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Evaluation of an Automated Turnout Inspection System

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Summary

Transportation Technology Center, Inc. is assisting in the development, evaluation, and implementation of automated turnout inspection systems for the benefit of the members of the Association of American Railroads.

This effort has included establishing a test facility at the Transportation Technology Center, Pueblo, Colorado, gathering an inventory of components with controlled defects to introduce into the turnouts during test mode, and testing and evaluating the performance of an automated inspection system and comparing it to the manual (visual) method of inspection.

The first test was conducted March 17 and 18, 2011, on the Zeta-Tech Automated Switch Inspection Vehicle (ASIV). The results show that the ASIV system, which uses running surface profile measurements, reported gage related defects and numerous (not all) running surface conditions present. The system is not designed to perform all inspections done by a human inspector at this time. However, turnout inspection programs with automated systems will likely experience improvements that will increase inspection reliability and/or allow reduction in the need for manual inspector input.

Anticipated benefits of using an automated system include:

- A reduction in the time required to conduct the inspection.
- Consistency, where each turnout is inspected in the same way.
- Better accuracy since the automated systems will use objective measures of evaluation.
- Ability to develop a historical record of inspections for use in predicting maintenance cycles and component life.
- Potential reduction in injuries with the reduced time inspectors spend on track.

Benefits of having an industry sponsored test facility include:

- Having a test facility with documented defects.
- Ability to operate inspection systems over defects without risk to railway operations.
- Ability to compare inspection systems on the same turnouts.
- Ability to develop improved systems and measure improvement.

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INTRODUCTION

The ASIV was evaluated in a blind test on March 17 and 18, 2011, over turnouts located at the Transportation Technology Center (TTC) and the Pueblo Chemical Depot (PCD) with the objective of evaluating its performance relative to its ability to identify and report the condition of the turnouts.

The ASIV is a laser and camera system designed to inspect the rail portions of turnouts. It is designed to provide full rail cross-section profiles, with the exception of the underside of the railhead, at 1-inch intervals at 8 mph. Profiles are generated on switch points, frog, stock rails, and closure rails. The profiles are used to develop 3-dimensional composite images of the turnout, which are then analyzed. The industrial grade, onboard Global Positioning System (GPS) is designed to provide precise (6 to 8 inch on a pass-to-pass basis) location and is saved for every rail profile.[1] The ASIV tested was mounted on a hi-rail pickup truck, as Figure 1 shows.

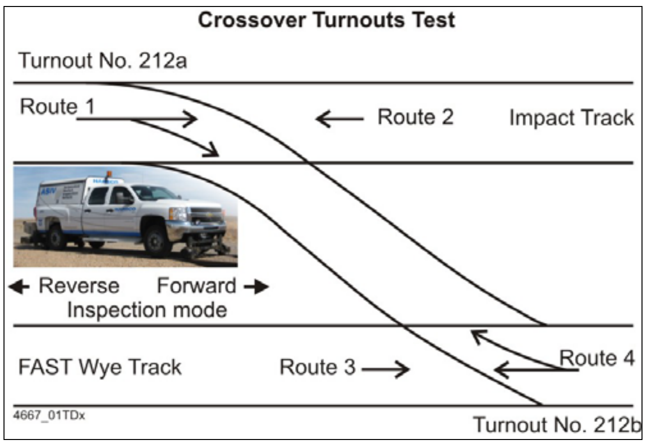

Figure 1. ASIV and Sketch of the Test Routes at the TTC Automated Turnout Inspection Test Facility

TURNOUT INSPECTION ESSENTIALS

A complete inspection process must include three fundamental functions: (1) Detection, (2) Evaluation, and (3) Reporting. The inspection method/technology (or combination thereof) used must have the capability of determining if the turnout is out of specification and detecting components that have conditions that adversely affect safety. The inspection result must evaluate and determine if the turnout is fit for service and whether it will remain fit for service until the next inspection. All anomalies, beyond specified limits, identified during an inspection must be documented and reported with a level of priority determined so that maintenance can be performed or scheduled.

