GUIDELINES FOR THE USE OF FOUR QUADRANT GATES

Purpose and Goals of the Guidelines

Background

Highway-rail grade crossing collisions are caused by a multitude of factors. One factor, which accounts for many of the incidents, occurs when vehicles go under or drive around automatic crossing gates. This type of behavior causes the majority of train-vehicle grade crossing serious incidents or fatalities.

One mitigating factor to minimize these types of grade crossing collisions is the use of four quadrant gates. Four quadrant gates close off the road grade crossing prior to the arrival of a train, under normal operations. Potential gate violators are discouraged from driving around the gates.

Four quadrant gates are currently implemented at several grade crossings across the United States, and in Europe and Asia. The actual installation characteristics differ among locations. Variables include exit gate failure modes, use of vehicle detection systems, use of medians, escape routes, interconnectivity with train control systems, skirts, and gap between gate tips.

Purpose

The purpose of these guidelines is to provide guidance for implementation and configuration of four quadrant gates at highway-rail grade crossings. These Guidelines for the Use of Four Quadrant Gates are applicable to all modes of rail including freight, passenger, commuter, light rail, and streetcars.

Goal

The goal of these guidelines is to define when and how to implement four quadrant gates at highway-rail grade crossings to enhance the level of safety.

B. Definition of Terms: Linda Meadows

Gate

An active traffic control device with an extended arm that lowers to restrict vehicular traffic from crossing the railroad tracks. In operation, when activated by an approaching train, the gate arm is lowered to form a horizontal barrier between approaching vehicles and the track. Entrance gates shall fail safe in the down position.

Four Quadrant Gates

Four quadrant gates consist of two additional gate arms on the exit side of the highway-railroad grade crossing. Additional dual gate arms, combined with standard entrance gates, close off the highway-rail grade crossing. Exit gates shall fail in the up position.

Three Quadrant Gates

Three quadrant gates are a variation of four quadrant gates, consisting of two entrance gates and one exit gate. They can also consist of a gate on the left turn vehicular movement at the highway-railroad grade crossing. Crossing geometrics may indicate the need for other configurations of gates, such as five quadrant gates or more.

Vehicle Presence Detection System

The system will detect the presence of vehicles crossing in the area between the gates. Various forms of vehicle detection are available. The vehicle presence detection system shall be designed to allow a vehicle to exit the crossing area. The system can be integrated into a four quadrant gate application to detect the presence of vehicles in the highway-rail grade crossing.

Median Island

A median island is a raised island with a vertical curb face placed in the center of the roadway that provides an obstacle so a vehicle cannot attempt to drive around an automatic crossing gate arm. If the roadway is not wide enough to accommodate a median, delineators, mounted directly to the roadway's centerline, can be used.

A. Information Required by PUC – Jesus Escamilla/Mark Christoffels

1. Contact PUC representative, railroad, rail transit agency, local agency, schedule field diagnostic meeting.

2. Can the crossing be closed? If not, why not?

3. Can the crossing be grade separated? If not, why not?

4. Can medians be constructed to prevent drivers from driving in the wrong direction around entrance gates?

5. Accident History: Train-vehicle accidents, Accidents in which motorists drove around the gates.

6. Risky behavior: Near misses. Records or history of near misses at a crossing. Observations of motorists engaging in risky behavior at a crossing, particularly driving around the gates.

7. Geometric concerns:
    a. Diagonal/skewed Crossings
    b. Driveways at off quadrants
    c. Frontage roads parallel and in near proximity to tracks
    d. Wide crossings with multiple tracks
    e. Sight distance problems
    f. Queuing on tracks.

8. Multiple train modes
    a. Multiple tracks
    b. Slow freight trains
    c. Train frequency

9. High Speed Trains (90-110 mph)

10. Supplemental Safety Measures/Quiet Zones

11. Complete railroad-local agency agreement.

12. File Formal Application with the PUC, as per California Public Utilities Code Sections 1201 to 1205, General Order No. 75-C, Resolution SX-31.

