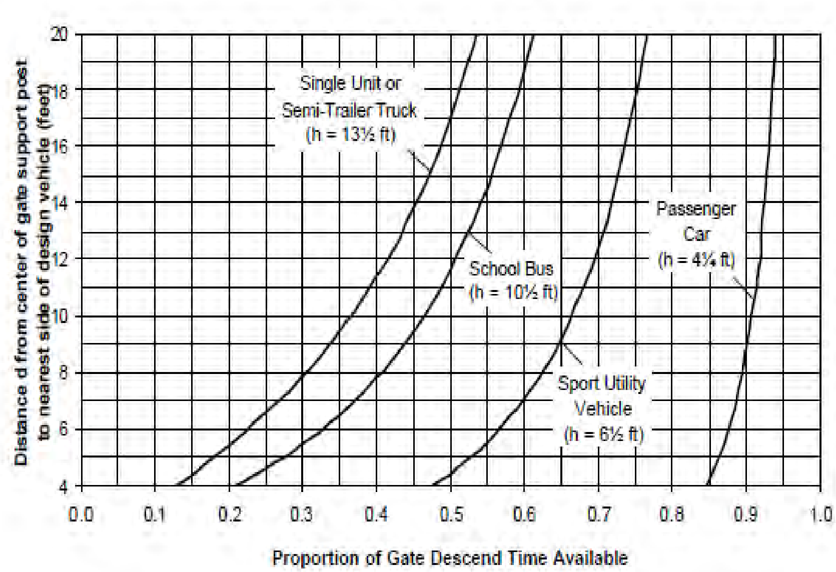


Figure 5 Proportion of gate descent time available as a function of the design vehicle height and the distance from the center of the gate mechanism to the nearest side of the design vehicle. (TXDOT)

Line #	Term	Definition	Link
65	Distance design vehicle must travel to clear DVL, MTCD, & CSD (auto-calc)	The distance, in feet, needed for design vehicle to clear the MTCD and CSD so that vehicles cannot store between the tracks and the traffic signal.	Back to Form
66	Total time for design vehicle to clear DVL, MTCD, & CSD (auto-calc)	The total time, in seconds, for design vehicle to clear DVL, MTCD, & CSD. This is calculated similarly to time for design vehicle to accelerate through DVCD (see line 12) except that CSD is added to the distance used. See definition line 12 for more information on how this value is calculated.	Back to Form
67	Total time for design vehicle to clear DVCD (auto-calc)	The time, in seconds, required for the design vehicle to accelerate from a stop and travel the complete design vehicle clearance distance.	Back to Form
68	Additional TCG time needed for design vehicle to clear CSD (auto-calc)	The extra track clearance green time required so that all vehicles clear CSD as well as DVCD so that no vehicles store between the tracks and the traffic signal. This option should be considered when the CSD does not have enough length to store the design vehicle (i.e. CSD = 45 ft and DVL = 50 ft). This is calculated by subtracting the total time for design vehicle to clear DVCD from the total time for design vehicle to clear DVL, MTCD, & CSD.	Back to Form

Section 10: Remove Track Clearance Green Phase

Remove Track Clearance Green Phase is another optional calculation included in the Utah Preemption Form. If it is decided that the Track Clearance Green Phase should be replaced by extended red time in the calculation, the following definitions should be used:

Line #	Term	Definition	Link
70	Track Clearance Green Time to be applied as extended red (auto-calc)	Extension of red clearance time that can be used to replace track clearance green time. If it is decided that a track clearance green phase should not be provided for the traffic signal (i.e. queue cutter signals or certain trail crossing signals), this option should be considered.	Back to Form

This page discusses the methods used for calculating each automatic calculation in the sheet. The calculations are called out by line number and worked through step by step.

3. DVL = Design Vehicle Length

This calculation is done when you select your design vehicle on line 14. It automatically enters the value for the design vehicle length entered on line 9, using either the column for Car, SU Truck, Bus, or Semi-Truck, depending on which column on line 14 has been answered "yes" to. For example, if the column for Semi-Truck had a "yes" on line 14 and the value 50 was input on line 9, the DVL would be 50.	73.5

4. L = Queue Start Up Distance

This calculation is done by adding the CSD (Line 1) to the MTCD (Line 2).	0

5. DVCD = Design Vehcile Clearance Distance

The design vehicle clearance distance is the sum of the design vehicle length (DVL) and the Minimum Track Clearance Distance (MTCD). This calculation is done by adding the DVL (Line 3) to the MTCD (Line 2)	73.5

9. DVL = Design Vehicle Length

This calculation looks up design vehicle length information in the AASHTO Designations Table (See AASHTO Designations Tab) based on which vehicle is selected for AASHTO Designation (Line 8).

10. Design Vehicle height

This calculation looks up design vehicle height information in the AASHTO Designations Table (See AASHTO Designations Tab) based on which vehicle is selected for AASHTO Designation (Line 8).

11. Time for design vehicle to start moving

This calculation is done using the formula 2+(L/20). L = Queue Startup Distance (Line 4)	2.0

12. Time for design vehicle to accelerate through DVCD (Line 5)

The time in seconds for the design vehicle to accelerate thru the DVCD. This is calculated using the 2 interpolations listed below. A. If DVCD (line 5) is less than 400 and the MTCD grade is 0, the acceleration table tab will be used to linearly interpolate the equation of a line for 4 separate scenarios: one for through passenger cars, one for SU trucks, one for S-BUS 40 and one for WB-50. The graph used to interpolate is shown below.	
I. The interpolation for a through passenger car yields	2.5
II. The interpolation for a SU truck yields	3.7
III. The interpolation for a S-BUS 40 yields	5.3
IV. The Interpolation for a WB-50 yields	11.5

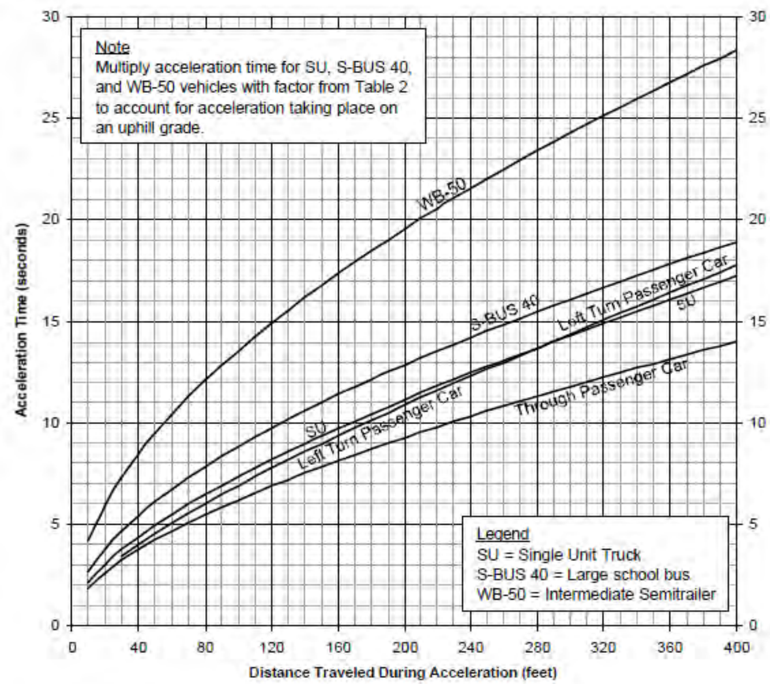


Figure 2 Acceleration time over a fixed distance on a level surface.

B. If the DVCD is less than 400, but the MTCD grade is greater than 0, a multiplier must be added to the values calculated above. These multipliers come from the table listed below (Grade Table<400) (Always use the larger value for percent grade and acceleration distance if between 2 values).

I. The multiplier applied to the calculation above for a through passenger car yields	2.5
II. The multiplier applied to the calculation above for a SU truck yields	3.7
III. The multiplier applied to the calculation above for S-BUS 40 yields	5.3
IV. The multiplier applied to the calculation for WB-50 yields	11.5

Table 2. Factors to account for slower acceleration on uphill grades. Multiply the appropriate factor (depending on the design vehicle, grade, and acceleration distance) with the acceleration time in Figure 2 to obtain the estimated acceleration time on the grade.

