U.S. Department of Transportation
Federal Railroad Administration

RESEARCH RESULTS
FRA OFFICE OF RAILROAD POLICY & DEVELOPMENT

RR 11-26 | December 2011

LOW-COST WARNING DEVICE INDUSTRY ASSESSMENT

SUMMARY

Virtually all of the grade crossing train detection and warning systems in the United States use a variant of the track circuit technology developed over a century ago. Track circuits have evolved through the years, but the design and principles of operation have changed little. Although highly reliable, track-circuit–based train detection systems are costly to install and maintain. Systems that leverage low-cost, nontraditional technologies are an attractive alternative at low-usage grade crossings. The challenge for the railroad industry is to develop systems that are low in cost and safe.

In response, the Federal Railroad Administration's Office of Railroad Policy and Development directed the John A. Volpe National Transportation Systems Center (Volpe Center) to conduct a technology assessment of low-cost active warning devices for application at passive highway-rail grade crossings. The purpose of this research was to present an objective assessment of the available low-cost warning device technologies and to recommend a migration path that could be implemented in the United States.

Although there is no "low-cost" threshold, the research has shown that the alternative technologies are 5–30 percent of the cost compared with a conventional track-circuit–based grade crossing system. The large deviation was attributed to the variation in performance and functional requirements at each application. One of these is the location of the train detection and warning equipment, which has been developed for both on the right-of-way (ROW) or off the ROW environments. On-ROW systems are installed on railroad property and typically interface physically or electrically with railroad infrastructure. Off-ROW systems are located externally to railroad property and provide nonintrusive train detection and warning functionality.

Many innovative on-ROW and off-ROW prototype systems have undergone extensive testing in North America, Europe, and Australia. However, a variety of technical, cost, and institutional issues must be resolved before these technologies are considered mature enough for railroads and government regulatory agencies to adopt. In recent years, regulatory bodies have become increasingly sophisticated in their knowledge of nonconventional train detection and warning technologies. This is reflected in the growing use of performance-based regulations, which offer more flexibility for railroads and railroad suppliers to demonstrate safety.

Figure 1. A Typical Passive Crossing (Secretary's Action Plan for Highway-Rail Crossing Safety and Trespass Prevention 1994)

BACKGROUND

Despite all of the successes during the past 20 years, the frequency of a train-highway vehicle collision at passive crossings still exceeds that of active grade crossings. Decreases of passive crossing incident rates reflect the concerted effort to either eliminate the riskiest crossings or upgrade them with active warning devices. The remaining group of passive crossings poses less of a risk but still requires serious attention. Working against this trend is the limited availability of Federal and State funding for crossing improvements as well as the competition with other highway improvement programs for funding.

OBJECTIVES

The Volpe Center performed a survey and assessment of the progress in low-cost warning device research. The following topics were considered: (1) the technologies that were selected for evaluation, (2) the criteria used to evaluate the technologies, (3) the implementation challenges and how they were resolved, (4) the benefits associated with the technologies, (5) the feasibility of leveraging the results of the previous research, and (6) lessons learned.

RESEARCH METHODS

The industry review included research funded by the Transportation Research Board (TRB), FRA, Transport Canada, and the Government of Australia. The Volpe Center then evaluated the implications of these activities for their benefits, implementation challenges, and system cost. The research scope also included an analysis of potential approaches to meet these challenges and identified the most promising technologies.

FINDINGS AND CONCLUSIONS

Minimum Requirements

The uniqueness of the grade crossing environment underscores the need to ensure that warning devices are highly reliable and fail-safe. These requirements are expensive to satisfy and represent some of the primary roadblocks to deployment of low-cost warning systems.

Title 49, Part 234 of the Code of Federal Regulations, Grade Crossing Signal System Safety, provides a minimum set of performance requirements for grade crossing safety, including a minimum warning time of 20 seconds and incorporation of fail-safe operation principles.

Cost

In 2004, the American Railway Engineering and Maintenance-of-Way Association (AREMA) Committee 36, Highway-Rail Grade Crossing Warning Systems, published an analysis of baseline grade crossing system costs derived from the minimum requirements set forth in the FRA grade crossing safety regulations (Table 1).

Table 1. Installation Costs

Cost Category	Cost %
Installation	31.7%
Gates, Lights, Masts and Signs	14.1%
Engineering and Site Survey	12.3%
Train Detection	11.3%
Bungalow and Racks	10.6%
Power Service	4.4%
Ground Materials	3.9%
Freight	3.2%
Batteries and Charger	2.8%
Crossing Controller	2.1%
Event Recorder	2.1%
Assorted Electrical	1.4%

Analysis of Previous Research

The Volpe Center performed a comprehensive survey and assessment of previous low-cost warning device research. A select number of studies are described herein. The full survey of research will be contained in the project final report.