D. *FACTORS TO BE CONSIDERED FOR USE OF FOUR QUADRANT GATES:* *Jim Curry/Joaquin Siques*

OVERALL: Four quadrants gates should be considered at crossings where there is a known or anticipated hazard related to motor vehicles driving around lowered crossing gates and where other solutions that could mitigate this hazard cannot be reasonably implemented.

There are three alternative solutions that are effective in eliminating the potential hazard of motorists driving around lowered crossing gates:

- crossing closure;
- grade separation; and
- median barrier of adequate size and length on all approaches to the crossing.

If one of these solutions can be reasonably implemented at a crossing, it is not necessary to consider four quadrant gates further.

For an existing grade crossing, the potential hazard related to motor vehicles driving around lowered crossing gates can be readily documented from accident history and near miss data, where available or obtained from train operators and engineers through interviews.

For a new grade crossing or one where there are significant changes being planned, the potential hazard related to motor vehicle driving around lowered crossing gates needs to be based on engineering judgement but experience has indicated that the following factors should be considered to increase the likelihood of motorists driving around lowered gates:

- Long gate down times that may make certain motorists more inclined to avoid the waiting time by driving around the lowered gates;
- Excessively long or inconsistent advance warning times;
- Wide crossings, typically with one or more tracks, that make the s-turn maneuver around the lowered gates easier to complete;
- Streets or alleys running parallel to the tracks and immediately adjacent to the tracks that allow motorists on the parallel streets to more easily drive around the lowered gates, especially where the intersections with the parallel streets are not controlled by traffic signals;
- Limited visibility for motorists of approaching trains, due either to obstructions that block the view or skewed crossing geometry; and
- Frequent occurrence of two trains at the same time or nearly at the same time which causes the gates to be held down.

VEHICLE DETECTION SYSTEM REQUIRED Jim Curry/Joaquin Siques

Once it has been determined that four quadrant gates are the preferred solution for mitigating the potential hazard associated with motorists driving around the lowered crossing gates, it is necessary to consider whether a vehicle presence detection system is required in conjunction with the four quadrant gates. This needs to be done by an engineering study.

The CPUC has implemented changes to General Order 75-C that specify requirements for the installation of four quadrant gates at highway-railroad intersections in the State of California. One of the concerns associated with the use of four quadrant gates is the possibility that motorists will be trapped in the track area behind lowered crossing gates, unable to exit from the track area and at risk of being hit by the approaching train. This hazard can be mitigated to some degree by implementing a time delay in lowering the exit gates, as called for by the CPUC. The CPUC has concluded that a track area vehicle detection system should be installed as part of a four quadrant gate system, subject to the recommendations of a diagnostic team review of the crossing and an engineering study performed by the railroad or local road agencies.

Track area vehicle detection should be required at any crossing equipped with three quadrant gates or other configuration where it is possible for a motor vehicle to enter the track area and be trapped by lowered entrance and exit crossing gates.

Vehicle presence detection shall be used at all grade crossings equipped with four quadrant gates where the train operator sight distance of the crossing is not adequate.

For any crossing where four quadrant gates are being considered, an engineering study needs to be conducted. The engineering study needs to be sufficiently detailed to establish track area vehicle detection requirements, track area vehicle detection technology, exit gate delay times, and train approach times. Traffic microsimulation models should be applied where there are signalized intersections in the vicinity of the crossing, in order to assess the likelihood of motorists being queued back onto the tracks and the expected queue lengths and dissipation rates for traffic backed up into the track area. A more detailed discussion of the scope of and technical approach to be used for the engineering study is presented elsewhere in this report.

Track area vehicle detection may not be required at all crossing where four quadrant gates are installed. This approach should only be done at crossings where it is determined that four quadrant gates are needed due to the potential for motorists driving around lowered gates but that motorists electing to drive around the lowered crossing gates will not be trapped by the exit gates as they are being lowered. For example, if it is determined that motorists will only drive around the lowered gates at times when there are two trains in the crossing at the same time, this approach could be used without any

concern about trapping motorists in the track area. Additionally, it may be determined that motorists electing to drive around lowered entrance gates at crossings which are not wide may be able to easily exit from the track area due to the limited with of the track area.

