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FIELD TESTING OF FOUR ALTERNATIVE TRAIN-PRESENCE DETECTION SYSTEMS

by Richard P. Reiff and Scott Gage

Summary

Field tests conducted by the Transportation Technology Center, Inc. on four alternatives to conventional track circuits for control of the island at grade crossings indicate these technologies can, when functioning properly, accurately determine train presence and departure. The four systems evaluated eliminated or were not susceptible to loss of shunt, which can interfere with proper operation of conventional island circuits.

However, these systems experienced equipment reliability and/or calibration problems during the field-test phase. Accordingly, the Train Presence Detection Task Force recommended no further field testing of these systems. Additional efforts by the manufactures are suggested to increase equipment reliability and improve field calibration techniques to ensure consistent operation.

The primary objective of this test was to evaluate alternative technologies in the field for detecting the presence of a train within the island limits of a grade crossing. The goal was to determine if any technology could accurately and reliably verify train presence within a typical 120-foot island. These field tests followed a series of screening tests conducted at the Federal Railroad Administration's Transportation Technology Center, where a number of technologies were evaluated to determine basic operating characteristics. These tests measured the consistency with which the systems could activate and release the island control relay under a variety of train speeds, configurations, and operating modes. Based on results of these screening tests, which were conducted under joint funding by the FRA and the Association of American Railroads, the Task Force selected the four systems for subsequent long-term field testing.

Vendors who participated by supplying prototype equipment for the TTC and field tests, along with engineering support to install, monitor, and evaluate the systems during this field test were Honeywell Microswitch, Harmon Industries, GEC Alsthom Signarail and Tiefenbach GMBH

Suggested Distribution:
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INTRODUCTION AND CONCLUSIONS

Warning systems for most common North American grade crossings utilize conventional track circuits. Typically the warning system is deactivated immediately after the end of train has passed the crossing limits in order to avoid unnecessary delay to highway traffic. Deactivation is controlled by a special circuit, with a minimum length of 120 feet, commonly referred to as the "island." The island circuit is an integral part of most state-of-the-art crossing warning systems.

The detection of a train within the island relies on the wheel and axle assemblies of passing trains to electrically shunt the two rails. Previous testing under this program has shown that under certain conditions the reliability of shunting can be reduced by the presence of contaminants on the rail and/or wheels. Such occurrences are termed "loss of shunt" (LOS). Severe LOS conditions can lead to sporadic operation of the warning system, even when the train is physically occupying the island. Other instances where LOS is a concern include short length circuits within turnout limits, interlockings, and other areas where detection of train occupancy in a limited length of track is needed.

Prior to the field test, a number of alternative technologies were evaluated at the Federal Railroad Administration's (FRA) Transportation Technology Center (TTC) for basic performance (FRA report "Interim Report: Screening Tests of Alternative Grade Crossing Detection Technologies," May 1998 - no report number) . Four systems were selected for extended field tests with the primary objective to evaluate the performance of these technologies in accurately and reliably verifying train presence within the typical 120-foot island. These field tests measured the consistency with which the systems activated train presence and released the island control relay when trains entered and departed the island limits, regardless rail-surface contamination or train type, speed, or direction.

Each of the alternative technologies evaluated during field testing properly interpreted train arrival and departure when the system was operating; however, all systems experienced various forms of failure that impacted reliability. Since long-term operating reliability was not satisfactory in all cases, and funding to continue long-term field testing was not available, the task force directing the technical aspects of this project elected to cease field testing. It is recommended that manufacturers take steps to enhance the operating ruggedness and/or in-field calibration process required by each system. The test program was jointly funded by FRA and the Association of American Railroads (AAR).

SELECTION PROCEDURE

To select technologies for this test, the Train Presence Detection Task Force C with members from AAR member railroads, the AAR, the FRA, and the Federal Highway Administration (FHWA) C was formed. Through a Request for Technical Information (RFTI), alternative detection systems were selected from a wide range of potential suppliers. Twelve responses to the RFTI were received. Each response was scrutinized by the task force for responsiveness to the RFTI, and in some cases additional information was required.

