US Department
of Transportation

Federal Railroad
Administration

Research Results

RR 07-20
June 2007

Intelligent Transportation System/Positive Train Control at Highway-Rail Intersections

SUMMARY

Since the mid-1990s, the U.S. Department of Transportation (U.S. DOT) Federal Railroad Administration (FRA) has sponsored research, conducted by the John A. Volpe National Transportation Systems Center of the U.S. DOT Research and Innovative Technology Administration (RITA), aimed at integrating Positive Train Control (PTC) and Intelligent Transportation System (ITS) technologies. The objective of this research is to improve safety and efficiency at highway-rail intersections (HRIs) by finding affordable, standardized systems that can be installed at HRIs to provide immediate safety benefits. The immediate goal is to validate, through demonstration projects, the cost-effective safety benefits of promising ITS technologies. By evaluating systems using evolving ITS technologies at HRIs in corridors where PTC will be installed, existing infrastructure may be utilized to minimize demonstration development and cost. Figure 1 shows a typical PTC configuration.

This study included (1) an evaluation of vehicle proximity alerting systems (VPAS), (2) two symposia on the implications of ITS for railroads, (3) participation in the development of standards related to infrastructure communications, such as the Institute of Electrical and Electronics Engineers (IEEE) *Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection* (IEEE Std 1570-2002, as shown in Figure 2), and (4) a periodically updated survey and review of relevant projects and promising technologies.

The VPAS tests, conducted in 1995–1996, were designed to measure the ability of the prototype systems to provide warnings to priority vehicles (i.e., emergency vehicles, school buses, vehicles carrying hazardous materials, and large trucks) from trains approaching and occupying nearby HRIs. The results demonstrated that the VPAS concept is feasible, but all systems tested would require further development [1].

In reviewing the ITS activities, the Volpe Center found that several of the projects provided beneficial safety features. For example, changeable message signs (CMS) were found to be one of the most cost-effective technologies available to provide increased information to motorists. Other promising technologies included dedicated short-range communication (DSRC) and Differential Global Positioning Satellite (GPS) systems, as well as video detection and monitoring.

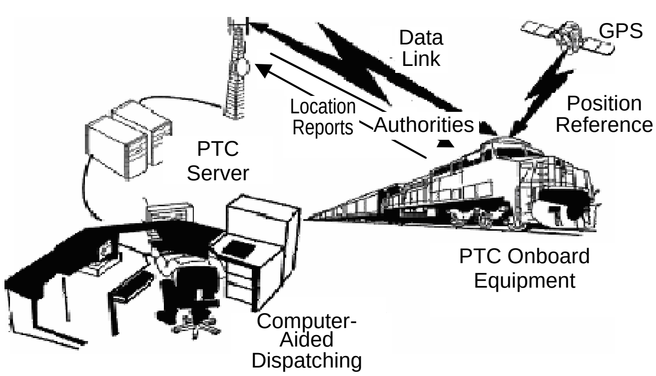

Figure 1. PTC System Flow

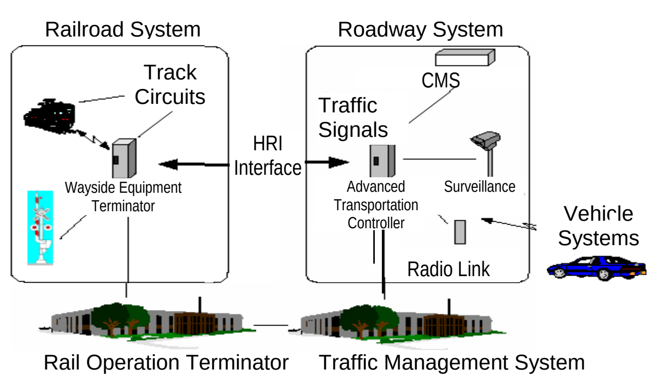

Figure 2. IEEE Std 1570-2002 HRI Interface Overview

As a result of recommendations from the ITS symposia, the updated survey and review of enabling technologies, the Volpe Center proposed a short list of demonstration scenarios: (1) a supplemental CMS at a crossing equipped with four quadrant gates with vehicle detection to notify motorists and pedestrians of approaching trains; (2) an in-vehicle GPS-based HRI warning system; (3) an HRI CMS for motorists that displays train location, speed, and arrival time; and (4) a system that would combine elements of the first two scenarios [2].

BACKGROUND

In railroad applications, ITS technologies can enable improved warning of approaching trains to motorists and pedestrians. They can also be used to reroute traffic around blocked or busy HRIs to alleviate congestion. One such technology, VPAS, is designed to alert motorists in the vicinity of grade crossings lacking active warning devices that a train is approaching. This is accomplished by transmitting in-vehicle visual and audible warnings to the motorist.