The engineering study to determine the need for vehicle presence detection at grade crossings equipped with four quadrant gates should consider the following factors:

- Roadway width
- Trackway width
- Queuing from adjacent intersections, driveways, or obstructions
- Grade Crossing Geometry
- Adequate train operator sight line to the crossing

Where it is determined that track area vehicle detection is required based on the diagnostic team review and engineering study, the track area vehicle detection system shall be designed and implemented with the following characteristics:

a. Ability to detect all motor vehicles, including all passenger motor vehicles, school buses, and trucks but not including motorcycles, bicycles, and shopping carts, within the limits of the track area bounded by:
   i. Alignment of the entrance and exit gates, when lowered; and
   ii. Edge of street pavement or traveled way.

   The ability to detect motor vehicles shall be verified by an acceptance test program, as determined by the engineering study and agreed to by the CPUC.

b. Ability to provide at least two independent, redundant “go/no go” indications to the railroad exit gate down control circuits as follows:
   i. Go indications when the track area is clear and the exit gates may be started down.
   ii. No go indications when there is a motor vehicle in the track area and the exit gates need to be held up in order to allow the motorist to exit from the track area.
   iii. Go and no go indications as required to verify the operation of the vehicle detection system and to verify that the ability to provide a no go indication is operational.
   iv. No go indications when the exit gates are fully lowered, unless determined otherwise by the engineering study.
   v. No go indications when a broken entrance gate arm is detected, unless recommended otherwise by the engineering study.
   vi. No go indications when a track area vehicle detection system malfunction is detected.
   vii. No go indications when there is no train occupying an approach track circuit.

   The go/no go indications will be generated for both exit gates at the same time (“non directional”) but may be implemented for each exit gate separately

("directional"), when recommended by the engineering study. When implemented for each exit gate separately, redundant "no go" indications shall be required for each exit gate down control circuit.

c. Ability to verify, not less often than one time each time that the crossing gates are called down, that the vehicle detection system is functioning and able to detect vehicle presence in the track area.

When it is determined that the track area vehicle detection system is not functioning, the system shall default immediately to a "no go" condition so that the exit gates are held in the up position and shall generate an alarm or warning message. The exit gates shall be held in the up position until the cause of the malfunction has been determined and the track area vehicle detection system has been restored to normal operation.

d. Ability to verify, not less often than one time each time that the crossing gates are called down that the ability to provide a "no go" indication is functioning.

When it is determined that the ability to generate a "no go" indication is not functioning, the system shall default immediately to a "no go" condition, if possible, and shall generate an alarm or warning message that is unique or clearly different from other alarms or warning messages. The "no go" condition shall be maintained, if possible, until the cause of the malfunction has been determined and the track area vehicle detection system has been restored to normal operation.

e. Ability to not generate false "no go" indications, more often than minimum threshold values to be determined by the engineering study, as the result of the following conditions:
   i. Train detected in the track area.
   ii. Hi-rail vehicle detected in the track area.
   iii. False activation of the vehicle detection system.
   iv. Motor vehicles located outside of, but immediately adjacent to, the track area.
   v. Motorcycles, bicycles, and shopping carts.

f. Ability to operate under battery backup power or to default immediately to a "no go" condition when external power is lost, based on the results of the engineering study.

g. Track area vehicle detection logic shall be implemented on a programmable controller. The controller shall incorporate a front panel display that continuously shows the status of all system controller inputs and outputs, including track area vehicle detects. The controller shall be able to monitor its own operation continuously and shall generate an alarm or warning message in the event that a malfunction is detected. The front panel display shall also show alarm and system error codes required for troubleshooting a system malfunction.

h. Track area vehicle detection system components, including the controller where the track area vehicle detection logic is implemented, shall meet the applicable

national and local engineering standards for these type of components based on the agreement between the railroad and local road agency regarding responsibility for system ownership, operation, and maintenance.

F. OPERATION & PUBLIC EDUCATION-Vijay Khawani

EXIT GATES FAIL UP **-** The exit gate mechanisms shall be designed to fail in the up position. The Railroad Control Center or Dispatch Center shall be notified of such a failure either via a communications system or through established Rules and Procedures of the railroad.

