Measure Name: Connected vehicles (V2V and V2I)

Definition: Wireless-based exchange of data between highway and rail-bound vehicles or roadside infrastructure to prevent highway-rail grade crossing collisions.

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

Connected vehicle (CV) technology refers to the suite of safety applications designed under the purview of the United States Department of Transportation (US DOT) Intelligent Transportation Systems (ITS) program. Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) safety technologies offer two different approaches to reducing grade crossing crash risk. Both involve wireless communication of situational awareness to a highway vehicle. V2I entails the transmission of warning device status (active or unactive) at an active grade crossing to approaching highway vehicles. V2V technology involves point-to-point communication of rail-bound equipment status (position, velocity, etc.) to approaching highway vehicles. In poor line-of-sight environments, a repeater may be deployed at the grade crossing to increase the transmission coverage area. The V2V approach is more appropriate for passive grade crossings.

FRA research of the V2I approach has resulted in the development of a reference implementation that has been tested at the Transportation Research Center in East Liberty, Ohio [1] and Michigan Technological University in Houghton, Michigan. The system is the grade crossing analog of a red-light violation warning system that transmits crossing status and intersection geometry messages to approaching equipped vehicles. If the onboard vehicle technology determines the potential for a conflict, visual and auditory alerts are generated. The conflicts covered by this technology include vehicle-train crashes and vehicle right-of-way incursions.

FRA has also funded research and testing of the V2V approach for point-to-point and poor line-of-sight environments (point-to-point-to-point). This configuration is the grade crossing equivalent of the highway V2V collision avoidance safety application that relies on transmission of vehicle position, velocity, and vector. Results from testing by Virginia Tech on the Shenandoah Valley Railroad in Virginia showed the system can provide 35-40 seconds alerting time in the point-to-point-point scenario and 25-30 seconds in the point-to-point configuration [2].

Additional search terms: *automated vehicles, V2I, V2V, CV, CAV*

Advantages

- V2I reference implementation design is consistent with the National ITS Architecture.
- The architecture is communications platform agnostic.
- V2I configuration infrastructure hardware interconnects passively with existing grade crossing wayside equipment and no modifications to grade crossing hardware are necessary.
- V2V configuration independent of railroad infrastructure.
- Potential for integration with Cooperative and Automated Vehicle technologies.

Drawbacks

- V2I configuration requires large up-front investments to procure roadside infrastructure and map grade crossing intersection geometry.

- Both V2I and V2V configurations are still under development and not ready for deployment.
- Low installed user base of equipped highway vehicles.
- Testing is needed to measure the safety impact of V2V and V2I configurations.
- Railroad industry concerns over installation of CV technology on its vehicles.
  Industry trends favor vehicle-based and automated systems with all intelligence contained on vehicle.

Notable Practices

- No notable practices available

References

[1] Sanchez-Badillo, A., Baumgardner, G., Paselsky, B., & Seitz, T. (2022). Rail Crossing Violation Warning Application – Phase II. Technical Report No. DOT/FRA/ORD-22/07. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration.

Abstract: Phase 2 of the Rail Crossing Violation Warning (RCVW) application provides the means for equipped connected vehicles (CV) on approach to a highway-rail intersection (HRI) to be warned of an imminent violation of an HRI active warning/protective system through the interconnection of a CV Roadside-Based Subsystem (RBS) with track-circuit based train detection systems in place at active HRIs. The objective of this project was to build upon the RCVW proof of concept to make refinements to the software and hardware to achieve improved performance and enhanced system functionality. This project explored the use of enhanced Global Positioning System (GPS) solutions, OBD-II sourced vehicle data as additional input to the system, integration of the Institute of Electrical and Electronics Engineers (IEEE) 1570 serial signal preemption protocol for fail-safe train presence detection and an updated driver-vehicle interface.

[2] Choi, J., Marojevic, V., Dietrich, C. B., & Ahn, S. (2022, March 22). DSRC-Enabled Train Safety Communication System at Unmanned Crossings. *IEEE Transactions on Intelligent Transportation Systems*, 1-14.