Section 1072 of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 required FRA to coordinate field-testing of VPAS technologies to determine the feasibility of using VPAS in priority vehicles.

In a concurrent effort to reduce collisions at HRIs, FRA initiated research to evaluate the feasibility of integrating ITS and PTC technologies. The safety benefits of combining these two technologies include reducing the risk of collisions between high-speed trains and motor vehicles at crossings and improved roadway worker protection.

In January 1997, the ITS National Architecture adopted User Service 30, the HRI User Service. This established a baseline from which new system configurations could be built with greater integration between rail wayside equipment and roadway traffic management systems, thereby improving the response time of rail and roadway systems to incidents and other traffic conditions.

Coordination between the highway and rail subsystems is part of creating a national ITS architecture encompassing multiple modes. At the time, however, existing standards addressed only analog interfaces between the two subsystems. As such, a standard was required to extend that information to include serial digital communication.

RESEARCH OBJECTIVES

Technology Assessment

- Determine the feasibility and effectiveness of VPAS for detecting trains at nearby HRIs that lack active warning systems.
- Develop scenarios for FRA demonstration projects that will integrate ITS and PTC capabilities to improve safety and efficiency at HRIs.

Public-Private Partnership

Provide a forum for stakeholder discussion of topics for use of ITS and PTC to improve safety and efficiency at HRIs.

- Increase railroad awareness of and participation in ITS activities through presentations, research, and documentation.
- Participate on industry technical standards development committees.

RESEARCH METHODS

Technology Assessment

From 1995–1996, three VPAS prototypes were tested at FRA's Transportation Technology Center (TTC), in Pueblo, CO:

1. A three-point radio frequency (RF) system, shown in Figure 3.
2. A two-point RF system that detects the Front to Rear End of Train (FRED) device. When the FRED signal is detected, a warning is given to the motorist.
3. An acoustic system on the highway vehicle that would detect the train horn of the approaching train and alert the motorist.

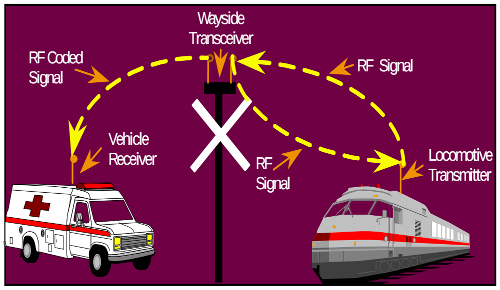

Figure 3. Three-point VPAS Concept

The testing showed that although VPAS is feasible, the prototypes demonstrated were not suitable for further field-testing without additional development work.

Public-Private Partnership

FRA and ITS America sponsored a joint technical symposium in June 1997, convened by the Volpe Center, on "Intelligent Transportation Systems and Their Implications for Railroads." The goals of the symposium included disseminating the HRI User Service Architecture to railroads and suppliers and accelerating transfer of ITS technological developments to railroads.

In May 1999, the Volpe Center hosted the first ITS-HRI Evaluation Workshop. Nearly 60 representatives from the Federal and State governments and the private sector met to discuss ITS technologies and compare several ITS-HRI demonstration projects currently deployed or under development.

In the late 1990s, a comparative analysis of innovative ITS HRI-related projects was performed and presented to further expand awareness of the existence and benefit of ITS technologies utilized to improve safety at HRIs. The analysis was conducted to identify the systems available and determine the potential redundancy of systems being developed [3].

From 2000–2001, the Volpe Center provided technical support to FRA by participating on an IEEE Rail Transit Vehicle Interface Standards Committee (RTVISC) working group to develop interface requirements between rail and highway systems at grade crossings.

In 2003, the Volpe Center conducted literature searches, attended conferences, and communicated with academia and the industry, as well as local, State, and Federal governments, involved in the fields of ITS and PTC to update and expand the previous body of work. New projects that used portions of either ITS or PTC capabilities were investigated. Projects depicting relevant enabling technologies were recorded and shared via presentations within the HRI community. The findings were used to propose demonstration scenarios,[2]; a sample of which is presented below.

The Minnesota In-Vehicle Warning System: This system was developed from the FRED VPAS sensing device to provide a supplemental in-vehicle warning to the driver. The improved system used radio transmitters affixed to crossbucks at 5 HRIs and receivers installed in 29 school buses. The system was designed to alert drivers of potentially dangerous railroad crossing situations.

The LIRR Second Train CMS System: This system incorporates text and graphic CMS with audible warnings and strobe lights to improve pedestrian awareness and safety at crossings and near stations.