DELAY IN EXIT GATES – The exit gates shall be delayed an appropriate interval after the entry gates have started down. The interval shall be based on a crossing-specific review by the railroad, local jurisdiction and and regulatory agencies. Some of the factors that should be included in establishing the interval are: angle of the crossing, width of the crossing, available storage space between the gates and the train envelope, proximity of downstream traffic signalized intersections, condition of crossing surface, speed of vehicular traffic at crossing and type of predominant vehicles (trucks, hazmat, school buses, etc) using the crossing. It is important to note that achieving the "appropriate" delay time at a four quadrant gate crossing that has a reliable vehicle presence detection system is less significant than it is at a four quadrant gate crossing that not have such a system. And finally, an "excessive" gate delay time may be not serve the purpose of the four quadrant gate system.

EVENT RECORDERS **–** An event recorder shall be installed at crossings equipped with four quadrant gate systems. The following events shall be recorded as a minimum:

? Time crossing warning is activated
? Time entrance gates start down
? Time entrance gates are fully horizontal
? Time exit gates start down
? Time exit gates are fully horizontal
? Time island circuit is occupied

The above events shall be stored in the event recorders memory and be able to be downloaded for analysis. The events shall be stored for the latest 24 hour period prior to the download time.

PUBLIC OUTREACH PROGRAM **-** In an effort to inform and educate the public about four quadrant gates, a public education and awareness program should be developed. The target audience should include residents, businesses, schools, community groups and emergency service providers (fire stations, hospitals/paramedics, police) within a half mile radius of the crossing where the four quadrant gates will be installed.

G. Model Agreement – Joe Kennedy/Jim Ball/Mark Christoffels

GUIDELINES FOR DRAFTING FOUR-QUADRANT GATE GRADE CROSSING AGREEMENTS

An agreement for the design, construction, operation and maintenance of a four-quadrant grade crossing gate system, between a railroad and an agency having jurisdiction over the street, road or highway involved, would be similar in format to existing agreements used for two-quadrant gate installations and other crossing improvements. Standard grade crossing agreements have been developed over many years of experience by Class I railroad law departments, shaped by accumulated interaction with local agencies, railroad regulatory agencies, state highway departments and the U.S. DoT.

In California standard "fill-in-the-blank" versions of these agreements have long been incorporated into Caltrans right-of-way and project management manuals as exhibits, and they have also been used by non-Class I railroads as a basis for their relationships with local agencies. As a result, versions of Class I railroad standard agreements can be found in use in almost all railroad – local agency negotiations throughout California. The following is derived from an Alameda Corridor – East agreement (presently in draft form), which itself is based on a standardized Union Pacific road crossing agreement.

1. Identify the Parties, and assign shortnames: The parties to the agreement should be identified and a shortname defined for each.

2. Recitals: The next portion of the agreement, usually preceding what is titled "the Agreement" itself, are the Recitals. In drafting a four-quadrant gate system agreement an assumption is that some verbal, correspondence or other form of informal agreement has already been reached that a particular crossing is a candidate for a four-quadrant gate system. All the parties named in the draft agreement may not yet have agreed on the installation of a four quadrant gate system, but there would have been enough preceding process so that, at this time, circulation of a draft agreement is a useful device for moving

the negotiation forward into specific areas of design, construction, operation and maintenance. The Recitals should summarize the events that have led to the provisional agreement to pursue a contractual negotiation. For example, there probably have been some on-site meetings and some analyses made based on observations, events and/or incidents. There probably has been some conceptual engineering work.. Available California Public Utilities Commission (CPUC) or Federal guidelines, and their underlying regulations or rules, may provide a rational basis for the provisional decision to pursue a four-quadrant gate installation. These kinds of activities should be described in the Recitals. If there is a specific regulatory order requiring the installation, or some site-specific finding by an agency having ultimate jurisdiction over the parties as to the expected benefit for the public, that should be referenced in the Recitals. If informal agreements regarding funding and cost allocation for the improvement exist, it may expedite the negotiation to describe them.