An additional feature of automated inspection is expected to be the ability to predict maintenance needs and extend service life based on monitored conditions. For example, a switch point and stock rail pair with high wear rates well behind the point of switch may require a switch throw adjustment.

TEST PLAN FOR AUTOMATED TURNOUT INSPECTION SYSTEMS

TTCI's conceptual plan for evaluating automated turnout inspection systems is to (1) manually inspect each turnout (control), (2) make repetitive passes over the same turnouts on the main line and through diverging routes at defined test speeds and directions, and (3) generate inspection reports.

The methodology for testing the automated turnout inspection systems will be completed in three parts: Part 1: turnout in as-found condition (PCD and TTC turnouts); Part 2: turnout with anomalies introduced (TTC turnout only); and Part 3: turnout returned to its original condition (TTC turnout—same as Part 2).

The automated system will make three passes over the main line and three passes over the diverging routes in both facing point and trailing point moves.

For all three test parts, the track inspector will conduct manual inspection over the main line and the diverging routes using a standard inspection guideline form.

AUTOMATED SWITCH INSPECTION VEHICLE TEST RESULTS

The ASIV was faced in the direction shown in Figure 1 during all the test runs. In that configuration, the vehicle moved forward over turnout No. 212a in facing point mode when it passed from route 1 to route 2 (straight). When the vehicle tested the diverging side of the same turnout, from route 4 to route 1, it traveled in reverse in trailing point mode. All routes shown in Figures 1 were ultimately tested at speeds of 5, 8, and 10 mph.

Part 1 testing was conducted on March 17, 2011. The real-time feedback after several runs at 10 mph, three runs at 15 mph, and three runs at 20 mph, verified that the ASIV performs more reliably in test mode when it is operated below 10 mph. As a result, the remaining runs of Part 1 were conducted at 5 and 10 mph. All of the runs for Parts 2 and 3 were made at 5, 8, and 10 mph; 8 mph was added because it is the published optimum performance speed, and the 10 mph runs were kept in the matrix as the absolute upper limit.

During Part 1 testing, 36 runs (three runs for each of 12 direction/speed combinations) were made over the TTC crossover turnouts No. 212a and 212b, and 72 runs (three runs for each of 24 direction/speed combinations) were made over the four turnouts at PCD facility. A run is defined as a single pass over a turnout in either straight or diverging mode, forward or reverse direction of travel, at one of the given speeds; in other words, a single opportunity to inspect the turnout under the given conditions.

Following the same convention, 18 runs (three runs for each of six direction/speed combinations) were made over the TTC crossover turnouts during Part 2 testing and again during Part 3 testing.

Graphics and Results Format

The Zeta-Tech report includes examples of the images used by the analysis software to evaluate the condition of the turnout rails.[1] The primary image is an actual rail profile taken by ASIV (shown in yellow), overlaid on a reference (new rail) profile (shown in red); Figure 2, a and b, shows two high-density, three dimensional composite images, where 2a is the frog at TTC turnout 212a (file No. 929, straight side, facing point, 5 mph) and 2b is the switch and stock rails of TTC turnout 212a (file No. 653, straight side, facing point, 5 mph). Individual profiles of maintenance and exception locations are also included for verification in the ASIV report.