Acceleration Distance (ft)	Design Vehicle and Percentage Uphill Grade														
	Single Unit Truck (SU)				Large School Bus (S-BUS 40)					Intermediate Tractor-Trailer (WB-50)					
	0-2%	4%	6%	8%	0-1%	2%	4%	6%	8%	0%	2%	4%	6%	8%
25	1.00	1.06	1.13	1.19	1.00	1.01	1.10	1.19	1.28	1.00	1.09	1.27	1.42	1.55
50	1.00	1.09	1.17	1.25	1.00	1.01	1.12	1.21	1.30	1.00	1.10	1.28	1.44	1.58
75	1.00	1.10	1.19	1.29	1.00	1.02	1.13	1.23	1.33	1.00	1.11	1.30	1.47	1.61
100	1.00	1.11	1.21	1.32	1.00	1.02	1.14	1.25	1.35	1.00	1.11	1.31	1.48	1.64
125	1.00	1.12	1.23	1.34	1.00	1.03	1.15	1.26	1.37	1.00	1.12	1.32	1.50	1.66
150	1.00	1.12	1.24	1.37	1.00	1.03	1.16	1.28	1.40	1.00	1.12	1.33	1.52	1.68
175	1.00	1.13	1.25	1.38	1.00	1.03	1.17	1.29	1.42	1.00	1.12	1.34	1.53	1.70
200	1.00	1.13	1.26	1.40	1.00	1.04	1.17	1.30	1.43	1.00	1.13	1.35	1.54	1.72
225	1.00	1.14	1.27	1.42	1.00	1.04	1.18	1.32	1.45	1.00	1.13	1.35	1.56	1.74
250	1.00	1.14	1.28	1.43	1.00	1.04	1.19	1.33	1.47	1.00	1.13	1.36	1.57	1.76
275	1.00	1.14	1.29	1.44	1.00	1.05	1.20	1.34	1.49	1.00	1.14	1.37	1.58	1.77
300	1.00	1.14	1.30	1.46	1.00	1.05	1.20	1.35	1.50	1.00	1.14	1.37	1.59	1.79
325	1.00	1.15	1.30	1.47	1.00	1.05	1.21	1.36	1.52	1.00	1.14	1.38	1.60	1.81
350	1.00	1.15	1.31	1.48	1.00	1.05	1.22	1.37	1.54	1.00	1.15	1.39	1.61	1.82
375	1.00	1.15	1.31	1.49	1.00	1.06	1.22	1.38	1.55	1.00	1.15	1.39	1.62	1.84
400	1.00	1.15	1.32	1.50	1.00	1.06	1.23	1.40	1.57	1.00	1.15	1.40	1.63	1.85

C. If ther DVCD is greater than 400, the following equation must be used to calculated the time to accelerate through the DVCD

$$T = e^{\left[a - b\sqrt{c + \frac{2}{b} * ln\left(\frac{d}{X}\right)}\right]}$$

Where T = time to accelerate through distance X
X = DVCD
a,b,c, and d = calibration parameters from table below (Grade Table>400).

For each design vehicle, 2 calculations and an interpolation between the two results must be performed in order to get the actual time for the design vehicle to travel through DVCD

I. The calculation for a through passenger car and any MTCD grade yields	N/A

II. The calculation for a SU truck must be split into 2 segemnts and then interpolated.	
a. The first calculation for a SU truck at any MTCD grade % yields	N/A
b. The second calculation for a SU truck at any MTCD grade % yields	N/A
c. The interpolation of the two yields	N/A
III. The calculation for a S-BUS 40 must be split into 2 segemnts and then interpolated.	
a. The first calculation for a S-BUS 40 at any MTCD grade % yields	N/A
b. The second calculation for a S-BUS 40 at any MTCD grade % yields	N/A
c, the interpolation of the two yields	N/A
IV. II. The calculation for a WB-50 must be split into 2 segemnts and then interpolated.	
a. The first calculation for a WB-50 at any MTCD grade % yields	N/A
b. The second calculation for a WB-50 at any MTCD grade % yields	N/A
c, the interpolation of the two yields	N/A

13. Queue Clearance Time

This is calculated by adding time required for design vehicle to start moving (Line 11) to time for design vehicle to accelerate through DVCD (Line 12) for each type of design vehicle.	
A. For a through passenger car, the calculation yields	4.5
B. For a SU truck, the calculation yields	5.7
C. For a S-BUS 40, the calculation yields	7.3
C. For a WB-50 truck, the calculation yields	13.5

17. Preemption Verification and Response Time

This is calculated by adding preempt delay time (Line 15) to controller response time to preempt (Line 17) and yields	0

22. Worst case conflicting vehicle time

This is calculated by summing min. green service time (Line 19), yellow change time (Line 20), and red clearance time (Line 21) and yields	0

28. Worst case conflicting pedestrian time

This is calculated by summing min. walk time during right-of-way transfer (Line 24), pedestrian change interval (Line 25), vehicle yellow change interval (Line 26), and vehicle red clearance (Line 27) interval and yields	0

29. Worst case conflicting vehicle or pedestrian time

This is calculated by taking the maximum of worst-case conflicting vehicle time (Line 22) and worst case conflicting pedestrian time (Line 28) and yields	0

30. Right-of-way transfer time

This is calculated by adding preempt verification and response time (Line 17) to worst case conflicting vehicle or pedestrian time (Line 29) and yields	0

31. Queue Clearance Time

Value taken from queue clearance time (Line 13) and rounded up to the nearest whole number. It chooses the value for the design vehicle that is picked for Use as design vehicle? (Line 14). If no vehicles are picked, the value will be 0.	14.0

32. Track Clearance Green

Calculated one of two ways. If no vehicle-gate interaction or time to clear CSD is used, this value equals the queue clearance time. If vehicle-gate interaction and/or time to clear CSD is used, this is calculated by adding queue clearance (Line 31), additional TCG time to account for design vehicle-gate interaction (Line 63), and additional TCG time needed for design vehicle to clear CSD (Line 68). This calculation yields	14.0

34. Maximum preemption time

This is calculated by adding right of way transfer time (Line 30), track clearance green time (Line 32), desired minimum separation time (Line 33), and additional RWTT due to Approach/Conflicting Vehicle clearance (Line 51) and yields	14.0

38. Clearance Time

This is calculated using the following equation:

$$CT = (MTCD - 35\ ft)\text{*}0.1\ \text{sec/ft}$$

CT = Clearance Time

MTCD = Min Track Clearance Distance

This is rounded up to the nearest whole second and yields	0

39. Minimum Warning Time

This is calculated by adding required minimum time (MT) (Line 37) and clearance time (CT) (Line 38) and yields	0

41. Total warning time provided by the railroad

This is calculated by summing minimum warning time (MWT) (Line 39) and buffer time (BT) (Line 40) and yields	14

42. Additional warning time required from railroad

This is calculated by subtracting minimum warning time (MWT) (Line 39) from Maximum preemption time (Line 34) and yields	0

44. Total Approach Time

This is calculated by adding total warning time provided by the railroad (Line 41), additional warning time required from railroad (Line 42), and RR equipment response time (Line 43) and yields	14

47. Approach vehicle clearance time

This value is calculated using one of the equations below depending on which design vehicle is selected.	
For a through passenger car, use the equation below, which yields.	N/A
$MAMT = 2.46 + 0.5483 * (line\ 45)^{0.5463}$	
For a SU truck, use the equation below, which yields	N/A
$MAMT = 2.48 + 0.6026 * (line\ 45)^{0.5474}$	
If there is there is a % grade for the MAMD, a mutiplier must be applied to the above calculation which yields	N/A
For a S-BUS 40, use the equation below which yields	N/A
$MAMT = 2.72 + 0.5333 * (line\ 45)^{0.5348}$	
If there is a % grade for the MAMD, a multiplier must be applied to the above calculation which yields	N/A
For a WB-50, use the equation below which yields	N/A
$MAMT = 3.99 + 1.2559 * (line\ 45)^{0.5188}$	
If there is a % grade for the MAMD, a multiplier must be applied to the above calculation which yields	N/A

