Glossary of Terms Applied to Highway-Railroad Grade Crossing Warning Gates and Signals

General Terms

The following terms apply to highway-railroad grade crossing warning devices in general:

Crossing Warning Devices: Traffic control devices and techniques implemented at highway-railroad crossings to advise drivers, cyclists, and pedestrians of approaching trains and designed to elicit appropriate stopping responses so that vehicles are not in the path of approaching trains.

Crossing Warning Gates: Physical barriers lowered across the roadway to inhibit vehicles from illegally entering the crossing zone.

Crossing Warning Signals: Audible and visible signals installed at highway-railroad grade crossings to warn the motorist of the approach of a train. Florida law prohibits motorists from entering the crossing zone while these signals are activated.

Crossing zone: The area at a highway-railroad grade crossing that is common to the highway and railroad usage. Vehicles within the crossing zone during the passage of a train are considered to be in jeopardy. The crossing zone for four-quadrant gates extends from the stop bar painted in advance of the entrance gate to the exit gate on the far side of the crossing.

Deterministic Analysis: The process for conducting evaluations based upon non-varying physical and natural laws. Application of this process assumes that there is no variation in any of the elements involved in the assessments. In other words, for a fixed set of initial conditions, the results will be repeatable. This form of analysis contrasts with the *stochastic process*, which assumes that there are variations in the results due to irregularities in the initial conditions, and the influence of variables not explicitly included in the problem definition.

Dilemma Zone: The region in time and space in which a driver can neither elect to stop nor proceed through the crossing zone safely. The elimination of the dilemma zone is generally used as the basis for setting the change and clearance intervals at traffic signals. The gate timing procedure for railroad crossings is similar, but the design must be more forgiving because of the critical consequences of a train arrival.

Dilemma Zone Incursion:. The entry into the dilemma zone by drivers who elect to stop and change their minds after it is too late to proceed through the crossing from their current position under the normal dilemma zone concept. The gate timing design must provide for some level of dilemma zone incursion. The extent of dilemma zone incursion is indicated by the proportion of the original stopping distance that is used by a driver who decides to stop before the decision is reversed.

Entrance Gate: The crossing warning gate installed on the normal vehicle entry side of the crossing zone.

Exit Gate: The crossing warning gate installed on the vehicle exit side of the crossing zone.

False Activation of warning devices: Warning signals and gates activated when no train approaches the crossing. This may be due to trains stopping on the tracks at upstream stations or other train stoppages close to the crossing. Repeated warnings without trains may alter perceptions of local drivers about the likelihood of trains actually approaching crossings.

Four-Quadrant Gate System: A highway-railroad grade crossing warning configuration involving four gates constructed to inhibit the illegal entry of vehicles into the crossing zone as a train approaches the crossing. This configuration consists of entrance and exit gates that have a fixed timing sequence initiated by a control system that senses an approaching train. The crossing zone for four-quadrant gates extends from the stop bar painted in advance of the entrance gate to the exit gate on the far side of the crossing.

Gate Encroachment: The obstruction of any part of the traveled roadway by a descending gate such that a vehicle may not enter the crossing area without changing course or striking the gate.

Gate Encroachment Plane: The vertical plane that represents the outside (i.e., closest to the edge of the roadway) surface of the vehicle as it passes the gate. A descending gate is considered to obstruct the roadway when any part of the gate arm has passed the encroachment plane at a height of 13'6" or less.

Gate Violation: Entering the crossing area after gates have descended. There are two types of violations: (1) entry into the crossing zone by damaging the obstructing gate and (2) entry into the crossing zone by maneuvering around the obstructing gate.

Measure of Effectiveness (MOE): A calculated value related to the safety and operational performance of the highway-railroad grade crossing. Examination of these values allows the user to determine the degree to which specific gate timing and safety objectives have been met.

Onset of Warning: The point in time at which an approaching train is detected by the crossing warning system. The gate timing design parameters are referenced to this point, which is designated as T_0.

PASSTIME: A computerized procedure for estimating the passage times of the rear end of a vehicle at each gate when the vehicle has started from a stopped position at the onset of warning (i.e., the foreseeable worst-case scenario).

Preparation Zone: The area of the roadway in advance of the crossing zone in which the driver of a highway vehicle takes an action (e.g., braking, accelerating) to come to a halt or to clear the crossing.

Stop Line: A transverse pavement marking on the roadway in advance of the crossing zone. All vehicles are legally expected to stop at this point when the crossing warning signals are active. Specific vehicles, such as trucks with hazardous cargo and school buses, are required to stop under all conditions.

Quad Gate Analysis Timing and Evaluation Spreadsheet (QGATES): A Microsoft Excel spreadsheet that performs a deterministic analysis of the position, velocity and acceleration of highway vehicles as they approach and traverse the crossing zone. This program computes the minimum values of the gate timing design parameters that will avoid a conflict between vehicles and gates.

Worst-Case Scenario: An unfavorable combination of input parameters that creates a situation that could cause a hazard for vehicles approaching a highway-railroad grade crossing. Two types of worst-case scenarios exist. The *foreseeable worst-case scenario* is that which the operating agency has a duty to consider in determining the gate timing parameters. An *anecdotal worst case scenario* involves circumstances that are beyond the range of the foreseeable worst case scenario and which cannot be accommodated in a practical manner in the design of the gate timing parameters. A disabled vehicle coming to a stop on in the crossing zone is an example of an anecdotal worst case scenario.

