Measure Name: Vehicle detection system at crossing

Definition: A vehicle presence detection system that monitors the status of crossing occupancy to control exit gate movement or relay that information to the locomotive engineer.

Tags:

Type of Incident:
- ☐ Non-Motorized Users Only
- ☒ Motor Vehicles Only
- ☐ Both

Intervention Strategy:
- ☐ Data: application and planning
- ☐ Education: outreach and messaging
- ☐ Enforcement: policy development and rulemaking
- ☒ Engineering: technological and physical deterrents

Type of Problem:
- ☐ Non-Motorized Users Violating Warning Devices
- ☐ Motor Vehicles Violating Warning Devices
- ☐ Vehicle ROW Incursion
- ☒ Vehicle Congestion
- ☐ Blocked Crossing
- ☒ Vehicle Hang-up

Measure Category:
- ☐ Risk Assessment
- ☐ Policy and Enforcement
- ☐ Collaboration, Training, and Education
- ☐ Public Communication
- ☐ Physical Barriers
- ☒ Detection and Lighting
- ☐ Infrastructure Modification
- ☐ Post-Incident Management
- ☐ Warning Devices

Description

This measure refers to the installation of a vehicle presence detection system at four quadrant gate crossings to keep the exit gate up during an activation when a vehicle is detected within the grade crossing. It is intended to prevent vehicles from being trapped inside the gates. Various forms of vehicle detection such as inductive loops, magnetometers, video analytics, radar, LiDAR, and infrared light have been developed and tested. However, embedded inductive loops are the standard choice for vehicle presence detection in crossing applications based on their demonstrated higher level of performance compared to the other vehicle detection systems. Almost all North American vehicle detection systems used at four quadrant gate railroad crossing utilize embedded inductive loops. [1]

Vehicle detection systems can also be integrated with Positive Train Control (PTC) to relay the status of the crossing occupancy to an approaching train, thus allowing the train stop safely before arriving at the crossing. Technology that relays the status of the crossing occupancy to approaching trains is currently in use on Amtrak's corridor in Connecticut. The system transmits the signal through an Automated Civil Speed Enforcement System (ACSES) transponder as part of the PTC technology. [2]

Additional search terms: *presence detection, four quadrant, gates, inductive loops, magnetometers, video analytics, radar, LiDAR, infrared light*

Advantages

- Prevents vehicles from being trapped on the crossing at four-quadrant crossings by releasing the exit gate when a vehicle is detected on the crossing during an activation.
- Vehicle detection is "considered an important safety factor in future communication-based crossing activation treatments implemented on fully deployed PTC infrastructure". [1]
- Radar-based detection systems are mounted above and outside the crossing, so installation and maintenance has minimal impact on safety and operation of trains and roadway users.
- Radar-based detection system are considerably less expensive and easier to install and maintain than embedded inductive loops. [1]
- Four-quadrant gate crossings with vehicle presence detection systems enable both entrance and exit gates to descend nearly simultaneously unless a vehicle is detected in the crossing area. This method of operation seals the crossing from violations 15 to 20 seconds prior to train arrival versus 4 to 6 seconds with pre-timed descent. [3]

Drawbacks

- Lightning storms can cause loop detection to generate false alarms and other anomalous behavior. [1]
- Embedded detection technologies such as inductive loops or magnetometers have "limited service life and susceptibility to damage due to temperature extremes, vehicle weight, and roadway resurfacing". [1]

- Installation and maintenance of Inductive loops/magnetometer vehicle detection systems require crossing roadway work and can impact safety and operation of trains and roadway users.
- Installation or replacement of loops generally takes a minimum of 2-3 weeks to complete. [1]
- Infrared and video-based detection systems "may be impaired by the presence of rain, fog, snow, or the glare of bright background sunlight". [1]

Notable Practices

- The exit gate shall be designed to fail-safe in the up position except if the crossing is equipped with remote health (status) monitoring. [4]
- The sensitivity of the loop should be adjusted to reduce the false alarm probability. For the School Street system, the minimum detection threshold "equated roughly to detection of metal objects with the cross-sectional area of a motorcycle (500 pounds)". [5]
- Vehicle detection is highlighted as a key functional requirement for Advanced Railroad Grade Crossing operation under the National Intelligent Transportation Systems (ITS) Architecture (V6.1[8]). [1]

References

[1] Hilleary, T. (2012). A Radar Vehicle Detection System for Four-Quadrant Gate Warning Systems and Blocked Crossing Detection.

> Abstract: The Wavetronix Matrix Radar was adapted for use at four-quadrant gate railroad crossings for the purpose of influencing exit gate behavior upon the detection of vehicles, as an alternative to buried inductive loops. Two radar devices were utilized, operating collaboratively, in order to realize a fully redundant system.
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> Performance variables including vehicle size and location, vehicle occlusion, and radar positioning were evaluated, along with sensitivity to rain, snow, and other environmental conditions.
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> Recommendations for utilization of the radars in conjunction with popular crossing warning system controllers are provided. Also included is a means for detecting vehicles that are stopped, stored, or deliberately placed in the crossing island, and rapidly communicating that information across cellular, PTC, ITCS, and ACSES, and other data networks.

[2] Cambridge Systematics, Rail Strategy Study – Grade Crossing Toolkit, July 2018.

> Excerpt: The Grade Crossing Toolkit provides information and tools to identify candidate crossing improvements across a range of options. The Toolkit describes rail crossing treatments, such as grade separations, closures, consolidation, passive treatments, active devices, quiet zones, and specialized treatments for pedestrian/bicycle issues.