Abstract: Although wireless technology is available for safety-critical applications, few applications have been used to improve train crossing safety. To prevent potential collisions between trains and vehicles, we present a Dedicated Short-Range Communication (DSRC)-enabled train safety communication system targeting passive crossings. Since our application's purpose is preventing collisions between trains and vehicles, we present a method to calculate the minimum required warning time for head-to-head collision. We therefore define the best and worst-case scenarios and provide empirical data collected at six operating crossings in the U.S. with numerous system configurations, including modulation scheme, transmission power, antenna type, train speed, and vehicle braking distances. From our measurements, we find that the warning application coverage range is independent of the train speed, that the omnidirectional antenna with high transmission power is the best configuration for our system, and that the communications latency is less than 1 ms on average and around 5 m worst case. We use the radio communication coverage and introduce the safeness level metric to evaluate the suitability of DSRC for collision avoidance. From the measured data, we observe that the DSRC-enabled train safety communication system is feasible for up to 35 mph train speeds which

is providing more than 25-30 s to avoid a collision for 25-65 mph vehicle speeds. Higher train speeds are expected to be safe, but additional data over extended distances are needed for a definite conclusion.

Additional Resources

Related Measures

Images

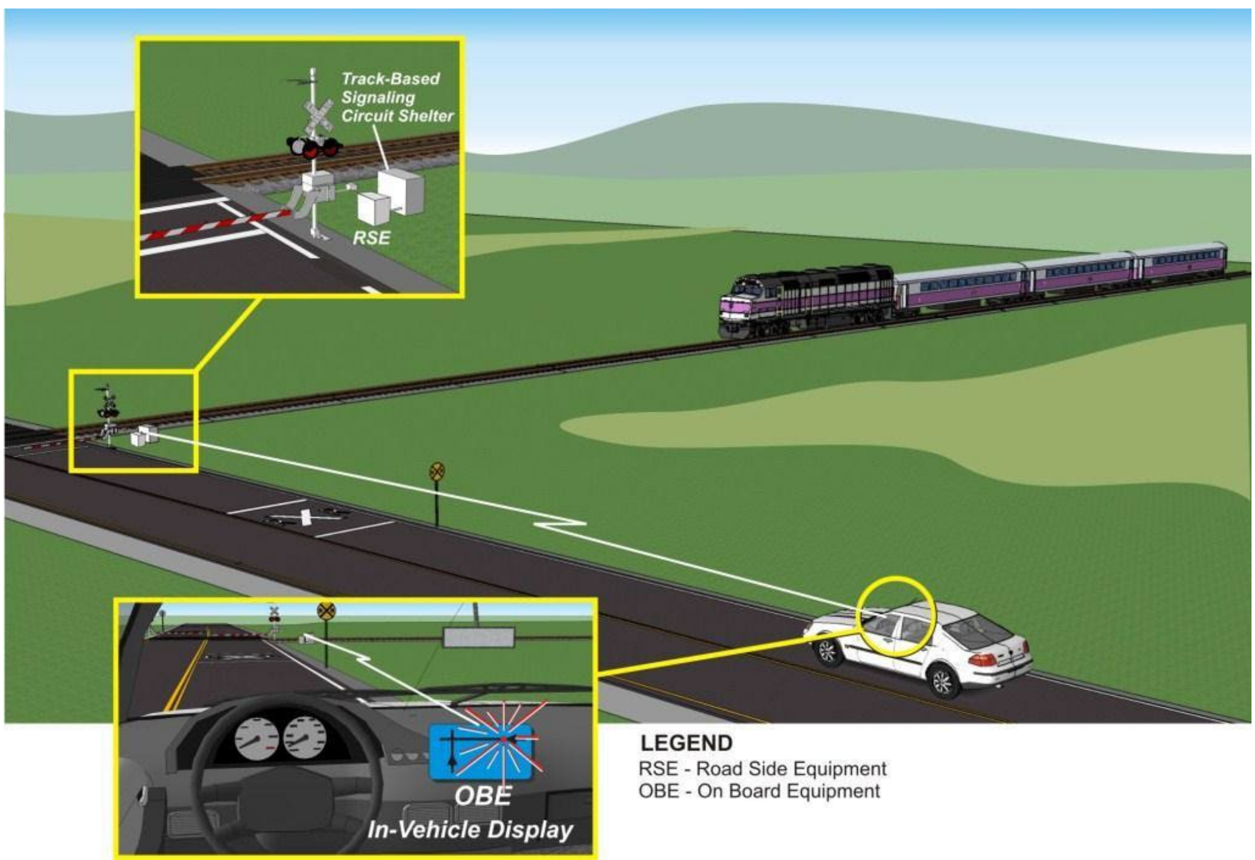

Figure 1. Vehicle-to-Infrastructure Concept of Operations
Image Credit: Volpe Center

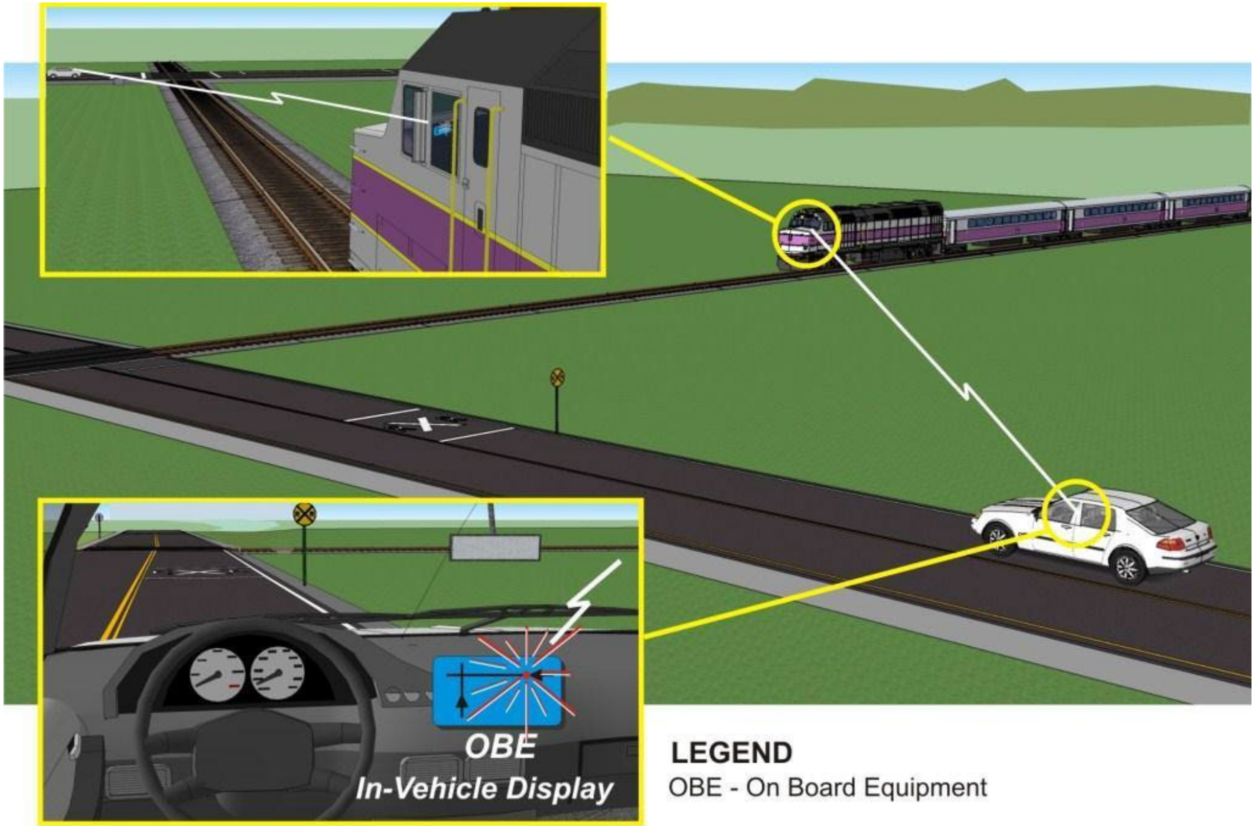

Figure 2. Vehicle-to-Vehicle Concept of Operations
Image Credit: Volpe Center