50. Conflicting vehicle clearance time

This value is calculated using one of the equations below depending on which design vehicle is selected.	
For a through passenger car, use the equation below, which yields.	N/A
$$MCMT = 2.46 + 0.5483 * (line\ 45 + line\ 3)^{0.5463}$$	
For a SU Truck, use the equation below which yields	N/A
$$MCMT = 2.48 + 0.6026 * (line\ 45 + line\ 3)^{0.5474}$$	
If there is a % grade for the MCMD, a multiplier must be applied to the above calculation which yields	N/A
For a S-BUS 40, use the equation below which yields	N/A
$$MCMT = 2.72 + 0.5333 * (line\ 45 + line\ 3)^{0.5348}$$	
If there is a % grade for the MAMD, a multiplier must be applied to the above calculation which yields	N/A
For a WB-50, use the equation below which yields	N/A
$$MCMT = 3.99 + 1.2559 * (line\ 45 + line\ 3)^{0.5188}$$	
If there is a % grade for the MAMD, a multiplier must be applied to the above calculation which yields	N/A

51. Additional RWTT due to Approach/Conflicting Vehicle clearance

This calculation takes the larger of approach vehicle clearance time (Line 47) and Conflicting vehicle clearance time (Line 50) and subtracts right of way transfer time (Line 30).	0.0

53. Time required for design vehicle to start moving

This is time required for design vehicle to start moving (Line 11). It chooses the value for the design vehicle that is picked for Use as design vehicle? (Line 14) and yields	N/A

54. Time required for design vehicle to accelerate through DVL

This is calculated using the 2 equations listed below.

A. If the MTCD grade is 0, the acceleration table tab will be used to linearly interpolate the equation of a line for 4 separate scenarios: one for through passenger cars, one for SU trucks, one for S-BUS 40 and one for WB-50. The graph used to interpolate is shown below.

I. The interpolation for a through passenger car yields	N/A
II. The interpolation for a SU truck yields	N/A
III. The interpolation for a S-BUS 40 yields	N/A
IV. The Interpolation for a WB-50 yields	N/A

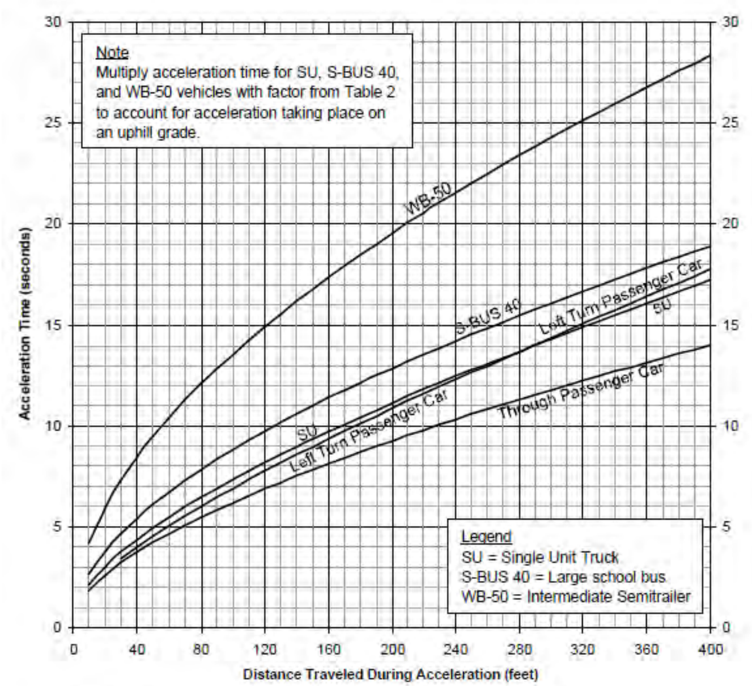


Figure 2 Acceleration time over a fixed distance on a level surface.

B. If the MTCD grade is greater than 0, a multiplier must be added to the values calculated above. These multipliers come from the table listed below (Grade Table<400) (Always use the larger value for percent grade and acceleration distance if between 2 values).	
I. The multiplier applied to the calculation above for a through passenger car yields	N/A
II. The multiplier applied to the calculation above for a SU truck yields	N/A
III. The multiplier applied to the calculation above for S-BUS 40 yields	N/A
IV. The multiplier applied to the calculation for WB-50 yields	N/A

Table 2. Factors to account for slower acceleration on uphill grades. Multiply the appropriate factor (depending on the design vehicle, grade, and acceleration distance) with the acceleration time in Figure 2 to obtain the estimated acceleration time on the grade.

Acceleration Distance (ft)	Design Vehicle and Percentage Uphill Grade														
	Single Unit Truck (SU)				Large School Bus (S-BUS 40)					Intermediate Tractor-Trailer (WB-50)					
	0-2%	4%	6%	8%	0-1%	2%	4%	6%	8%	0%	2%	4%	6%	8%
25	1.00	1.06	1.13	1.19	1.00	1.01	1.10	1.19	1.28	1.00	1.09	1.27	1.42	1.55
50	1.00	1.09	1.17	1.25	1.00	1.01	1.12	1.21	1.30	1.00	1.10	1.28	1.44	1.58
75	1.00	1.10	1.19	1.29	1.00	1.02	1.13	1.23	1.33	1.00	1.11	1.30	1.47	1.61
100	1.00	1.11	1.21	1.32	1.00	1.02	1.14	1.25	1.35	1.00	1.11	1.31	1.48	1.64
125	1.00	1.12	1.23	1.34	1.00	1.03	1.15	1.26	1.37	1.00	1.12	1.32	1.50	1.66
150	1.00	1.12	1.24	1.37	1.00	1.03	1.16	1.28	1.40	1.00	1.12	1.33	1.52	1.68
175	1.00	1.13	1.25	1.38	1.00	1.03	1.17	1.29	1.42	1.00	1.12	1.34	1.53	1.70
200	1.00	1.13	1.26	1.40	1.00	1.04	1.17	1.30	1.43	1.00	1.13	1.35	1.54	1.72
225	1.00	1.14	1.27	1.42	1.00	1.04	1.18	1.32	1.45	1.00	1.13	1.35	1.56	1.74
250	1.00	1.14	1.28	1.43	1.00	1.04	1.19	1.33	1.47	1.00	1.13	1.36	1.57	1.76
275	1.00	1.14	1.29	1.44	1.00	1.05	1.20	1.34	1.49	1.00	1.14	1.37	1.58	1.77
300	1.00	1.14	1.30	1.46	1.00	1.05	1.20	1.35	1.50	1.00	1.14	1.37	1.59	1.79
325	1.00	1.15	1.30	1.47	1.00	1.05	1.21	1.36	1.52	1.00	1.14	1.38	1.60	1.81
350	1.00	1.15	1.31	1.48	1.00	1.05	1.22	1.37	1.54	1.00	1.15	1.39	1.61	1.82
375	1.00	1.15	1.31	1.49	1.00	1.06	1.22	1.38	1.55	1.00	1.15	1.39	1.62	1.84
400	1.00	1.15	1.32	1.50	1.00	1.06	1.23	1.40	1.57	1.00	1.15	1.40	1.63	1.85

The value that is used for the design vehicle specified in the preemption form yields	0.0

55. Time required for design vehicle to clear descending gate

This calculation adds right of way transfer time (Line 30), time required for design vehicle to start moving (Line 53), and time required for design vehicle to accelerate thru DVL (Line 52) and yields	N/A

56. Duration of flashing lights before gate-descent starts

This is the value of Duration of flashing lights before gate descent starts (Line 35) and yields	0.0

57. Full gate descent time

This is the value of full gate descent time (Line 36) and yields	0.0

59. Proportion of non-gate interaction descent time

For this calculation the Gate-Interaction Table tab will be used to linearly interpolate the equation of a line for 4 separate scenarios: one for through passenger cars, one for SU trucks, one for S-BUS 40 and one for WB-50. The graph used to interpolate is shown below. The value of line 56 must be between 4 ft and 20 ft because the graph only includes distances within that range.