The task force selected eight systems for screening tests at TTC. Four of these systems successfully interpreted train presence under a wide range of train operations conducted to simulate typical field scenarios. For details of this process, refer to the FRA interim report "Alternative Track Circuits for Grade Crossings," May 1998.

The TTC screening tests evaluated a number of technologies including:

- Count-in/count-out wheel sensors
- Buried magnetic sensors
- Radar sensor
- Overlay circuits

A prototype for each system was installed at TTC. Test trains with a variety of configurations and cars (loaded, empty, long, and short), work equipment, locomotive types, and train lengths were operated over the crossing. Included was a range of typical operating modes, speeds, switching, and backup moves to determine if the alternative detection technologies could properly determine train presence and departure.

Of the systems tested, three performed with sufficient accuracy to be selected by the committee for additional field testing. A fourth was later selected after improvements were incorporated, and it was re-tested (at vendor's expense) to the same screening test procedure. The systems not selected by the Task Force were eliminated due to their performance or susceptibility to outside influences observed during these screening tests.

For field testing, technologies were selected that consisted of:

- Two "count-in/count-out" using magnetic or inductive proximity wheel sensors (referred to as systems 1 and 4)

- Two overlay circuits (referred to as systems 2 and 3)

The count-in/count-out technologies utilized wheel sensors mounted to the rail at the island limits. These wheel sensors were connected by wire to a centrally located computer system which determined island occupancy by passing wheel count and direction data, and then interpreting through proprietary software. The overlay circuits apply an additional signal or modify the existing signal on the rail (through various proprietary means) during the passage of the train. The overlay voltage, which was only in effect during train passage, is able to perforate any film on the rail or wheel that might cause LOS.

FIELD TEST PROCEDURE

Three sites were selected for field testing to include a broad range of rail traffic, including bulk commodity, unit, and intermodal trains, as well as switching moves. Site support was provided by member railroad representatives. Sites included:

- BNSF at Sterling, NE — a location where LOS has been documented in the past. This location is subjected to loaded and empty unit trains and mixed freight.
- UPRR at Columbus, NE — a location featuring frequent switching moves along with a very high volume of freight traffic of all types.
- ICRR at Effingham, IL — a location subjected to mixed freight, Amtrak, and some switching moves.

Initially systems 1-3 were installed at all three sites. After passing screening tests at TTC, system 4 was installed at a later date. The test systems were installed parallel to the conventional island control circuit which acted as a baseline. Test systems did not operate any warning devices; the data-collection system monitored the existing island circuit operation, along with the island-relay drive condition for each of the test systems.

All systems (including the baseline) were monitored remotely for six types of failure:

- Premature release of the island relay.
- False release and rearming of the relay during island occupancy (LOS).
- Multiple releases during occupancy (multiple LOS).
- Delayed release or failure to release.
- Late detection of train entering the island limit.
- Failure to detect a train.

The data collected consisted of island-relay voltage vs. time for each of the test systems and the conventional base system. Comparison of total time the island relay was activated provided the primary performance measure. The time differences between the base and test systems were calculated, and in cases of a system "hang-up – failure to release," recorded for a maximum of 10 minutes after train departure This data is summarized in Exhibit 1 for groupings of times differing from the baseline as follows:

- 0 and up to +/- 2 seconds difference
- -2.1 to –10 seconds shorter than baseline
- > -10.1 seconds than baseline
- 2.1 to 10 seconds longer than baseline
- 10.1 seconds or longer than baseline

The time period of monitoring at each site was from Dec. 1, 1997, to March 27, 1998. However, unscheduled rail replacement programs required removal of some test systems during some of that time. Exhibit 1 also shows the number of trains monitored by the baseline system at each site, along with the total for each of the test systems. At times, when two or more systems were not operating, data collection ceased until field representatives could be sent to correct the problem. For this reason the number of trains seen by the baseline system will not always match those of the test systems. Also, since systems 2 and 3 are both overlay circuits there was a concern that they might interfere with each other. For this reason they were normally not operated together, but alternated every other week during the monitoring period.

