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Evaluation of Automated Turnout Inspection Systems

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Summary

Transportation Technology Center, Inc. (TTCI) is working with members of the Association of American Railroads and potential inspection service providers in the development, evaluation, and implementation of automated turnout inspection systems for North American freight railroads and joint-use passenger and freight railroad track.

TTCI has developed a three-part conceptual plan for evaluating automated turnout inspection systems. The evaluation process involves a comparison of performance and results between the manual/visual method and automated systems.

Some of the anticipated benefits of using automated systems include:

- **Efficiency.** Reduction in time (especially track time) required to inspect turnouts.
- **Consistency.** The automated system will inspect each turnout in the same way.
- **Accuracy.** The automated system will use objective measures for evaluation.
- **Data Storage.** The automated system can record inspection results and recall them for future inspections. This capability will ultimately allow better maintenance planning and design improvement.
- **Safety.** An automated system that replaces all manual inspection functions should improve safety by detecting a higher percentage of any defects in turnouts.

Automated systems, however, have limitations. Automated systems for inspecting turnouts do not have the capability to perform some of the mechanical and qualitative checks that are commonly done with the manual/visual method of inspection.

The general methodology currently used for conducting a manual/visual inspection (walking inspection) of turnouts focuses on the condition of the primary components as well as the movable parts, the fastening system, and the track geometry. Any automated part of such an inspection system, regardless of the method and technology used, must at a minimum be able to detect deviations in the parameters that it is designed to detect, and record them in such a way that the information is made available.



INTRODUCTION

Turnouts are perhaps the most complex track work commonly in use on the railway today. Turnouts allow trains to move from one track to another by use of a pair of movable rails. Figure 1 shows a mainline turnout, which consists of a switch, a frog, and connecting rails. The switch portion allows selection of the route for the train. The frog allows wheel flanges to cross rails of other tracks. Due to the moveable parts and special supporting components, turnouts require considerable track time and expertise to inspect and adjust properly.

In recent years, the leading causes of turnout related accidents have involved the operation of the switch (human factors) and switch point condition issues.¹ An automated switch inspection system must be able to inspect critical conditions effectively.



Figure 1. Typical Mainline Turnout

Turnouts are essential to the safety, efficiency, and capacity of the railway network. Because they are the control points for the system, they must operate reliably. Improvements in turnout inspection (and maintenance) can significantly affect the operating results of the railway.

Railroads are considering developing or adopting automated inspection technology for special trackwork, such as turnouts and crossing diamonds. Automated inspection for open track is well established, with systems such as track geometry cars. More recently implemented systems include rail profile and track gage strength measurement systems. Special trackwork inspection is more difficult to automate due to the relative complexity of the track, the wide variety of turnout designs, and the numerous components.

This study is being done to assist in the development, evaluation, and implementation of automated track inspection systems that will benefit AAR member railroads. This *Technology Digest* documents the current manual/visual turnout inspection methods and outlines a conceptual evaluation plan for automated systems. This information will be used to establish a capability baseline to be used in the comparison of automated inspection systems.

BENEFITS AND LIMITATIONS OF AUTOMATED INSPECTION

The goal of automation is process improvement. Automated processes, however, have limitations. The ultimate goal is to develop an automated process, in this case for inspecting turnouts, with benefits that outweigh its limitations. Once the benefits and the limitations are identified, the strategy should be to integrate the use of automated and manual/visual processes in a way that enhances the quality of the inspection.

An example of how a combination of processes may improve inspection quality is to use automated methods to perform more frequent, automated inspections and to continue to use manual/visual (or a combination of manual/visual and automated) methods at intervals where more detailed inspections are required.

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- **Safety.** An automated system that replaces all manual inspection functions should improve safety by detecting a higher percentage of any defects in turnouts.

A fundamental part of a manual/visual inspection requires that the inspector interact physically with some of the components of the turnout. An example is the common instruction found in turnout inspection guidelines to “throw the switch to check for proper fit and adjustment.” Another hands-on instruction is to “check that the stand is securely fastened.”² Automated systems lack the ability to interact with some of the components to determine their condition as it relates to qualitative feel.

Minor repairs and adjustments are typically performed during manual/visual inspection. Automated inspections will require track maintenance personnel to be dispatched to address any anomalies.

An automated system traveling on the main line will likely conduct a partial inspection of the turnouts, because it will not “see” all of the components on the diverging route.

These are some of the anticipated limitations of automated systems. The benefits, however, far outweigh the limitations. The use of automated turnout inspection systems will likely place a powerful tool at the disposal of the track engineer.

CURRENT INSPECTION PHILOSOPHY

Current inspection practices on North American freight railroads have been developed over many years to suit their designs, operations, and federal safety regulations. The high tonnage rates and dynamic loading experienced by North American turnouts suggest that rapid degradation can occur. Thus, effective risk management methods, including good designs and effective inspection are essential to safe operations.

CURRENT INSPECTION METHODS

The turnout inspection process currently used relies almost entirely on manual/visual methods. Policies vary by railroad, but typically require at least a weekly walking inspection of mainline turnouts. Manual/visual turnout inspections can be supplemented by automated track geometry and rail flaw inspections that are carried out on the railway. These measures, however, are supplementary; they may entirely skip key components such as frogs, or provide nonbeneficial information when used in turnout environments.