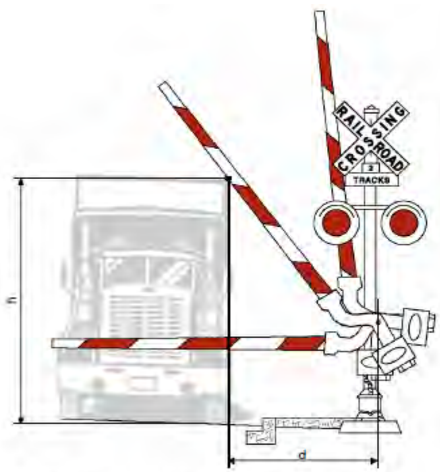
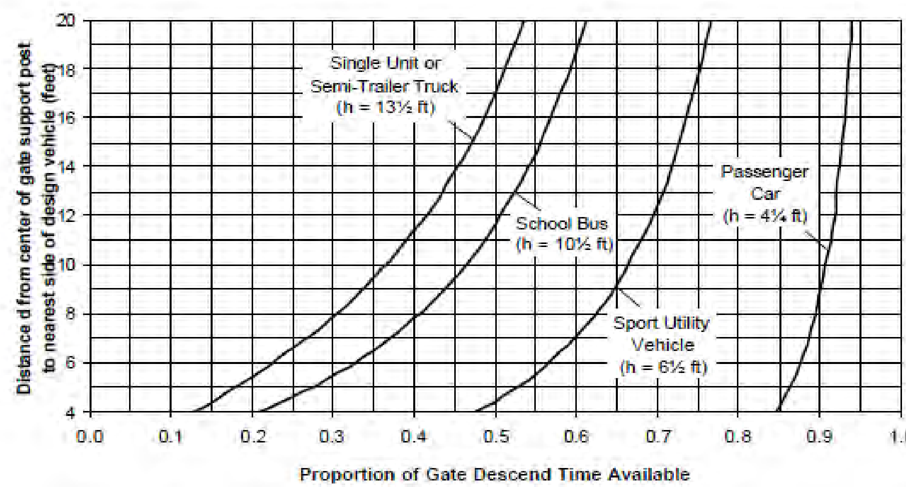


Figure 4 Gate interaction with the design vehicle.



I. The interpolation for a through passenger car yields	N/A
II. The interpolation for a SU truck yields	N/A
III. The interpolation for a S-BUS 40 yields	N/A
IV. The Interpolation for a WB-50 yields	N/A
The value that is used for the design vehicle specified in the preemption form yields	N/A

60. Non-interaction gate descent time

This is the multiplication of full gate descent time (Line 57) and proportion of non-gate interaction descent time (Line 59) and yields	N/A

61. Time available for design vehicle to clear descending gates

This calculation adds duration of flashing lights before gate descent starts (Line 56) and Non-interaction gate descent time (Line 60) and yields	N/A

62. Advance preemption time to avoid design-vehicle gate interaction

This calculation subtracts time available for design vehicle to clear descending gates (Line 61) from time required for design vehicle to clear descending gate (Line 55) and yields	N/A

63. Additional TCG time to account for design vehicle-gate interaction (sec)

This is calculated by subtracting maximum preemption time (Line 34) and minimum warning time (Line 39) from advance preemption to avoid design vehicle-gate interaction (Line 62) and yields	0.0

65. Distance design vehicle must travel to clear DVL, MTCD, & CSD

This is calculated by adding Clear Storage Distance (Line 1), Minimum Track Clearance Distance (Line 2), & Design Vehicle Length (Line 3) and yields	73.5

66. Time for design vehicle to accelerate through CSD

The time in seconds for the design vehicle to accelerate thru the DVCD. This is calculated using the 2 interpolations listed below. A. If DVCD (line 5) is less than 400 and the MTCD grade is 0, the acceleration table tab will be used to linearly interpolate the equation of a line for 4 separate scenarios: one for through passenger cars, one for SU trucks, one for S-BUS 40 and one for WB-50. The graph used to interpolate is shown below.	
I. The interpolation for a through passenger car yields	2.5
II. The interpolation for a SU truck yields	3.7
III. The interpolation for a S-BUS 40 yields	5.3
IV. The Interpolation for a WB-50 yields	11.5

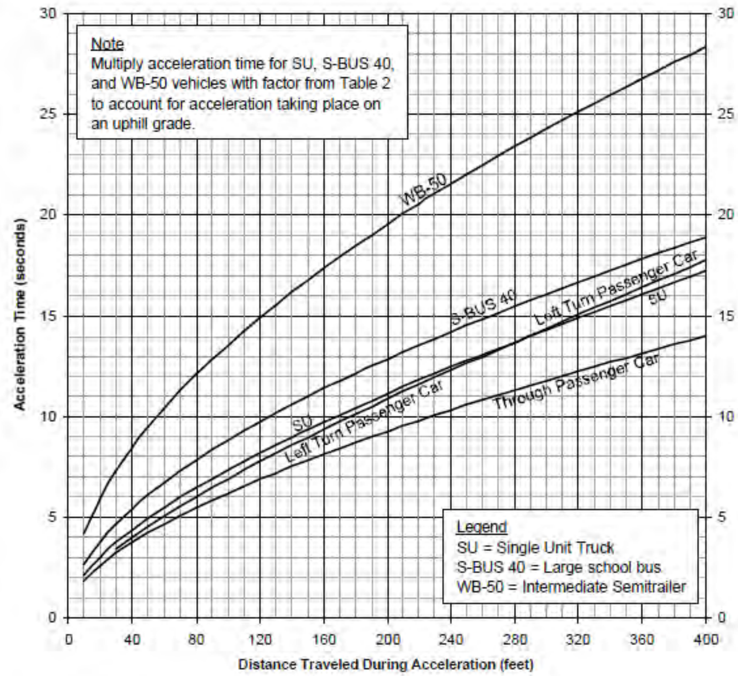


Figure 2 Acceleration time over a fixed distance on a level surface.

B. If the DVCD is less than 400, but the MTCD grade is greater than 0, a multiplier must be added to the values calculated above. These multipliers come from the table listed below (Grade Table<400) (Always use the larger value for percent grade and acceleration distance if between 2 values).

I. The multiplier applied to the calculation above for a through passenger car yields	2.5
II. The multiplier applied to the calculation above for a SU truck yields	3.7
III. The multiplier applied to the calculation above for S-BUS 40 yields	5.3
IV. The multiplier applied to the calculation for WB-50 yields	11.5

Table 2. Factors to account for slower acceleration on uphill grades. Multiply the appropriate factor (depending on the design vehicle, grade, and acceleration distance) with the acceleration time in Figure 2 to obtain the estimated acceleration time on the grade.

Acceleration Distance (ft)	Design Vehicle and Percentage Uphill Grade													
	Single Unit Truck (SU)				Large School Bus (S-BUS 40)					Intermediate Tractor-Trailer (WB-50)				
	0-2%	4%	6%	8%	0-1%	2%	4%	6%	8%	0%	2%	4%	6%	8%
25	1.00	1.06	1.13	1.19	1.00	1.01	1.10	1.19	1.28	1.00	1.09	1.27	1.42	1.55
50	1.00	1.09	1.17	1.25	1.00	1.01	1.12	1.21	1.30	1.00	1.10	1.28	1.44	1.58
75	1.00	1.10	1.19	1.29	1.00	1.02	1.13	1.23	1.33	1.00	1.11	1.30	1.47	1.61
100	1.00	1.11	1.21	1.32	1.00	1.02	1.14	1.25	1.35	1.00	1.11	1.31	1.48	1.64
125	1.00	1.12	1.23	1.34	1.00	1.03	1.15	1.26	1.37	1.00	1.12	1.32	1.50	1.66
150	1.00	1.12	1.24	1.37	1.00	1.03	1.16	1.28	1.40	1.00	1.12	1.33	1.52	1.68
175	1.00	1.13	1.25	1.38	1.00	1.03	1.17	1.29	1.42	1.00	1.12	1.34	1.53	1.70
200	1.00	1.13	1.26	1.40	1.00	1.04	1.17	1.30	1.43	1.00	1.13	1.35	1.54	1.72
225	1.00	1.14	1.27	1.42	1.00	1.04	1.18	1.32	1.45	1.00	1.13	1.35	1.56	1.74
250	1.00	1.14	1.28	1.43	1.00	1.04	1.19	1.33	1.47	1.00	1.13	1.36	1.57	1.76
275	1.00	1.14	1.29	1.44	1.00	1.05	1.20	1.34	1.49	1.00	1.14	1.37	1.58	1.77
300	1.00	1.14	1.30	1.46	1.00	1.05	1.20	1.35	1.50	1.00	1.14	1.37	1.59	1.79
325	1.00	1.15	1.30	1.47	1.00	1.05	1.21	1.36	1.52	1.00	1.14	1.38	1.60	1.81
350	1.00	1.15	1.31	1.48	1.00	1.05	1.22	1.37	1.54	1.00	1.15	1.39	1.61	1.82
375	1.00	1.15	1.31	1.49	1.00	1.06	1.22	1.38	1.55	1.00	1.15	1.39	1.62	1.84
400	1.00	1.15	1.32	1.50	1.00	1.06	1.23	1.40	1.57	1.00	1.15	1.40	1.63	1.85

C. If ther DVCD is greater than 400, the following equation must be used to calculated the time to accelerate through the DVCD

$$T = e^{\left[a - b\sqrt{c + \frac{2}{b} * ln\left(\frac{d}{X}\right)}\right]}$$

Where T = time to accelerate through distance X

X = DVCD

a,b,c, and d = calibration parameters from table below (Grade Table>400).