FIELD TEST RESULTS

`System 1:` At the Sterling and Effingham sites system 1 performed with virtually no excessive time differences. The occurrences of differences at these sites correspond to times when one of the wheel sensors was found to be out of physical alignment specifications and/or loose from its rail mounting. The Columbus site contained a manually controlled turnout very near the island limit and physical placement of the sensor at this end resulted in an occasional higher-than-baseline warning time when very slow switching moves were conducted.

Columbus, Nebraska — Union Pacific Railroad 2,508 Total Trains				
¸Seconds	**Syst. 1**	**Syst. 2**	**Syst. 3**	**Syst. 4**
<-10.1	5	0	0	1
-10 to -2.1	39	0	0	2
-2 to 2	836	538	780	30
2.1 to 10	6	156	202	0
>10	298	605	328	0
Total	**1,184**	**1,299**	**1,310**	**33**

Effingham, Illinois — Illinois Central Railroad 2,017 Total Trains				
¸Seconds	**Syst. 1**	**Syst. 2**	**Syst. 3**	**Syst. 4**
<-10.1	13	1	0	0
-10 to -2.1	4	0	0	0
-2 to 2	1,984	966	603	21
2.1 to 10	1	167	403	0
>10	8	22	234	0
Total	**2,010**	**1,156**	**1,240**	**21**

Sterling, Nebraska — Burlington Northern Santa Fe 3,232 total Trains				
¸Seconds	**Syst. 1**	**Syst. 2**	**Syst. 3**	**Syst. 4**
<-10.1	6	0	0	0
-10 to -2.1	0	0	0	3
-2 to 2	3,111	1,749	1,627	784
2.1 to 10	83	35	360	25
>10	32	17	20	8
Total	**3,232**	**1,801**	**2,007**	**821**

Exhibit 1. Groupings of Times Differing (¸Seconds) from Baseline

Systems 2 and 3: Performance trends of both overlay systems was similar at all sites. System 2 suffered from several power-supply failures. The power supplies were from a third party and were not integral to the system. A production unit would use existing wayside power. System 3 was initially installed per manufacturer specifications that indicated no calibration was needed. After early results indicated significant extended (hang-up) times, vendor representatives field-calibrated voltages to each site, after which performance was acceptable. The vendor has since modified this system to address voltage/calibration issues.

System 4: With the exception of the Sterling site, system 4 was installed too late at the other sites to obtain significant data. At the Sterling site the few long differences in time were attributed to sensors that came off the rail and were not always accurately counting passing wheels.

Upon completion of the official data-collection period, the test equipment at all sites was left in place for up to five months before removal. During the site visits to remove and return equipment, it was noted that at several locations the wheel counters of both systems 1 and 4 had become detached from the rail and were found in the ballast or exhibited damage from dragging equipment.

SUMMARY

When operating, the four detection systems interpreted train presence (arrival and departure) within the 120-foot island limits within 2 seconds of that measured by the baseline system. Failures of test-system components occurred at times, resulting in missed trains, inaccurately detected arrival/departure, or inoperative (turned off) systems. Track-circuit overlay systems must be compatible with all potential existing frequencies and may require initial and subsequent calibration to ensure proper operation. It is suggested that reliability of components be investigated by venders with special attention to typical North American operating environments and inspection policies. Damage to wheel counters and vibration from passing trains resulted in most of the failures observed for the count-in/count-out technologies. Inspection protocol may require changes for sites where such equipment is to be installed.

Note: Contact Richard Reiff at (719) 584-0581 with questions or comments about this document.

E-mail: richard_reiff@ttci.aar.com

Web site: www.ttci.aar.com

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780.