U.S. Department Of Transportation

Federal Railroad Administration

Research Results

Research Results RR07-21

Alternative Rail Intruder and Obstacle Detection Systems

SUMMARY

Since the mid-1990s, the U.S. Department of Transportation (U.S. DOT) Federal Railroad Administration (FRA) has sponsored a research program on alternative detection technologies for railroad right-of-way (ROW) and highway-rail grade crossing applications. In support of this effort, the John A. Volpe National Transportation Systems Center (Volpe Center) of the U.S. DOT Research and Innovative Technology Administration has assessed the potential applicability of various technologies, tested prototype systems, and maintained a public-private partnership program to disseminate information. The application of non-track circuit-based technologies for train, highway vehicle, and intrusion/obstacle detection would improve the safety of rail operations and passengers and road users. These technologies would also protect the general population and environment from the risks associated with hazardous material shipments and help relieve congestion by reducing the number of incidents and delays due to those incidents.

The main objective of rail intruder and obstacle detection systems (IODS) is to provide train engineers, railroad dispatchers, and security organizations timely information on the status of sections of railroad track and crossings. The intent is to allow them sufficient time to perform the appropriate emergency actions to decrease train speed or stop a train to avoid or mitigate the effects of a collision or security breach. Several types of non-track circuit-based IODS system prototypes have been field-tested in recent years. These systems incorporate technologies, such as magnetic, infrared, ultrasonic, and acoustic sensors, as well as radar and video detection. New applications of these existing technologies, as well as delivery platforms, have emerged in the past few years.

In 1998, under sponsorship of FRA, the Volpe Center held a national workshop on railroad IODS. The main objective of this workshop was to assemble a representative set of researchers and rail industry representatives to brainstorm possible IODS requirements and constraints. The workshop topics ranged from accurate detection and timely communication to reliability and redundancy, and the proceedings were published in the FRA report *Intruder and Obstacle Detection Systems (IODS) for Railroads–1998 Requirements Workshop* [1]. In 1999, the Volpe Center assessed the performance of a four-quadrant gate crossing, employing an inductive loop IODS at School Street in Mystic, CT, on the Northeast Corridor (NEC) from 1999–2000.

Following the guidelines set forth in the IODS Workshop, in 1999, FRA tasked the Volpe Center and the Transportation Technology Center, Inc. (TTCI) to evaluate available technologies for their ability to detect trains and highway vehicles in the crossing environment. The findings of this effort were published in the FRA report *Evaluation of Alternative Detection Technologies for Trains and Highway Vehicles at Highway Rail Intersections* [2]. Since then, a host of novel detection approaches involving both existing and emerging technologies have appeared. In 2005, the Volpe Center began updating the evolution of relevant IODS, focusing on highway-rail crossings and ROW trespass.

Figure 1. Video image of trespass incident

BACKGROUND

The dramatic increase in speed associated with high-speed rail (HSR) service increases the risk and severity of collisions at grade crossings. As such, in the 1980s and early 1990s, the Federal Highway Administration and FRA developed an interest in researching IODS for detecting motor vehicles, pedestrians, and other obstacles at HSR and conventional speed grade crossings.

Section 1036(c) of the Intermodal Surface Transportation Efficiency Act of 1991 called for a technology demonstration program to facilitate the establishment of HSR service. An obstacle detection system with four-quadrant gates at a grade crossing was one of the technologies demonstrated under this program.

RESEARCH OBJECTIVES

Public-Private Partnership

- Provide a forum for stakeholder discussion of IODS technologies and potential applications.
- Develop a high-level functional concept and define the architecture for IODS.

Technology Assessment

- Evaluate the performance of prototype technologies for detecting train and highway vehicles in grade crossings.
- Maintain a database of existing and potential technology solutions that could be considered for use as IODS or capable of performing integral functions within such systems for railroad ROW and crossings.
- Recommend potential technology concepts for future field-testing.
- Determine whether integration of four-quadrant gates, inductive loop obstruction detection technology, and in-cab signaling can yield a high level of safety to motorists without adversely affecting rail operations.

RESEARCH METHODS

Public-Private Partnership

An IODS Workshop for Railroads was held in June 1998 at the Volpe Center. Participants included U.S. DOT staff and consultants, State highway and rail representatives, railroads, railroad suppliers, and research and development organizations. They reviewed the operational, technical, and regulatory issues concerning obstacle detection and formulated a consensus statement to guide the next steps.