For each design vehicle, 2 calculations and an interpolation between the two results must be performed in order to get the actual time for the design vehicle to travel through DVCD	
I. The calculation for a through passenger car and any MTCD grade yields	N/A
II. The calculation for a SU truck must be split into 2 segemnts and then interpolated.	
a. The first calculation for a SU truck at any MTCD grade % yields	N/A
b. The second calculation for a SU truck at any MTCD grade % yields	N/A
c. The interpolation of the two yields	N/A
III. The calculation for a S-BUS 40 must be split into 2 segemnts and then interpolated.	
a. The first calculation for a S-BUS 40 at any MTCD grade % yields	N/A
b. The second calculation for a S-BUS 40 at any MTCD grade % yields	N/A
c. The interpolation of the two yields	N/A
IV. The calculation for a WB-50 must be split into 2 segemnts and then interpolated.	
a. The first calculation for a WB-50 at any MTCD grade % yields	N/A
b. The second calculation for a WB-50 at any MTCD grade % yields	N/A
c. The interpolation of the two yields	N/A
The final value for the design vehicle chosen on line 14 is as follows	N/A

67. Total time for design vehicle to clear DVCD

Value taken from time for design vehicle to accelerate through DVCD (Line 12) and rounded up to the nearest whole number. It chooses the value for the design vehicle that is picked for Use as design vehicle? (Line 14). If no vehicles are picked, the value will be 0.	N/A

68. Additional TCG time needed for design vehicle to clear CSD

This is calculated by subtracting 67. Total time for design vehicle to clear DVCD (Line 67) from Total time for design vehicle to clear DVL, MTCD, & CSD (Line 66) and yields:	0.0

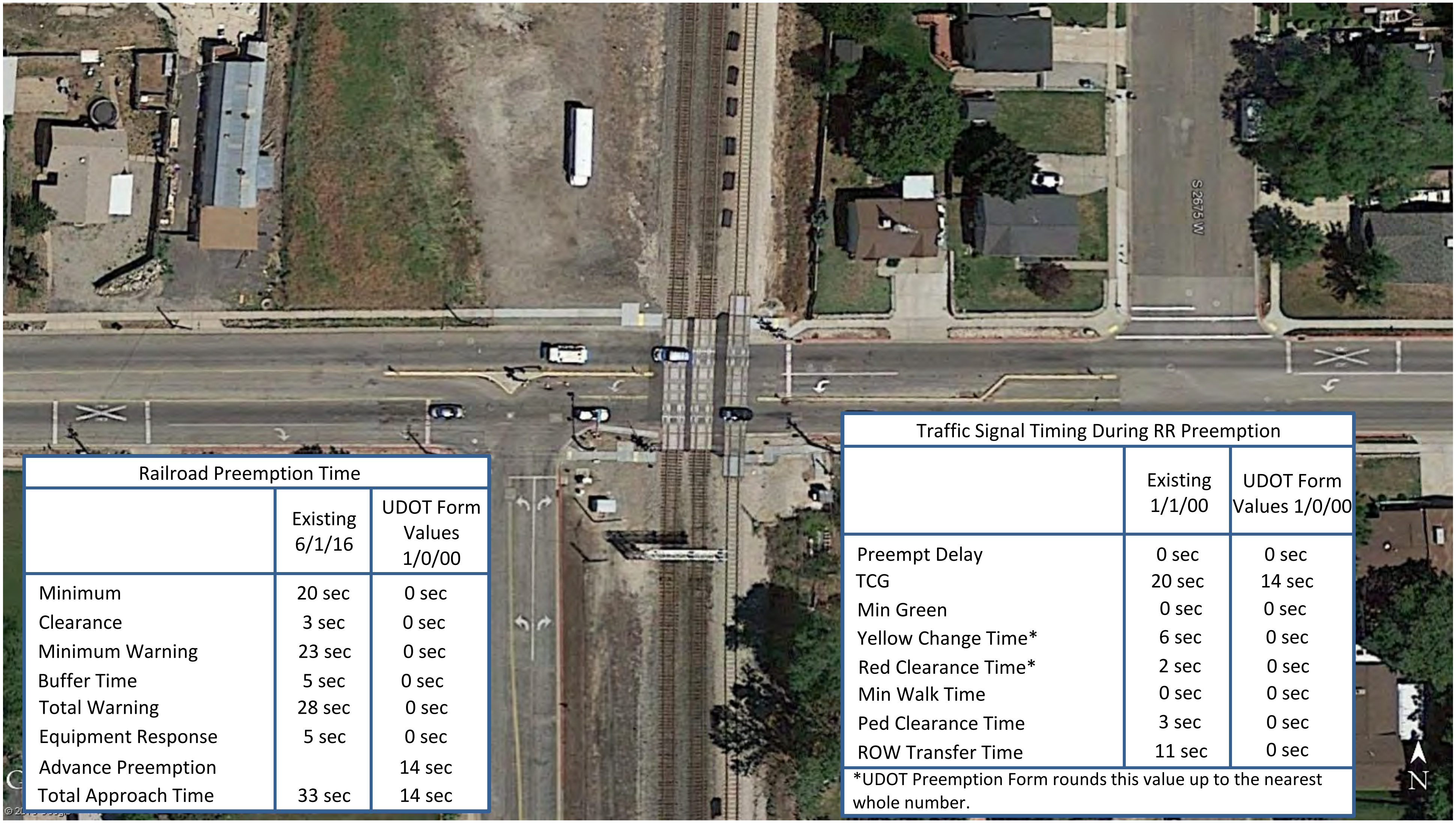
70. Track Clearance Green Time to be applied as extended red

This is calculated by removing Track Clearance Green Time (Line 32) and applying it as extended red time (Line 70) and yields:	N/A

Utah Preemption Form - Preemption Calculation Comparison Exhibit

Crossing Name: ____ DOT #: ____ Railroad Owner/Operator: ____ Railroad Contact No.: (800) 848-8715

Highway Authority: ____ City: ____ UDOT Signal No.: 7051 UDOT Contact No.: ____



Railroad Preemption Time	Existing 6/1/16	UDOT Form Values 1/0/00
Minimum	20 sec	0 sec
Clearance	3 sec	0 sec
Minimum Warning	23 sec	0 sec
Buffer Time	5 sec	0 sec
Total Warning	28 sec	0 sec
Equipment Response	5 sec	0 sec
Advance Preemption		14 sec
Total Approach Time	33 sec	14 sec

Traffic Signal Timing During RR Preemption	Existing 1/1/00	UDOT Form Values 1/0/00
Preempt Delay	0 sec	0 sec
TCG	20 sec	14 sec
Min Green	0 sec	0 sec
Yellow Change Time*	6 sec	0 sec
Red Clearance Time*	2 sec	0 sec
Min Walk Time	0 sec	0 sec
Ped Clearance Time	3 sec	0 sec
ROW Transfer Time	11 sec	0 sec