Site-Specific Data Items Required for Gate Timing Computations

Many of the gate timing computations involve time-space relationships of vehicle speeds and trajectories. To establish a consistent and unambiguous terminology, the following notation will be used:

- *Time* will denote a specific number of seconds relative to the onset of warning.
- *Interval* will denote a duration bounded by two specific times.
- *Position* will denote a specific number of feet from the stop line
- *Distance* will denote the number of feet separating any two points when one of the points is not the stop line

The following information is required to perform the gate timing computations described in other sections of this document

Allowable Dilemma Zone Incursion (percent): The proportion of the original stopping distance that may be used up by a driver who decides to stop and then proceeds through the crossing. The gate timing design must allow for some indecision on the part of the driver to provide a safety factor.

Approach Grade: Percent: Change of inclination of road surface with respect to the horizon, expressed as vertical change per 100 units of horizontal distance (feet or meters). A highway grade less than 3 percent will have little effect on the speed of a moving vehicle. However, such a grade will have a significant effect on a heavy vehicle entering the grade from a stopped position. Highway-railroad grade crossings may include highway grades, often in excess of 3 percent. The default value is zero.

Coefficient of Friction: The resistance to the motion of a vehicle's tires over a pavement surface (sometimes referred to as the coefficient of braking). The values may range from 0 to 1.00. For a treadless tire in contact with a dry pavement surface the value will be about 0.90; and for a smooth tire on a partially frozen wet surface of a poorly textured pavement surface the value may be as low as 0.10. These values typically range between 0.25 and 0.75. The default value for the QGates model is 0.30.

Decision Interval (seconds): The time required by the driver to initiate a braking or accelerating response. This interval includes the time required to sense the need to respond, decide on the appropriate action, and initiate a response is often referred to as Perception-Reaction Time (PRT). A nominal value of 2.5 seconds is generally accepted. The default value used in the QGates model is 2.5 seconds.

Exit Gate Delay Interval: The time interval between the beginning of the descent or closure of the entrance gate and the beginning of descent of the exit gate.

Gate Activation Time: The time relative to the onset of warning at which a gate is activated and begins to descend.

Gate Descent Interval: The time interval between the gate activation time and the "down and locked" condition.

Gate Closure Time: The time relative to the onset of warning at which a gate reaches the horizontal position.

Gate Encroachment Angle: The angle (degrees from vertical) at which any portion of the gate crosses the encroachment plane (normally 2 ft. from the edge of pavement) at a height of 13'6''.

Gate Separation Distance (feet): The distance, measured parallel to the roadway lane lines, between entrance and exit gates in a four-quadrant gate configuration. This distance will vary depending on the number of tracks and the angle between the tracks

and the roadway. There is no fixed formula for determining this distance; therefore it should be measured in the field for any specific application of the model.

Gate Encroachment Time (Seconds): The time referenced to the onset of warning at which the entrance or exit gate begins to obstruct the approach for a vehicle in the lane closest to the gate. This is a function of the programmed delay in starting the gate in motion, the lateral distance from the curb to the gate mechanism and the angular velocity of the gate as it begins to close.

Initial Vehicle Speed (mph): An approach vehicle's velocity at the initiation of the analysis period. This speed, obtained from empirical data or assumed, is normally set at a distance of 300 to 400 feet from the stop bar and may be within a range of 0 to 53 mph. In the case of a vehicle stopped at or near the stop line at the onset of warning, the initial vehicle speed is zero mph.

Margin of Safety: The difference between the computed vehicle passage time and the actual gate closure time.

Maximum Approach Speed (mph): This is the highest achievable vehicle velocity and can be used to determine whether the road vehicle can clear the entry gate after the vehicle has cleared the dilemma incursion zone. This speed depends on the acceleration characteristics of the vehicle and other factors such as the coefficient of tire-pavement friction and vehicle loading.

Maximum Vehicle Acceleration Rate (feet/second^2): The maximum acceleration that can be achieved by a particular vehicle type can be entered. The default is provided for a large loaded truck at 1.2 ft/sec^2.

Gate Position (feet): The distance between the edge of the stop line and the entrance or exit gate. The default value is 8 feet.

Track Clearance Speed (mph): The vehicle's average velocity between the entry and exit gates. Based on empirical results, the default value for a vehicle that did not stop prior to the crossing is 15 mph. The default value for vehicle that stops prior to the crossing is 7 mph.

Transverse Gate Offset Distance (feet): The distance between the open (vertical) gate and the encroachment plane of the roadway.

Vehicle Length (feet): The distance from bumper to bumper of a vehicle. The nominal value for a passenger car is 18.0 feet. Trucks and buses vary over a range of 30.0 for a single unit truck or bus to 66.0 feet for large semi-trailer. The worst-case scenario will frequently suggest a vehicle length greater than 66 feet because of towed vehicles, double bottom trailers, etc.

Vehicle Passage Time (sec): The time, relative to the onset of warning, corresponding to the rear of the vehicle clearing the entrance or exit gate. The vehicle passage times for the entrance and exit gates are the principal product of the computational procedures presented in this document.

Total Warning Time (seconds): The time between the onset of warning and the entry of the train into the crossing zone. The warning time default value for trains in the corridor being examined is 30.0 seconds. Government and industry standards require a minimum of 25.0 seconds total warning time when gates are utilized in a highway-railroad grade crossing warning system.