Technology Assessment

Locomotive engineer acceptance of the four-quadrant gate/vehicle detection technology used at School Street on the NEC in Connecticut was determined by administering a survey to evaluate their experiences and reactions. The survey was administered to Amtrak train operators who traveled through the four-quadrant gate system to collect data on their experience and reactions to the barrier and vehicle detection system.

In 1999, under sponsorship of FRA, the Volpe Center evaluated five technologies for their ability to detect motor vehicles and trains approaching and occupying a highway-rail intersection at FRA's Transportation Technology Center in Pueblo, CO:

1. *Two train presence detection systems*—Both employing vibration and magnetic anomaly sensors.
2. *Two integrated train and vehicle detection systems*—One using inductive loops for train detection and radar for vehicle detection, the other double wheel sensors (axle counters) for train detection and low power laser and video imagery for vehicle detection.
3. *A vehicle detection system*—Employing passive infrared and ultrasonic detectors.

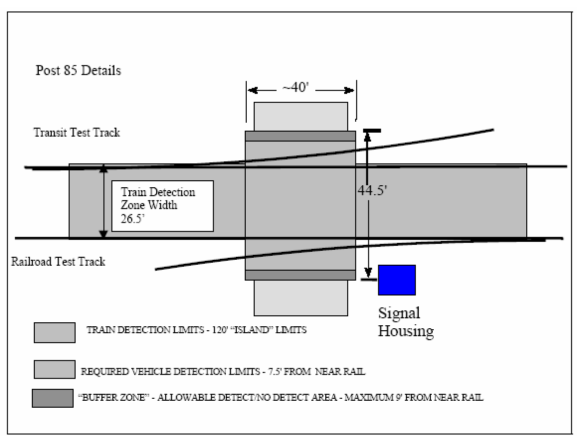

Figure 2. Detail of road crossing showing island limits and vehicle detection limits

Technology Assessment—IODS Research

In 2005, the Volpe Center conducted research into the potential of future IODS technologies. Over 20 IODS technologies were reviewed and then classified into 1 of 3 categories, as shown in Figure 3:

- Infrastructure-based systems, which depend on active cooperation between sensory equipment mounted along the ROW and train-borne warning devices.
- Infrastructure/locomotive cooperation systems, which use passive cooperation between train-mounted sensors, such as radar or laser, and markers or reflectors along the route.
- Locomotive-based systems, which are capable of monitoring the entire rail network, are mounted on rail vehicles, and do not interact with any wayside equipment.

FINDINGS AND CONCLUSIONS

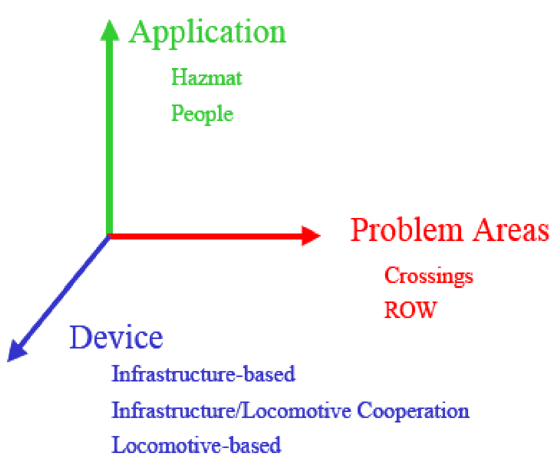

Figure 3. Potential IODS solutions

Public-Private Partnership

The output of the IODS workshop was the functional requirements for sensors, processing, communication, and decision support. Those requirements were used for the train and vehicle detection tests at TTCI [2].

Technology Assessment

The vehicle detection circuitry at the four-quadrant gate crossing in Connecticut is vitally interconnected to the Amtrak in-cab signaling train control system. If the sensors detect that the crossing is occupied once all four gates are fully deployed, the control circuitry will cause the exit gates to release, thereby allowing trapped motor vehicles to safely exit the crossing.

All of the train operators who responded to the survey at School Street stated that no changes were required in their train-handling strategy upon entering the four-quadrant gate/vehicle detection system island circuit. Most of the respondents stated that the four-quadrant gate system (as compared with the pre-existing dual-gate system) reduced their anxiety level at the School Street grade crossing [3].