The Alameda Corridor-East Integrated Roadway/Rail Interface System: This system was designed to reduce large queues and traffic delays near HRIs. It uses magnetometers to predict the arrival time of trains within 5 miles of an HRI and transmits this information for adjustment of traffic signals and use in CMS.

The Minnesota Low-Cost Active Warning for Low-Volume HRI Warning Project: This system demonstrated a non-vital system consisting of solar-powered red flashers added to the crossbuck signs at an HRI and amber flashers added to advanced warning signs near the HRI. These flashers are activated via a low power radio communications link with approaching locomotives.

FINDINGS AND CONCLUSIONS

Technology Assessment

The concept of VPAS for warning motor vehicles of a train approaching an HRI was demonstrated to be feasible. RF systems appeared to be more suitable for a warning system than acoustic systems, and the three-point design seemed to be the most reliable [1].

Public-Private Partnership

The "Intelligent Transportation Systems and Their Implications for Railroads" symposium provided a forum to disseminate the architecture for applying ITS at HRIs and to encourage projects that integrate ITS and PTC [4]. The ITS-HRI workshop provided an opportunity for members of the ITS-HRI community to meet, share findings, obtain peer critique, and give feedback to the Federal government on other potential directions for the program. This was also the first time for the group to meet and discuss the details of the demonstration projects [5].

The output of the IEEE RTVISC working group was IEEE Std 1570-2002. This standard defines the logical and physical interfaces, and the performance attributes for the interface between the rail subsystem and the highway subsystem at an HRI.

The projects and technologies surveyed provided the Volpe Center with successfully demonstrated strategies, technologies, and equipment for proposing four alternative FRA demonstration scenarios that could potentially improve safety and efficiency at HRIs [2].

In-Vehicle HRI Approach Advisory System: This scenario would use either a GPS-based product or a localized transmitter installed at HRIs to provide an advance warning to vehicles when it is within a certain distance of an HRI. The vehicle would be equipped with a receiver and an in-vehicle display (such as the one used in the Minnesota in-Vehicle Warning System) or equipped with an in dashboard radio unit with a data radio system protocol transmission that interrupts the features of the in-dash unit to display a text message.

Train Approaching HRI CMS System: This scenario would use one or more CMS interfaced to a PTC system to provide advance warning of approaching trains to motorists and pedestrians. The PTC system would transmit train location and speed to the HRI and activate CMS text messages to disseminate information about a train approaching the HRI, a second train approaching, and the estimated delay time. On rail corridors not equipped with PTC, alternative methods of train detection could be implemented to provide accurate and reliable signals to warn of approaching trains.

CMS and In-Vehicle HRI Alert System: This scenario would combine elements of the first two to provide wayside CMS and in-vehicle warnings.

School Street CMS Overlay: This scenario would add CMS to the current FRA/Volpe Center Four-Quadrant Gate/Vehicle Detection System in Groton, CT, to notify motorists and pedestrians of approaching trains.

REFERENCES

[1] *Vehicle Proximity Alert System for Highway-Railroad Grade Crossings: Prototype Research*. Smailes, J.; Carroll, A.; Anderson, J. Paper presented to the 7th International Symposium on Railroad-Highway Grade Crossing Research and Safety, Monash University, Melbourne, Australia, February 2002.

[2] *Review of Intelligent Transportation Systems Applications at Highway-Rail Intersections in The United States*. Bousquet, P.; Peck, S. Paper presented at the Transportation Research Board Annual Meeting, January 2004.

[3] *Comparative Analysis of Innovative ITS Highway-Rail Grade Crossing Projects: An Interim Report*. Chappell, D. Paper presented at the Highway-Rail Grade Crossing Safety Transport Canada/U.S. Department of Transportation Federal Railroad Administration Cooperative Research Working Meeting. June 12, 2000.

[4] *Intelligent Transportation Systems and Their Implications for Railroads, Proceedings of A Joint FRA-ITS America Technical Symposium, Washington, DC, June 4–5, 1997.* Carroll, A. March 1998. DOT/FRA/ORD-97/11, DOT-VNTSC-FRA-97-8.

[5] *ITS Technologies at Highway-Rail Intersections: Putting It to the Test*. Carroll, A.; Oxley, C. Proceedings from the ITS Joint Program Office Highway-Rail Intersection Evaluation Workshop, May 6–7, 1999.

CONTACT

Dr. Thomas Raslear
Federal Railroad Administration
Office of Research and Development
1120 Vermont Avenue NW–Mail Stop 20
Washington, DC 20590
Tel: (202) 493-6356
Fax: (202) 493-6333
E-mail: Thomas.Raslear@dot.gov

KEYWORDS

Vehicle proximity alert systems, VPAS, intelligent transportation system, ITS User Service 30, highway-rail intersection, positive train control