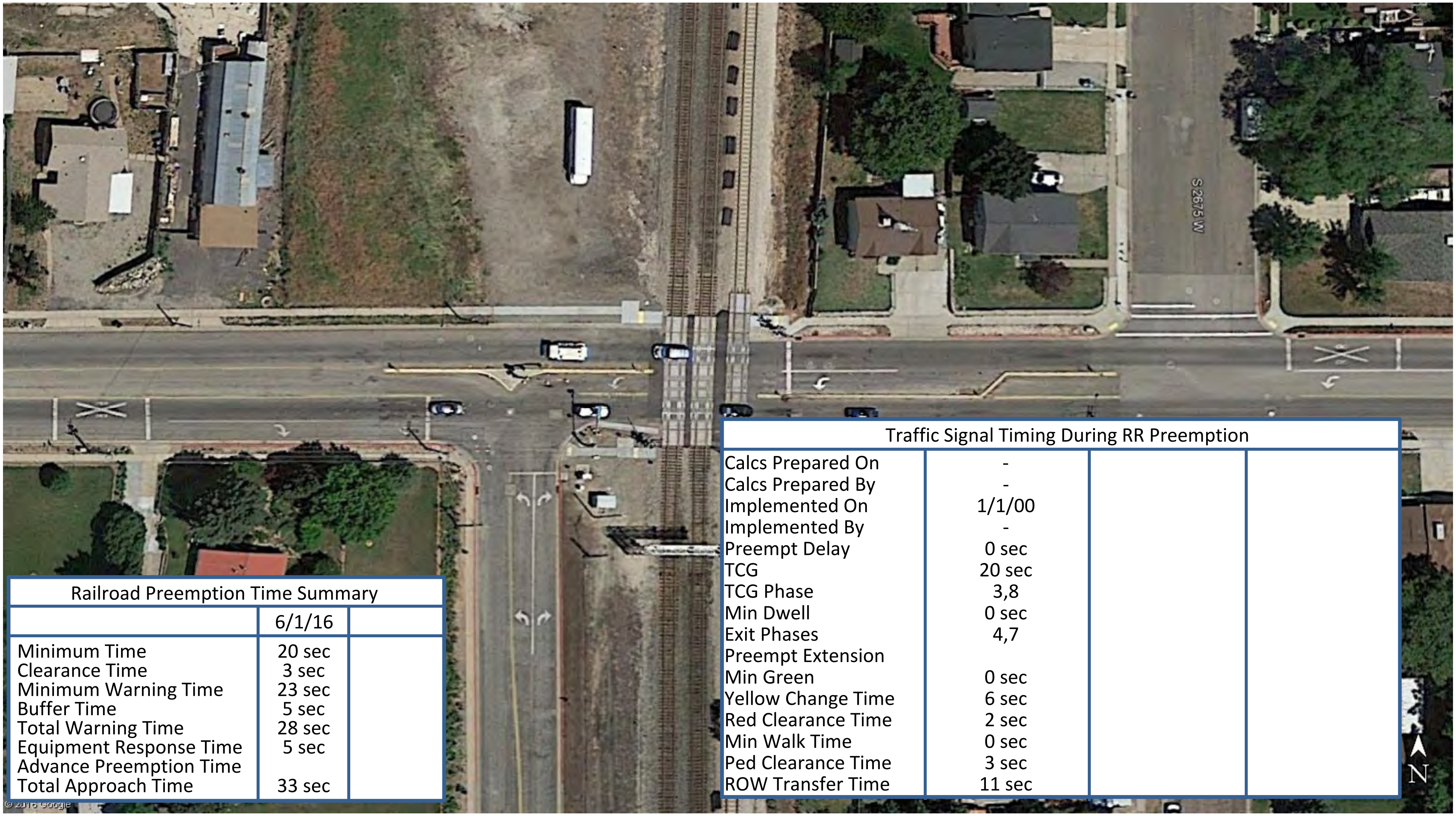
*UDOT Preemption Form rounds this value up to the nearest whole number.

Comments:

Utah Preemption Form - Traffic Signal Cabinet Exhibit

Crossing Name: ______ DOT #: ______ Railroad Owner/Operator: ______ Railroad Contact No.: (800) 848-8715

Highway Authority: ______ City: ______ UDOT Signal No.: 7051 UDOT Contact No.: ______



Railroad Preemption Time Summary		
	6/1/16	
Minimum Time	20 sec	
Clearance Time	3 sec	
Minimum Warning Time	23 sec	
Buffer Time	5 sec	
Total Warning Time	28 sec	
Equipment Response Time	5 sec	
Advance Preemption Time		
Total Approach Time	33 sec	

Traffic Signal Timing During RR Preemption			
Calcs Prepared On	-		
Calcs Prepared By	-		
Implemented On	1/1/00		
Implemented By	-		
Preempt Delay	0 sec		
TCG	20 sec		
TCG Phase	3,8		
Min Dwell	0 sec		
Exit Phases	4,7		
Preempt Extension			
Min Green	0 sec		
Yellow Change Time	6 sec		
Red Clearance Time	2 sec		
Min Walk Time	0 sec		
Ped Clearance Time	3 sec		
ROW Transfer Time	11 sec		

Comments:

Appendix B

UDOT Safety Audit Checklist

Reason for Inspection:				
Crossing Name:	Nearby Intersection:	City/County:	FRA DOT No.:	
			Crossing Hotline #:	
Date of Review	Begin Time:		End Time:	
Railroad Key Representative	Name:	Organization:	Phone No:	Email:
Highway Authority Representative	Name:	Organization:	Phone No:	Email:

SECTION 1: RAILROAD DATA & DESIGN INFORMATION

LOCATION DATA

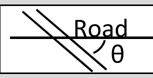
Railroad (R.R.):	R.R. Line/Branch:	R.R. Division/Region	R.R. Subdivision/District	Nearest R.R. Timetable station	R.R. Milepost:

RAILROAD DATA

Crossing Type	Crossing Purpose	Crossing Position	Public Access *(if Private Crossing)*	Type of Train	
☐Public	☐Highway	☐At Grade	☐Yes	☐Freight	☐Transit
☐Private	☐Pathway, Ped.	☐RR Under	☐No	☐Intercity Passenger	☐Shared Use Transit
	☐Station, Ped.	☐RR Over		☐Commuter	☐Tourist/Other

Type of Land Use
☐Open Space ☐Farm ☐Residential ☐Commercial ☐Industrial ☐Institutional ☐Recreational ☐RR Yard

Is there an Adjacent Crossing with a Separate Number?
☐Yes ☐No If Yes, Provide Crossing Number

TRAIN VOLUME		TYPE & NUMBER OF TRACKS		
Passenger		Main		If Other, Specify:
Freight		Other		

MAXIMUM SPEED OF TRAIN		NOTES
Passenger mph	Freight mph	Any Permanent Speed Restrictions?

Can more than 1 train occupy the crossing at the same time? ☐Yes ☐No

SECTION 2: HIGHWAY DATA

ROADWAY DATA & OBSERVATIONS

Any Historical Vehicle Queuing over the tracks? ☐Yes ☐No If yes, describe frequency and queue lengths:	Any Vehicle Queuing Observed During Field Review? ☐Yes ☐No If yes, describe frequency and queue lengths:

Visibility concerns of RR signs or equipment? ☐Yes ☐No
If yes, describe:

Ex Qty	Type	Existing Condition/Status	Notes
	R3-1 Blank Out Sign 		
	R3-2 Blank Out Sign 		
	R5-1 Blank Out Sign 		
	W10-7 Blank Out Sign 		
	Other:		

Safety Audit Checklist

Highway-Rail Interconnected Grade Crossing

Reason for Inspection:			
Crossing Name:	Nearby Intersection:	City/County:	FRA DOT No.:
			Crossing Hotline #:

TRAFFIC SIGNAL TIMING

Preemption Type: ☐ Advanced ☐ Simultaneous

Vehicle Detection Type: ☐ Video ☐ Loop Detectors ☐ Radar ☐ Other: ☐ None

Track Clearance Checks	From As-Built	Currently Programmed	Notes
Track Clearance Green Time	Seconds	Seconds	
Track Clearance Green Phases			
Preemption Operation	☐ Limited Service ☐ All Red Flash	☐ Limited Service ☐ All Red Flash	Permitted Phases in Limited Service:

ROW Transfer Time	From As-Built	Currently Programmed	Notes
Pedestrian Clearance prior to TCG:	Seconds	Seconds	
Walk before TCG:	Seconds	Seconds	
Red before TCG	Seconds	Seconds	
Yellow before TCG:	Seconds	Seconds	
Minimum Green before TCG:	Seconds	Seconds	
Additional Time before TCG (Overlaps):	Seconds	Seconds	
TOTAL ROW Transfer Time (sum above):	**Seconds**	**Seconds**	

Verified Worst-Case ROW Transfer Time? ☐ Yes ☐ No	If so, how long is it? Seconds
Worst case conflicting pedestrian phase?	Worst Case Vehicle Conflicting phase?