The results of the train-detection testing suggested that alternative systems could detect trains. The system using magnetic anomaly and vibration detectors provided train direction, speed, and length information. The outlying approach sensors on that system can be placed to permit stopping of the train before reaching the grade crossing, or the warning system can be activated at a pre-determined time before train arrival. The wheel-sensor system consistently detected train arrival and departure within the island limits and provided train speed information. Both the wheel-sensor system and the inductive loop system provided train direction. This evaluation assisted the Intelligent Transportation Systems community in determining benefits and limitations to some promising detection technologies [2].

Infrastructure-based systems maximize the integration of Positive Train Control technology and have been the focus of most IODS research. An example is the Florida DOT Advanced Warning Alerts for Railroad Engineers (AWARE) Pilot Program, which was specifically developed for crossing applications. This project combined an automated video monitoring system with a global positioning system-based train location and communication system.

This combination allowed for real-time communication between monitoring equipment at

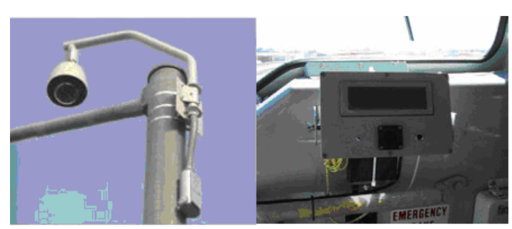

Figure 4. AWARE project

the crossing and an informational system on board specially equipped trains. Figure 4 shows the video monitoring and onboard systems.

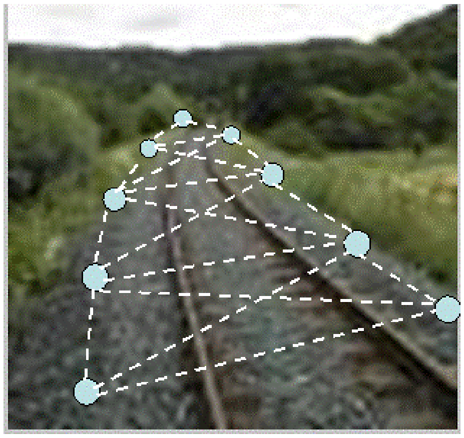

Figure 5. A wireless sensor network

Two of the most prominent infrastructure /locomotive cooperation systems, wireless sensor networks and optical detection of obstacles (ODO), were developed for application to entire rail corridors. Wireless sensor network technology employs a mesh of low power wireless sensors, as illustrated in Figure 5 (seismic, acoustic, magnetic, passive, infrared, video), to detect, locate, and characterize vehicles and people on the railroad ROW. ODO technology uses fiber optic-relayed laser radar that is capable of detecting obstacles off the line of sight (curves, hills, etc.).

Although proving to be the most technically challenging approach, locomotive-based systems are capable of providing 100 percent route coverage. One such system prototype is the Railway Electro Optical System for Safe Transportation. This ongoing research, funded by the European Union, is focused on the use of locomotive-based sensors to detect obstacles on the railroad track. The major sensing components are optical cameras mounted in a specially built housing on top of the locomotive [4].

REFERENCES

[1] *Intruder and Obstacle Detection Systems (IODS) for Railroads–1998 Requirements Workshop.* Carroll, A.; Meltzer, N.; Carpenter, JE. December 2001. DOT-VNTSC-FRA-00-07, DOT/FRA/ORD-01/13.

[2] *Evaluation of Alternative Detection Technologies for Trains and Highway Vehicles at Highway Rail Intersections*. Reiff, R.; Gage, S.; Gordon, J. February 2003. DOT-VNTSC-FRA-03-02, DOT/FRA/ORD-03/04.

[3] "Preliminary Evaluation of the School Street Four-Quadrant Gate Highway-Railroad Grade Crossing." Carroll, A.; Hellman, A. Paper presented to the Transportation Research Board, January 2002.

[4] *State-of-the-Art Technologies for Intrusion and Obstacle Detection for Railroad Operations*. daSilva, M.; Baron, W. February 2007. DOT-VNTSC-FRA-07-04, DOT/FRA/ORD-07/06.

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KEYWORDS

Obstacle detection, obstacle intrusion systems, intrusion detection, alternative detection technology systems, trespass detection, loop detectors