At a minimum, a reader of the Recitals twenty years from now (assuming the agreement is executed), should be able to understand, in summary, why the location in question is getting the proposed improvement; without having to retrieve other contemporaneous workfiles, letters, minutes, or other informal and ephemeral sources of information.

3. Definition of Terms: A four-quadrant gate agreement should probably have a definition of terms section. In standard grade crossing agreements, citing widely recognized references such as the Code of Federal Regulations, CPUC General Order 75-C, the AREMA Signal and Communications Manual of Recommended Practice, Caltrans' T*raffic Manual*, etc. may sufficiently establish the precise meaning of technical terms so that a definition of terms section is not necessary. Additionally, where technical terms are not immediately clear upon first use in an agreement, succeeding sections on design, maintenance, etc, may make them clearer; subsequently they may not need explicit definition. However, four quadrant gate systems will, for the near future, continue to involve research and development of various alternatives. Some terminology will probably require precise definition in the front of the agreement, to remove ambiguity that could confuse the negotiation or subsequent interpretation of an executed

contract.

If new technical terms are defined, it should be done so on an exception basis, only when necessary. Definitions of technical elements that are already well defined in a standard reference can be included for the convenience of the reader, but it should be done verbatim and it is better if the reference is cited. Redefining terms should be avoided, as it could create a misunderstanding between the parties.

4. Additional diagnostic observation and analysis: If additional analysis or additional traffic observations are to occur, beyond those which have led to drafting of an agreement, a section on this activity should be included. For example, a four-quadrant gate system will probably require site-specific determination and programming of railroad crossing warning device advance warning times and similar site-specific timing of railroad preemption of any adjacent traffic signals electrically interconnected with the railroad warning devices. Use of the minimum warning times cited in 49 CFR 234 and GO – 75-C will probably not be adequate for operation of a four-quadrant gate system; if so, the responsibility for making decisions about advance warning times, change intervals, track clearance intervals, etc, and the rational criteria upon which those decisions will be based, should be clearly called out. If there are to be additional observations and analyses during operation of the four-quadrant gate system for the purposes of determining their effectiveness, safety or optimal programming, that also should be agreed upon and set forth in writing. For proposed new crossings, modeling of expected traffic may form a suitable substitute for analysis of on-site observations and traffic counts.

The railroad is well-advised to clearly make determination of advance warning times for the location in question the responsibility of the local agency. The railroad, out of necessity, has to rely upon the local agency to make best judgments about interpretation of motor vehicle accident and incident reports, observations of motorist run-around of lowered gates, average and peak hour traffic counts, numbers of multiple-axle trucks and other slow-moving vehicles, schoolbuses, vehicles carrying hazardous materials and extra

high/extra wide loads, and other data. Similarly, the local agency will have to rely on the railroad for information on how crossing warning systems operate. Both parties and the public benefit when there are clear and documented understandings in these areas.

5. Final Design: An agreement will probably include provisions for design of the four-quadrant system beyond the concept level, which led to the provisional decision to install four-quadrant gates. Final design of a four-quadrant will probably include some research and development elements until such time as all system components are available as manufactured items on a competitive basis. Motor vehicle detectors and exit gate controllers may be one-of-a-kind items for the location in question. The agreement should be clear as to which party will be responsible for design or obtaining design of a system element, and a single party should be assigned responsibility for overall coordination of the design effort. If appropriate, design milestones and a schedule for design activities can be included as an exhibit.

6. Construction: A majority of the responsibilities for construction of the four-quadrant gate system will probably be split between the local agency and the railroad in the same manner as conventional grade crossing signal work. Responsibility for construction of elements unique to four-quadrant gates systems will have to be specifically called out. Testing leading to start-up of the system, and a specific process for each party's acceptance of the completed system, can be addressed under this construction section or in a separate section, but in either case a detailed process for start-up testing and acceptance, including witness points, documentation or certification of these processes, should be included. If possible, the parties should include testing and acceptance of systems elements as part of a systems safety oversight plan, with regulatory agency oversight. If the four-quadrant gate installation is a test, with a defined timeline and data-collection regime leading to some kind of analysis and final determination whether the installation will continue as a permanent installation, this should be included in the agreement.