In 1999, the Volpe Center and the Transportation Technology Center, Inc., initiated research to evaluate the performance of non–track-circuit–based train and vehicle detection technologies. Three systems that included a train detection component were evaluated. Only one double-wheel sensor technology did not exhibit any failures, missed detections, or false alarms [2].

In 2004, the Texas Transportation Institute (TTI) was funded by the TRB National Cooperative Highway Research Program to identify and assess potential low-cost warning technologies. The results, published in 2006, included an evaluation of 12 potential low-cost grade crossing warning device technologies against a set of cost and performance criteria they had developed. In contrast to the AREMA Committee 36 research, TTI defined the baseline system as train detection and warning lights, but no gates. The research also established several cost categories: (1) ultralow, less than $25,000; (2) low, $25,000 to $50,000; and (3) moderate, $50,000 to $75,000 [3].

From August to October 2006, TTI tested two of these technologies, radar and acoustic, at a four-quadrant gate crossing in College Station, TX. These technologies were selected because they could be installed off the railroad ROW and were not constrained by railroad liability issues. The performance of each of these technologies was compared with the track circuit signaling system that was already installed at the grade crossing and was recorded in shadow mode. Both systems not only detected 100 percent of the trains but also exhibited high false train detection rates [4].

From 2001 to 2005, the Minnesota Department of Transportation (Mn/DOT) developed and deployed a low-cost warning system on the Twin Cities and Western railroad. Mn/DOT defined “low cost” as $10,000 to $15,000, roughly 10 percent of the cost of a conventional grade crossing warning system. The core features of this system were a global positioning system for locomotive determination and wireless communications between locomotives and grade crossings. In addition to the traditional cross bucks and flashing lights, an active warning sign was installed on each approach lane in advance of the crossings (see Figure 2). All of the crossing equipment, including the controller, was powered by a 14-volt battery with a solar panel charging system. The research findings showed that the active warning system accurately warned and provided adequate warning times to motorists for approaching trains [5].

Figure 2. (left) Mn/DOT Flashing Lights with Solar Panel and (right) Advance Warning System [5]

Other research projects to note are the North Carolina Department of Transportation’s testing of a magnetometer-based train detection and warning system [6], New Brunswick’s (Canada) evaluation of a radar-based low-cost warning device system for private and farm crossings [7], and similar research conducted by Australia’s Sate of Victoria [8]. More detailed information on these research initiatives will be contained in the project final report.

Conventional, track-circuit train detection and warning systems have a long history as the industry-accepted standard for grade crossing control systems. The challenge for the railroad supplier industry is to ensure that the safety and reliability of non–track-circuit technologies are not compromised while still maintaining low cost.

REFERENCES

[1] Petit, B. (2002 May). *The previously untold story about grade crossing costs: Railway track and structures.*

[2] Reiff, R., Gage, S., Carroll, A., & Gordon, J. (2003 Feb.). *Evaluation of alternative detection technologies for trains and highway vehicles at highway rail intersections* (Report No. DOT-VNTSC-FRA-03-02, DOT/FRA/ORD-03/04).

[3] Roop, S., Roco, C., Olson, L., & Zimmer, R. (2005 March). *An analysis of low-cost active warning devices for highway-rail grade crossings* (Report No. NAS 118 HR 3-76B).

[4] Roop, S. (2007). *An analysis of low-cost active warning devices for highway-rail grade crossings.* Presented at the 2007 National Highway-Rail Grade Crossing Safety Training Conference

[5] URS Corporation and TranSmart Technologies, Inc. (2005 Dec.). *Low-cost highway-rail intersection active warning system field operational test.*

[6] Jennings, L. (28 April 2005). *EVA signal system report.* Prepared for North Carolina Department of Transportation.

[7] Hildebrand, E., Roberts, C., & Robichaud, K. (2007 May). *A low-cost rail warning system for private and farm road crossings* (Report No. TP 14735E).

[8] Jordan, P. (2006 Feb.). *A trial of a low-cost level crossing warning device.* The Institution of Railway Signal Engineers, Australasian Section.

ACKNOWLEDGMENTS

Special thanks to Daniel Lafontaine, Chief Engineering, Grade Crossing and Access Control Programs, Transport Canada, for providing invaluable technical information.

AUTHORS

Adrian Hellman
Marco daSilva
John A. Volpe National Transportation Systems Center
Systems Engineering and Safety Division
55 Broadway
Cambridge, MA 02142
Tel: (617) 494-2171
Adrian.Hellman@dot.gov

CONTACT

Leonard W. Allen III
Federal Railroad Administration
Office of Railroad Policy and Development
1200 New Jersey Avenue, SE – Mail Stop 20
Washington, DC 20590
Tel: (202) 493-6329
Leonard.Allen@dot.gov

KEYWORDS

Low-cost warning devices, passive grade crossing, solar powered, advance warning sign