TRAFFIC SIGNAL INTERCONNECTION AND PREEMPTION

Traffic Signal Cabinet

Controller Type:	Software Type:	Notes:
Controller Preempt Response Time:	Preempt Delay Time (if any):	

Condition	Traffic Signal Observations
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	
☐ Test Preemption ☐ Train Event	

Reason for Inspection:			
Crossing Name:	Nearby Intersection:	City/County:	FRA DOT No.: Crossing Hotline #:

Yes	No	Type	Notes
GENERAL OBSERVATIONS			
☐	☐	Does RR preemption exist as shown on plan?	If no, explain differences.
☐	☐	Do motorists have clear visibility of traffic signal indications from RR Stop Line?	If no, explain.
☐	☐	Do motorists have clear visibility of RR Flashers from RR Stop Line?	If no, explain.
☐	☐	Is there vehicle detection prior to the crossing?	
☐	☐	Are left turn movements toward the track "protected" movements?	
☐	☐	Does the traffic signal have battery back-up?	If yes, how many hours can it provide power for?
☐	☐	Is the traffic signal in coordination with an adjacent signal(s)?	If so, which one(s)?

Yes	No	Type	Notes
PREEMPTION OPERATIONS			
☐	☐	Is an interconnected warning label present in the traffic cabinet?	
☐	☐	Is the interconnection cable a minimum of 7 Conductor ISMA 20-1 Traffic Signal Cable?	
☐	☐	Is the interconnection a "double break" or "supervised circuit"?	
☐	☐	Is there a Maximum Preemption Timer?	
☐	☐	During simultaneous RR Preemption, does traffic signal immediately transition to track clearance green?	If no, explain.
☐	☐	Does track clearance green continue after RR gates are down?	If so, for how long?
☐	☐	Does the track clearance phase have a protected left?	
☐	☐	Does the traffic signal go to flashing red operations during RR Preemption?	
☐	☐	After track clearance green, are non- RR conflicting traffic movements allowed while in preemption?	
☐	☐	Are blankout signs activated at the simultaneous RR Preemption call?	If no, explain.
☐	☐	At the end of RR preemption, do RR warning lights stop flashing before motorists receive a green traffic signal indication?	If no, explain.
☐	☐	Does the traffic signal create a lagging yellow left turn condition during transition to the track clearance interval?	
☐	☐	Are vehicular movements toward the tracks restricted during preemption?	

Reason for Inspection:			
Crossing Name:	Nearby Intersection:	City/County:	FRA DOT No.: Crossing Hotline #:

PEDESTRIAN OPERATIONS			
Yes	No	Type	Notes
☐	☐	Are Pedestrian push buttons provided?	
☐	☐	Are pedestrian movements restricted during track clearance green?	If no, explain.
☐	☐	During signal transition to preemption operations, are pedestrian movements allowed?	If yes, explain.
☐	☐	Do pedestrians have countdown heads?	
☐	☐	Is pedestrian phasing ever "rest in walk"?	If so, when?
☐	☐	Are any pedestrian phases automatically recalled?	If so, what ones?

Reason for Inspection:			
Crossing Name:	Nearby Intersection:	City/County:	FRA DOT No.: Crossing Hotline #:

PRE-SIGNAL OPERATIONS			
Yes	No	Type	Notes
☐	☐	Does a pre-signal exist at the crossing?	Describe location in relation to the RR tracks.
☐	☐	Do motorists routinely stop at pre-signal stop line?	
☐	☐	Are right turns on red restricted across RR tracks?	
☐	☐	Are downstream intersection traffic signal heads visible at pre-signal stop line?	If no; explain.

Detail what relay(s) are being provided to traffic signal controller cabinet and its function.

TCR:

XR/XMP:

GD:

ISLR:

HLTH:

SECTION 3: PHOTO REVIEW CHECKLIST

PHOTO REVIEW CHECKLIST	
☐	Roadway Approach to Crossing (both directions)
☐	Railway Approach to Crossing (both directions)
☐	Adjacent Intersection(s) - each approach
☐	Nearby Driveways, Schools, Attractions, Trucking Facilities
☐	Train Events (if possible)

Reason for Inspection:			
Crossing Name:	Nearby Intersection:	City/County:	FRA DOT No.:
			Crossing Hotline #:

PHOTO REVIEW CHECKLIST (CONTINUED)	
☐	Conditions that need improvement
☐	RR Interconnect Label on/in Traffic Signal Cabinet and RR Signal House (if interconnection currently exists)
☐	Traffic Signal Cabinet and as-built plans in cabinet
☐	Traffic Signal Controller
☐	Battery Backup for Traffic Signal
☐	RR Signal House and cabinet prints
☐	Railroad Crossing Predictor type/unit
☐	Emergency notification signs
☐	Sight Distance/Visibility Concerns
☐	Queuing across tracks

SECTION 4: FIELD RECOMMENDATIONS (This section to be completed by Diagnostic Team)

POTENTIAL IMPROVEMENTS FOR CONSIDERATION

Yes	No	Category	Describe
☐	☐	Sight Distance Improvement	
☐	☐	Crossing Surface	
☐	☐	Roadway Surface	
☐	☐	Traffic Signs	
☐	☐	Traffic Striping	
☐	☐	Traffic Signal Equipment	
☐	☐	Traffic Signal Operations	
☐	☐	RR Crossing Equipment RR Crossing Signal Operations	
☐	☐	Other	

FIELD VISIT ATTENDEE INFORMATION

Railroad Attendees

No.	Name	Company	Email	Cell Phone No.
1.				
2.				
3.				
4.				
5.				

Reason for Inspection:				
Crossing Name:	Nearby Intersection:	City/County:	FRA DOT No.:	
			Crossing Hotline #:	
FIELD VISIT ATTENDEE INFORMATION (CONTINUED)				
Railroad Attendees				
No.	Name	Company	Email	Cell Phone No.
6.				
7.				
Highway Authority Attendees				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
Other Attendees				
15.				
16.				
17.				
18.				

Reason for Inspection:			
Crossing:	Nearby intersection:	City/State:	FRA DOT No.:
			Crossing Hotline #:
SECTION 5: PREPARER			
Prepared By:		Title:	
I certify that the above notes are accurate to the best of my knowledge			
Signature:		Date:	

SECTION 6: REVIEWER	
Reviewed By:	Title:
Professional Engineer License No.:	Type:
Signature:	Date:

Appendix C

UPRR Highway Rail Grade Crossing Traffic Signal Preemption Request Form

Highway Rail Grade Crossing Traffic Signal Preemption Request Form

The purpose of this form is to document the preemption operation and timing parameters being requested by the public agency responsible for the traffic signal and convey the information to Union Pacific Railroad. A report was provided to the public agency on behalf of Union Pacific. This report included recommendations to the public agency for consideration to enhance the preemption operation system. Union Pacific Railroad recognizes that the public agency is the final authority regarding the design and operation of the preemption system in accordance with the 2012 (MUTCD) Chapter 8C, Section 8C.09.

Please provide the following information in order to process your request :

Date of Request: ______________________ Public Agency: ______________________

Requested by (Name/Title): ______________________

Phone: ______________________ Email: ______________________

Grade Crossing Information:

State: ______________________ DOT #: ______________________

District: ______________________ RR Subdivision: ______________________

City: ______________________ Mile Post: ______________________

County: ______________________

Crossing Street Name: ______________________

Parallel Street Name: ______________________

1) Is this request for Simultaneous Preemption Operation? ☐ Yes ☐ No — If "Yes" what is the requested Additional Warning Time? ______ Sec

2) Is this request for Advanced Preemption Operation? ☐ Yes ☐ No — If "Yes" what is the requested Additional Warning Time? ______ Sec

3) Indicate below which circuits are being requested:
   a. Advanced Preemption ☐ Yes ☐ No
   b. Simultaneous Circuit (XR) ☐ Yes ☐ No
   c. Gates Down Circuit ☐ Yes ☐ No
   d. Supervised Circuit ☐ Yes ☐ No
   e. Traffic Signal Health Circuit ☐ Yes ☐ No

Comments / Additional Info:

If you have additional or enhanced preemption operation/interconnect requirements, please submit a detailed description below. A circuit drawing or additional information should be provided to assist designers in accommodating your needs.