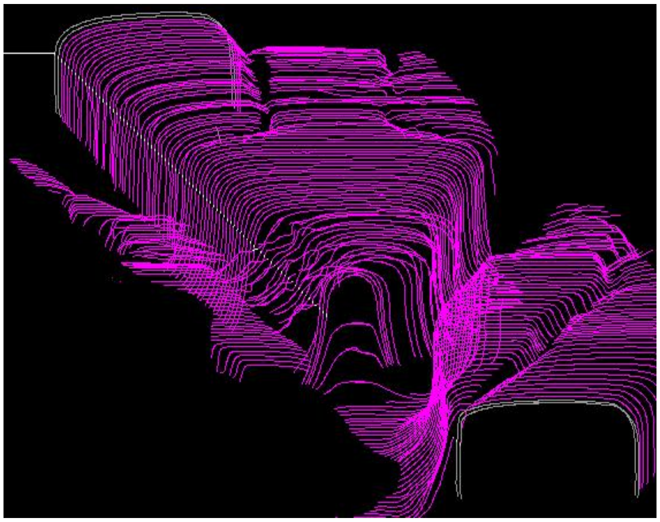

Figure 2a. Frog at TTC Turnout 212a showing Flangeway Obstruction

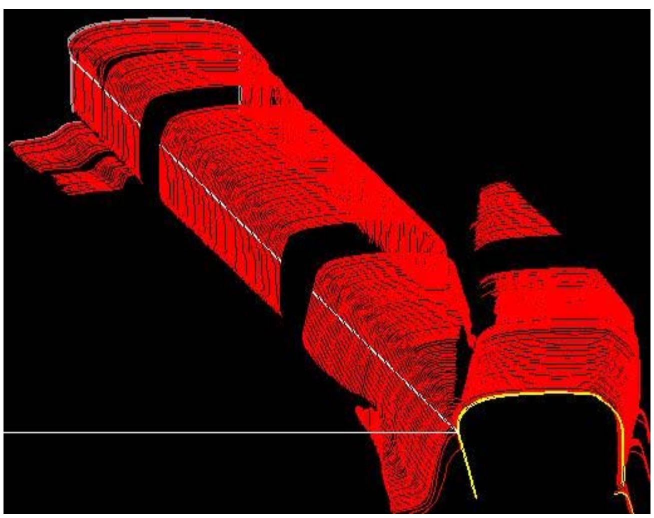

Figure 2b. Switch and Stock Rails at TTC Turnout 212a

A number of graphs, like the one in Figure 3, were included in the report showing the results of continuous-type measurements as a function of distance along the track.

Figure 3 shows track gage, where the switch rail is between the 0- (point of switch, POS) and 223-inch locations. The frog area is between 926 inch and 1036 inch, and the frog point is at 963 inch.

In addition to the graphic views, each turnout report consists of three color-coded parts: Part 1, a turnout identification section; Part 2, an inspection report (table) containing both quantitative and qualitative information; and Part 3, a maintenance limits and exceptions report (table).

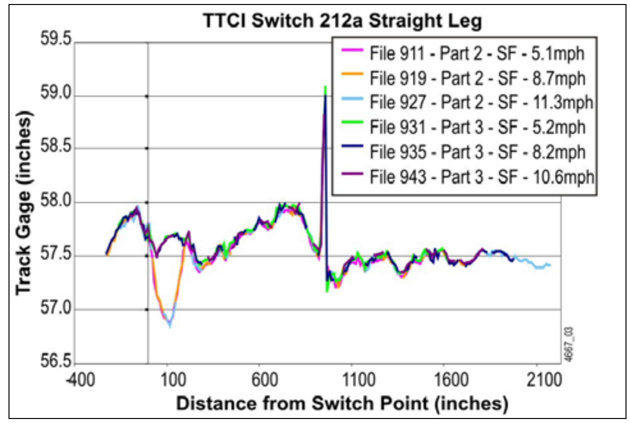

Figure 3. Track Gage along TTC Turnout 212a. Switch Rail 0-223 inch; Frog area 926-1036 inch; Frog Point 963 inch

FINDINGS

Data post-processing is required with the current ASIV. The ASIV successfully reported numerous maintenance considerations and FRA-exception conditions as a result of its inspection, including "Point Below Stock." This point had a 4-inch chip broken off, as Figure 4 shows. Interestingly, this condition was reported quantitatively but not in the qualitative section of the report where "Point Condition and Point Fit" were both described as "Good."

Figure 4. Four-inch Chip Broken off a Switch Point

Other conditions reported by ASIV include "Switch Rail above Stock," where the switch rail did not rise properly above the stock, as well as railhead metal flow (lip), vertical rail wear, and "Relative Height of Frog Nose/Wing Rail."

