U.S. Department of Transportation
Federal Railroad Administration

RESEARCH RESULTS
FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

RR 19-12 | **April** 2019

FIBER-OPTIC TRAIN TRACKING – PHASE 1

SUMMARY

The Federal Railroad Administration (FRA) sponsored a test conducted by Transportation Technology Center, Inc. (TTCI), in September 2017, to evaluate the capability of Fiber-Optic Acoustic Detection (FOAD) to track trains and identify track occupied in multiple track territories. Testing results showed that FOAD is capable of tracking a train, but spatial resolution can be largely influenced by speed and weight of the train. The ability of FOAD to identify the occupied track by the train is currently not possible without a secondary data input such as wheel sensors.

Due to the known limitation of FOAD to be used for track identification, the participating FOAD vendor installed wheel sensors at the crossover points between the Railroad Test Track (RTT) and the Transit Test Track (TTT) to provide supplemental data set to the FOAD. The intention of the wheel sensor data is to provide the FOAD system with definitive data about the track being occupied by the train. Once the occupied track was determined, the FOAD system could then track movement of the train. At the time of testing, the two systems were not yet integrated, so only standalone FOAD data was provided to TTCI by the participating vendor.

TTCI worked with FOAD vendor engineers to analyze and verify data results from testing. All data was collected by the FOAD vendor and then shared with TTCI. Part of this project included the vendor working to improve upon current train tracking algorithms. Once the vendor made improvements to the tracking algorithm the data was reprocessed with the “optimized” algorithm and reported.

BACKGROUND

The North American railroad industry has expressed an interest in determining the reliability of FOAD systems to perform train tracking and identify track occupancy of the train. TTCI, under contract to FRA, conducted a series of tests to determine baseline capabilities of FOAD to perform these functions.

OBJECTIVES

The objective of the project was to evaluate the ability of FOAD to determine train position, speed and direction of travel on single and multiple track environments, including identification of track occupancy in multiple track territory.

METHODS

TTCI solicited participation from FOAD vendors to test FOAD integrator capabilities at the Transportation Technology Center. TTCI developed a test implementation plan (TIP) detailing the type and number of test runs to be performed for each of the test scenarios. The TIP was then reviewed by an advisory group (AG) consisting of members of the railroad community and the on-site FRA Contracting Officer Technical Representative.

Based on the test scenarios identified in the TIP, the RTT FOAD test bed was selected to be used for this testing. Once the test bed was configured and verified, the participating FOAD vendor interrogator systems were installed along the RTT fiber-optic test bed, as shown in Figure 1.

Figure 1: RTT Fiber Optic Test Bed

Testing consisted of two main tests: train tracking and track identification. After testing was completed, the test results were analyzed by the FOAD vendor to determine the system capabilities at the time of the test. The FOAD vendor was then tasked with using the test data to improve on system detection algorithms and reprocess the data with the improved algorithms and report enhancements.

The data provided by the FOAD vender was then analyzed and verified by TTCI engineers prior to reporting the results.

TRAIN TRACKING TEST

Train tracking testing included train passes, with a 10–11 car consist, at speeds ranging between 0 and 40 mph. Testing included evaluating the systems' capability to track the end of train (EOT) and head of train (HOT) when the train comes to a full stop. Train position data was collected by the FOAD vendor and compared against Real-time kinematic (RTK) Global Positioning Software data to determine accuracy in the following:

- Train location
- Train speed
- Head of train location
- End of train location
- Direction of travel

TRACK IDENTIFICATION TEST

The objective of this test was to evaluate the ability of a FOAD system to identify the track being occupied by a train in multiple track territories. The series of tests also included testing to determine the potential capability of a FOAD system to track a train from one track to another and identify which track is being occupied by the train throughout this transition.

This testing was performed using the RTT and TTT at the Post 85 crossover. TTCI used the data collected during the track identification testing to determine the ability of FOAD technology to perform occupied track identification.

RESULTS

Loaded trains traveling >20 mph were able to be tracked by the FOAD system consistently. However, unloaded (empty) and slow-speed trains revealed problems with the FOAD tracking algorithm. In these conditions, the FOAD system was not able to consistently track the train through the entire test zone.

While tracking in these conditions, the FOAD system periodically dropped the train tracking ID and then resumed tracking with a new ID later in the test zone. To address this issue, the FOAD vendor reprocessed data sets with an algorithm they optimized for train tracking. The optimized train tracking algorithm was able to correct the problem of the train tracking stopping and starting throughout the test zone, but not without a loss of some spatial and speed accuracy.

Track identification testing was performed to determine the capability of the FOAD system to identify which track the train is occupying in multiple track territories. All testing in this section was performed on parallel adjacent tracks on the RTT and TTT. FOAD data supplied to TTCI from the FOAD vendor for analysis and verification does show track occupancy; however, it does not include any information about the track being occupied.

The participating FOAD vendor acknowledged the limitations of FOAD to be able to determine track occupancy as a standalone system. For this reason, the vendor was working to develop a hybrid FOAD and wheel sensor system capable of determining occupied track identification at the time of this test. The wheel sensors were installed at the crossover point between the RTT and TTT as a means of supplemental data input to the FOAD data. As this system was not fully integrated at the time of testing, the vendor was only able to provide data from the FOAD and the wheel sensors separately. Only the FOAD data was able to be verified by TTCI engineers.

FUTURE ACTION

Future work may include additional testing to verify improvements made to system algorithms or evaluation of a fully integrated FOAD/wheel sensor system. Continued work will be required with the FOAD vendors to communicate the needs and requirements of the railroads for train tracking and track occupancy identification.

CONCLUSION

The results from this project demonstrated that the FOAD system is able to track train movements under a variety of operational scenarios. However, the level of accuracy in some conditions still require improvement to satisfy the practical needs for railroad applications. The FOAD system tracks trains best at sustained speeds greater than 20 mph. Slower speeds and variable speeds both have negative effects on the ability of the FOAD system to track train movement.

Future work may include additional track testing to verify improvements made to system algorithms or evaluation of a fully integrated FOAD/wheel sensor system. Continued work will be required with the FOAD vendors to communicate the needs and requirements of the railroads for train tracking and track identification.

CONTACT

Richard Orcutt
General Engineer – Signal, Train Control and Communications
Federal Railroad Administration
Office of Research, Development and Technology
1200 New Jersey Avenue, SE
Washington, DC 20590
(719) 584-0507
richard.orcutt@dot.gov

Sam Alibrahim
Chief – Signal, Train Control & Communications
Federal Railroad Administration
Office of Research, Development and Technology
1200 New Jersey Avenue, SE
Washington, DC 20590
(202) 493-6362
SamAlibrahim@dot.gov

KEYWORDS

North American railroads, Fiber Optic Acoustic Detection, FOAD, fiber optic, wayside detection, safety