[3] Mullinax, R. (2015). Dynamic Gate Operations with Vehicle Detection at $-Quadrant Gated Highway-Rail Grade Crossings. Federal Railroad Administration and Federal Transit Administration 2015 Right-of-Way Fatality & Trespass Prevention Workshop.

Excerpt: This PowerPoint presentation provides information on evaluation of dynamic gate operations with vehicle detection system that was presented at 2015 Right-of-Way Fatality and Trespass Prevention Workshop.

[4] Federal Highway Administration. (2012). Manual on Uniform Traffic Control Devices.

Document Excerpt: The Manual on Uniform Traffic Control Devices (MUTCD), by setting minimum standards and providing guidance, ensures uniformity of traffic control devices across the nation. The use of uniform TCDs (messages, locations, sizes, shapes, and colors) helps reduce crashes and congestion, and improves the efficiency of the surface transportation system. Uniformity also helps reduce the cost of TCDs through standardization. The information contained in the MUTCD is the result of years of practical experience, research, and/or the MUTCD experimentation process. This effort ensures that TCDs are visible, recognizable, understandable, and necessary. The MUTCD is a dynamic document that changes with time to address contemporary safety and operational issues.

[5] Hellman, A., Carroll, A., and Chappell. (2007). Evaluation of the School Street Four-Quadrant Gate/In-Cab Signaling Grade Crossing System.

Abstract: Under sponsorship from the U.S. Department of Transportation Federal Railroad Administration, Office of Research and Development, the John A. Volpe National Transportation Systems Center performed an evaluation of the four-quadrant gate/obstruction detection system at the School Street crossing in Groton, CT. The primary objectives of this evaluation were to assess the safety benefits and to document the operational performance provided by this non-standard technology. Highway-railroad grade crossing risk mitigation research in the United States has historically focused on the safety benefits of active warning devices, such as flashing lights, bells, and dual crossing gates. In addition, clear agreement has predominated within the research community that grade separation or closure provides the highest level of risk treatment. As the economic and societal costs of these treatments have increased, however, research has been increasingly concentrated on technologies that provide many of the same benefits without the obtrusiveness of grade separation or closure.

Additional Resources

Hellman, A., Ngamdung, T. (2009). Illinois High-Speed Rail Four-Quadrant Gate Reliability Assessment. Technical Report No. DOT/FRA/ORD-09/19. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration.

Abstract: The Federal Railroad Administration (FRA) tasked the John A. Volpe National Transportation Systems Center (Volpe Center) to conduct a reliability analysis of the four-quadrant gate/vehicle detection equipment installed on the future high-speed rail (HSR) corridor between Chicago and St Louis. A total of 69 highway-rail grade crossings on a 121-mile (195 km) segment of the 280- mile corridor were equipped with four-quadrant gates and inductive loop vehicle detection technology. This segment, between Mazonia and Springfield Illinois, will eventually carry passenger trains at speeds up to 110 mph (177 km/h) at many of the highway-rail grade crossings.

The analysis was based on maintenance records obtained from the Union Pacific Railroad (UPRR), the owner and operator of the highway-rail grade crossings. The results were used to assess the impact of the equipment reliability on the proposed HSR timetable. The Volpe Center study showed that the total average delay to the five scheduled daily high-speed passenger roundtrips was an estimated 38.5 minutes, or approximately four minutes per train. Overall, extensive analysis of the trouble ticket data showed that the four-quadrant gate and vehicle detection equipment had a minimal direct impact on the frequency and duration of grade crossing malfunctions.

Horne, D. (2014). Radar Vehicle Detection Within Four Quadrant Gate Crossings. 2014 Global Level Crossing Symposium.

Document excerpt: This document provides information on radar vehicle detection within four quadrant gate crossings that was presented at 2014 Global Level Crossing Symposium.

Medina, J., Benekohal, R. (2013). Field Evaluation of Smart Sensor Vehicle Detectors at Railroad Grade Crossings —Volume 3: Performance in Favorable Weather Conditions.

Abstract: The performance of a microwave radar system for vehicle detection at a railroad grade crossing in Hinsdale, Illinois, was evaluated through field-testing in favorable (normal, good) weather conditions. The system was installed at a crossing with three tracks and used two radar units aimed at the crossing from opposite quadrants. The performance was assessed in terms of false calls, missed calls, stuck-on calls, and dropped calls, using datasets collected in favorable (good) weather conditions. First, the system performance was assessed using the initial setup. In the initial setup, the most frequent error type was false calls (0.55%), mainly the result of activations caused by pedestrians and bicyclists in the crossing; followed by missed calls caused by one of the radars missing a vehicle (0.07%). These results were shared with the product developer to see whether he wanted to make any modification to the initial setup. In the modified setup, the detection zones and the aim of one of the radars were changed. Then, the system performance was evaluated. Results for the modified setup showed an increased frequency of false calls (0.96%), mostly the result of activations generated by moving gates and also by pedestrians. Missed calls in the modified setup were slightly increased to 0.09%, and they were due to one of the two radar units missing a vehicle. There were no missed calls when the system relied on the two radar units because at least one of the two always detected the vehicles occupying the crossing. The system did not generate any stuck-on or dropped calls in the selected data for both the initial and the modified setup in favorable (good) weather conditions. Additional testing is under way to evaluate the system in adverse weather conditions, including snow-covered roadways, rain, fog, and wind.

Related Measures

- Four quadrant gates
- Automatic gates
- Barrier gates
- Long gate arm
- Traffic signal preemption
- Pre-signal

Images

- No image available