Wide track gage was incorrectly reported as FRA-exceptions for the four turnouts at the PCD. For the TTC turnouts, track gage values were not shown in the ASIV report form (Part 2 tables). The graph in Figure 3, however, was presented in the Zeta-Tech report[1] (graph has been enhanced by TTCI) and contains gage data for six runs over turnout 212a. Based on Figure 3, it's clear that the ASIV has the capability to measure track gage, given the correct relative difference shown at about 100 inches past the switch points. This is the location where an alteration was done to tighten the gage. The absolute gage measurements, however, are incorrect.

In addition to the tight gage indication shown in Figure 3, where the gage was adjusted to 55 7/8 inches, another critical condition correctly detected and reported by ASIV was the obstruction in the flangeway gap of the frog at turnout 212a.

The speed at which the ASIV traversed the turnouts affected the performance of the system. The system appears to capture more rail profiles at slower speeds, where 8 mph is recommended by the manufacturer to achieve one rail profile per track-inch. The number of turnouts per data file also affected the performance. On several occasions, attempts to save four successive turnouts on a single file at the PCD yard caused the system to shut down. Creating one file per turnout appears to have worked well.

The graphs (like the one shown in Figure 3) of selected runs presented in the Zeta-Tech report indicate good repeatability for data acquired in straight/diverging, facing/trailing, and forward/reverse modes.[1]

Because the ASIV is not designed to detect nonrail related anomalies, it was not expected that the system would detect the numerous anomalies of that type that were recorded by the track inspector during the manual inspection. Those anomalies include: transit clips in contact with tie plates; loose, missing, and broken bolts in the frog, heel block, and joints; loose chair brace wedges; cracked joint bars; missing tie plates; and bent rod. Photographs of all the conditions listed above are on file. In addition, a qualitative condition reported by the track inspector was difficulty in lining one of the switches.

There were a number of rail related conditions that were not reported by the ASIV. The most critical include two switch points with a 1/8-inch gap (Figure 5 shows one of the points), a crushed wing rail and heel rail (Figures 6 and 7), chair brace (No. 1 at POS) missing (Figure 8), a weld repaired frog point in very poor condition, cracked joint bars, and missing joint bar bolts.

Table 1 is a comparison of conditions reported by the ASIV tested and those reported by the manual method of inspection.

Figure 5. Switch Point with a 1/8-inch Gap

Figure 6. Crushed Wing Rail

Figure 7. Crushed Heel Rail

Figure 8. Chair Brace Missing (No. 1 at POS)

Table 1. ASIV vs. Manual Inspection Capabilities

Condition	Reported by ASIV	Reported by Track Inspector
GPS coordinates	✓	
Switch point height vs. stock rail (relative measurement)	✓	
Rail wear; rail gage face angle; rail metal flow (measurement)	✓	
Switch point gap (measurement), fit, condition	✓	✓
Switch open flangeway width at POS, No. 1 and No. 2 rods (measurement)		✓
Frog point and wing condition	✓	✓
Frog/wing relative height (measurement)	✓	
Frog flangeway width and depth (measurement)	✓	✓
Frog guard face and check gage (measurement)		✓
Guardrail gap and condition (measurement)		✓
Track alignment, surface		✓
Rail braces, transit clips, and bolts/cotter pins		✓
Track gage (measurement)	✓	✓
Maintenance and FRA exceptions	✓	✓

To determine the most effective way to use the ASIV, TTCI wants to know the operating modes (speed, vehicle direction of travel, facing/diverging point) that provide the best "view" of the turnouts. Zeta-Tech has provided TTCI with a complete-profile count for all the runs over all the turnouts, and an analysis will be performed.

CONCLUSION

ASIV is the first automated system evaluated at TTC's facility. The results show that this system, which uses rail profile measurements, reported gage related defects and some, but not all, of the running surface conditions present.

Additional testing will be conducted as automated systems evolve in their capabilities and efficiencies.

REFERENCE

1. Zeta-Tech, a Harsco Rail Business Unit. June 2011. "Measurement and Evaluation of Turnouts using the Automated Switch Inspection Vehicle (ASIV) at Transportation Technology Center, Inc. (TTCI)."