Please sign, scan this page, and submit electronically along with support documentation to appropriate Manager of Industry and Public Projects.

______________________ ______________

Signature of public agency representative Date

____

Print or Type Name of public agency representative

Note: UTA is currently developing its own Preemption Request Form. This form will be included in the Manual once it is completed.

Appendix D

Ranking Preemption-Eligible Projects

Appendix D: Ranking Preemption-Eligible Projects

The ranking process presented in this appendix is useful when resource constraints (e.g., funding and staffing) limit the UDOT Chief Railroad Engineer from implementing all relevant preemption-eligible projects within a given fiscal year. The process presented is then applied to generate a list of ranked preemption eligible projects that can then be implemented in the order of the established ranking. A process similar to what is presented herein may be used by a Highway Authority to rank their preemption-eligible projects.

1.1 Ranking Process

The following steps represent a process that can be used to rank preemption-eligible projects. The Manual strongly recommends the use of engineering judgement when evaluating data and arriving at a prioritized list/ranking of preemption-eligible projects.

Step D.1: Collect Necessary Data

Considering that UDOT's goals are to enhance safety at all Crossings, accident history, near-miss data, and site-specific data for Crossings and associated intersections become valuable for prioritizing preemption-eligible projects. This necessary safety data should be collected from the following sources.

Accident Data

- The Federal Railroad Administration (FRA) maintains an inventory of accident reports for all crossings in the nation (both public and private) through its Office of Safety Analysis located at the following link: 8.01 - Query by Location.
- UDOT documents its own accident data for state highways. While not publicly available, the data is available upon request to the UDOT Safety Programs Engineer. If UDOT does not have accident data for a particular road, relevant data should be obtained from the local roadway authority.

Near-Miss Data

- UTA and UPRR collect near-miss data that may also be useful in identifying potential safety issues.

Consider the date of the accident or near-miss event when reviewing the data. Crossings are dynamic in terms of train volumes and vehicle volumes and speed. Crossing or roadway improvements could have been made since an accident/near-miss event occurred that may positively contribute to fewer accidents or near-misses in the area. As such, more recent data is typically more valuable when evaluating a Crossing.

Site-Specific Data

Since the prioritization process can be performed for existing, as well as potential preemption-eligible locations, site-specific data (e.g., storage distances, queue lengths, traffic volumes, sight distance, bus/hazardous material traffic, public complaints, and local knowledge) may or may not be available. This data, if not available, may be acquired through site visits (existing locations) or design drawings (proposed locations) to gain a better perspective on the traffic and train operations near a Crossing and its adjacent traffic signal(s).

Step D.2: Assess and Rank Projects

Step 2 involves assessing the data collected (Step 1) in order to establish a ranking of preemption-eligible projects.

- **Establish an initial ranking:** The initial ranking of preemption-eligible projects is developed by using the FRA’s Web-based Accident Prediction System (WBAPS) located at the link: FRA's Web Accident Prediction System (WBAPS) to assess safety issues associated with preemption-eligible locations.
- **Revise the initial ranking:** The initial rankings are then subjectively adjusted based on the site-specific information gathered.

- **Revise the ranking based on economic analysis (as needed and as appropriate):** Cost of implementing preemption improvements may become a factor for certain types of projects (e.g., projects requiring changes to Railroad or Highway Authority infrastructure). Economic analysis procedures (e.g., cost-effectiveness, benefit-cost ratio, and net annual benefit analysis) detailed in the *FHWA Grade Crossing Handbook* (pp 155-161) may be applied in such cases to further refine the preemption-eligible project rankings.

Step D.3: Finalize the Ranking

The UDOT Chief Railroad Engineer reviews the supporting information to finalize the rankings. The rankings should be documented and disseminated for information purposes to the relevant Railroad and Highway Authority overseeing a Crossing and its adjacent intersections, respectively. The preemption-eligible projects are funded in the ranked order.

Appendix E

Preemption Definitions and References

Appendix E: Preemption Definitions and References

The following table lists preemption-specific terms used in both the *Preempting Traffic Signals near Railroad Crossings in Utah Manual* and the Utah Preemption Form. The table includes definitions and references to both the Manual and Utah Preemption Form.

Preemption Definitions and References

Term	Definition	Utah Preemption Form Reference	Manual Reference
Advance preemption time (APT)	The additional time needed, in seconds, beyond the minimum warning time to provided safe preemption for the worst case-scenario at the crossing. This is also known as the additional warning time required from the Railroad.	Line 42	Section 3.2.1
Buffer time (BT)	Time, in seconds, added by the Railroad to account for train handling.	Line 40	Section 3.2.1
Clearance time (CT)	The additional time, in seconds, that may be provided for wide or skewed-angle crossings. Clearance time is a calculation when the MTCD exceeds 35 feet.	Line 38	Section 3.2.1
Clear Storage Distance (CSD)	The shortest distance from 6 feet past the near rail to the adjacent street intersection's stop bar or the normal stopping point on a road.	Line 1	Table 6
Design vehicle length	The longest vehicle length that typically uses a Crossing.	Line 3 and Line 9	Section 3.1.2
Equipment response time (ERT)	The amount of time the railroad train detection equipment needs once a train has entered the track circuit before it is acted upon. This is also known as the railroad (RR) equipment response time.	Line 43	Section 3.2.1
Maximum approach move distance (MAMD)	The distance (in feet) from the farthest intersection stop bar towards a Crossing.	Line 6	Table 6
Maximum conflicting move distance (MCMD)	The longest distance (in feet) across the adjacent intersection that crosses the path of the track clearance phase.	Line 7	Table 6
Maximum preemption time (MPT)	The total amount of time required after the preempt call is initiated by the railroad warning equipment to complete right-of-way transfer to the track clearance interval, initiate track clearance phases, move the design vehicle out of the MTCD, and provide a separation time before the train arrives at a Crossing.	Line 34	Section 3.2.2
Minimum green time	The maximum number of seconds that any vehicle phase must display a green indication before the controller unit will terminate the phase through yellow change and red clearance.	Line 19	Section 3.1.3

Preemption Definitions and References

Term	Definition	Utah Preemption Form Reference	Manual Reference
Minimum time (MT)	The least amount of time active warning devices should be active before the arrival of the train at the grade crossing.	Line 37	Section 3.2.1
Minimum track clearance distance (MTCD)	The distance from the gate, Crossing stop bar (if no gates are used), or 12 feet from track centerline if no stop bars or gates are used to 6 feet past the far rail. For four-quadrant gate systems, the distance is extended to the point where the rear of a vehicle would be clear of the exit arm.	Line 2	Table 6
Minimum warning time (MWT)	The actual minimum time that active warning devices can be expected to operate at the crossing before the train approaches the grade crossing.	Line 39	Section 3.2.1
Pedestrian change interval (pedestrian clearance time)	The clearance time, in seconds, for the worst case pedestrian phase. This is the flashing don't walk time before transitioning to vehicle yellow change time and red clearance time.	Line 25	Section 3.1.3
Pedestrian walk time	Minimum pedestrian walk time, in seconds, for longest crosswalk.	Line 24	Section 3.1.3
Queue clearance time (QCT)	The total amount of time required after the signal turns green to begin moving a queue of vehicles through the queue startup distance and then move the design vehicle from a stopped position at the far side of the crossing completely through the MTCD.	Line 13 and Line 31	Section 3.2.2
Red clearance time	The maximum required red clearance interval for any vehicle phase.	Line 21	Section 3.1.3
Right-of-way transfer time (RWTT)	The maximum amount of time needed for the worst case condition before track clearance green.	Line 30	Section 3.2.2
Separation time (ST)	Additional time that can be provided between the time the traffic clears the track and the train arrival at a Crossing.	Line 33	Section 3.2.2
Total approach time (TAT)	The total time needed after the train crosses over the approach circuit before the train reaches the crossing to avoid a conflict using the worst-case scenarios.	Line 44	Section 3.2.1
Total warning time (TWT)	The sum of the minimum warning time and buffer time. This is also known as the warning time provided by the Railroad.	Line 41	Section 3.2.1
Track clearance green (TCG)	The traffic signal time to clear stopped vehicles from the track area on the approach to the signalized highway intersection.	Line 32	Section 3.2.2
Yellow change time	The maximum required yellow change time for any vehicle phase.	Line 20	Section 3.1.3