The construction of roadway pavement, sidewalks, curb and gutter, and motor vehicle detection loops, etc, within railroad right-of-way by the local agency (within the local agency's roadway easement), will require railroad safety protective services by railroad personnel (flaggers and inspectors). Railroad protective insurance will be required, or certification of self-insurance. Temporary encroachment(s) by the local agency outside the roadway easement for the purposes of construction will require a right-of-entry for city personnel and any contractors. Rights-of-entry, flagging, inspection and insurance requirements should be specifically addressed in the agreement.

The costs of installing railroad crossing warning devices and related equipment, providing railroad safety protective services, and railroad inspection and engineering support during construction will probably be recollected by the railroad from the local agency or a third party. Reimbursable costs should be identified and cost estimates provided (cost exhibits). Invoicing procedures and any requirements for invoice formatting and availability for audit of back-up documentation (timesheets, equipment rental receipts, signal vendor invoices, etc), should be addressed. If state or Federal procedures govern these areas the applicable rules and regulations should be cited.

7. Operation and Maintenance: The railroad will be obligated to operate and maintain the grade crossing warning devices as required under Title 49, Parts 212 and 234 of the Code of Federal Regulations and California Public Utilities Commission (CPUC) General Order 75-C. The railroad will also maintain that portion of the crossing surface lying between the rails and two feet outside of the rails, parallel to the track; and roadway pavement between any two tracks 15 feet or less apart, pursuant to PUC General Order 72-B. It is likely this latter responsibility will not include maintenance of any pavement inductive loops or other pavement devices used for the purposes of detecting motor vehicles. Nor is it likely that the railroad will accept responsibility for maintenance and operation of any exit gate controller, although the railroad signal department may want immediate automatic notification of any exit gate and entry gate fail-safe condition (false activations).

The agreement should provide a specific regime for operation and maintenance of any vehicle detection system and exit gate controller. The Federal requirements for operation and maintenance of the railroad crossing warning system itself provide a baseline model for specifying operational and maintenance requirements for any subsystem affecting operation of grade crossing exit gates. Operation and maintenance of the four-quadrant gate system should include periodic testing and maintenance of the vehicle detection system and the exit gate controller, and there should be agreement on what this testing shall be, how frequently it will be done and how it will be documented.

If the costs of operating and maintaining four-quadrant gate system elements are to be recollected by one party from another, those costs should be identified and an invoicing/payment procedure described. Reimbursement of the local agency's share of automatic grade crossing warning device maintenance costs by the State of California will be as described in Public Utilities Code §1202.2 and §1231.1, and related CPUC decisions, rules and regulations. It should be remembered that a railroad's ability to identify the actual costs of maintaining its portion of four-quadrant gate systems will eventually provide a basis for California's determination of the local agency share of these costs, as part of California's periodic state-wide study of average crossing signal maintenance costs and revision of the state's reimbursement rates for each category of automatic warning devices.

9. Railroad Preemption of Traffic Signals – Maintenance of Programming: Where automatic grade crossing warning signals and adjacent traffic signals are electrically interconnected to

provide railroad preemption of traffic signal operations, the railroad and the local agency should post in their respective signal control shelters or cabinets a notice to that effect. The notices should have names and telephone numbers for both emergency contact personnel and also routine non-critical exchange of information between both parties. The agreement should discuss these notices and how their information will be kept current.

10. Other Sections: The agreement will probably have some form of mutual hold-harmless and indemnification clauses. A term for the agreement will include an effective date and provisions for termination of the agreement. There may be language describing how the agreement can be amended. A section naming persons or officers by level of authority authorized to receive notices and communications may be included. There may be a section stating that the covenants and provisions of the agreement shall be binding upon and inure to the benefit of the successors and assigns of the parties.

11. Signatures: Signature lines for persons authorized by the parties to execute agreements and for approval of the form of the agreement by their attorneys should be provided, along with a date line for each.

12. Exhibits: Any attachments to the agreement should have been identified within the agreement by a unique number or letter.