Many railroads conduct a thorough annual inspection of mainline turnouts. The inspection is conducted jointly by the track and signal engineers. The switch is thrown and adjusted, moving parts are lubricated, track components are inspected for the presence of damage or wear, fasteners are tightened, and any unusual wear or performance is noted. Any additional required maintenance is scheduled.

The less thorough weekly inspections are conducted by track inspectors. They verify that components are not missing and inspect for any damage or unusual wear, which may indicate a performance or reliability issue. Minor repairs and adjustments are performed during the inspection visit. Inspections are usually conducted using visual methods and simple hand tools, such as a tape measure.

The Federal Railroad Administration Track Safety Standards Part 213.235(a) requires that each switch, turnout, track crossing, and movable bridge lift rail assembly or other transition device be inspected on foot at least monthly.

The general methodology used for conducting a manual/visual inspection (a walking inspection) of a turnout focuses on the condition of the primary components as well as the movable parts, fastening systems, and track geometry. A basic set of instructions for inspecting a turnout is as follows:³

- Track gage within tolerance throughout the turnout including gage at the point of switch, heel of the switch, and in the frog area.
- Stock rails seated in the switch plates with all braces tight against the stock rail.
- All switch plates properly spiked and lubricated.
- Fit of the switch point against the stock rail and height above the stock rail within tolerances.
- Switch point throw within tolerances.
- Switch targets correctly oriented and clearly visible.

- Frog condition including wheel contact areas, guard check gage, guard face gage, flangeway depth and width, lateral movement, and flangeway obstructions.
- Guardrails properly positioned and fully fastened.
- Turnouts fully spiked and anchored; bolts tight and cotter keys in place.
- Line and surface within tolerances throughout the turnout.

Additional inspection details include wear or damage to the switch point or rail, heel blocks, switch rods, connecting rods, transit clips, switch stand, switch lock, switch ties, rail joints, and ballast.

Turnout Inspection Essentials

Any automated part of such an inspection system, regardless of the method and technology used, must at a minimum be able to detect deviations in the parameters that it is designed to detect, and to record them in such a way that the information is made available.

Regardless of the method and technology used, the inspection process must have the capability to detect turnouts with unfit conditions; e.g., out of specification (geometry, dimensional), loose, broken, cracked, bent, out of adjustment, contacting other components, worn, damaged, missing, lacking lubrication, mismatched, over tightened, and skewed. Table 1 and Figure 2 show an example of dimensional specification.

Table 1. Gage Limits of the Guard Check

Class of track	Guard check gage The distance between the gage line of a frog to the guard line ¹ of its guardrail or guarding face, measured across the track at right angles to the gage line, ² may not be less than—	Guard face gage The distance between guard lines ¹ , measured across the track at right angles to the gage line, ² may not be more than—
Class 1 track	4 ft 6 1/8 in.	4 ft 5 1/4 in.
Class 2 track	4 ft 6 1/4 in.	4 ft 5 1/8 in.
Class 3 and 4 track	4 ft 6 3/8 in.	4 ft 5 1/8 in.
Class 5 track	4 ft 6 1/2 in.	4 ft 5 in.

¹A line along that side of the flangeway which is nearer to the center of the track and at the same elevation as the gage line.

²A line 5/8 inch below the top of the center line of the head of the running rail, or corresponding

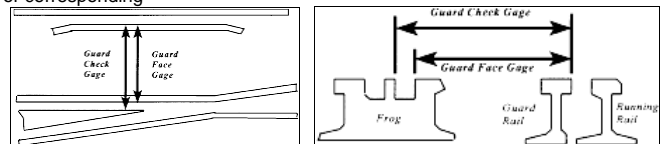


Figure 2. Guard Place between a Frog and its Guardrail

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 identified during an inspection must be documented and reported. A level of priority must be determined so that maintenance can be performed or scheduled accordingly.

CONCEPTUAL PLAN FOR THE EVALUATION OF AUTOMATED TURNOUT INSPECTION SYSTEMS

Evaluation of an automated turnout inspection system should include a field proof and calibration test. The test should include comparison with the currently used manual/visual method of inspection, and it should be conducted on a variety of turnout designs and crossing diamonds in different environmental conditions (e.g., weather conditions, temperature changes).

TTCI recommends the following three-part conceptual plan:

Part 1: Turnout As Found (control) – The inspection is carried out by the manual/visual inspector and the automated system with turnout conditions as found.

Part 2: Turnout with Defects – Specific defects are introduced into the turnout and the two inspections are repeated. The defects will be introduced by manipulating a number of random conditions and components listed in the Current Inspection Methods section.

Part 3: Adjusted Turnout – The two inspections are repeated after the defects have been corrected.

Recommendations for all three parts are:

- Manual/visual inspector — conducts a single, complete inspection over the main line and the diverging route using a standard inspection guideline form. The time it takes to complete the inspection and the report form is documented.
- Automated system — four major variables: (1) main line and diverging, (2) facing and trailing point, (3) number of passes, and (4) speeds. The automated system makes two passes over the main line and two passes over the diverging route at 5, 10, 20, 30, and 40 mph in both facing- and trailing-point moves. Up to sixty-four passes are made. Table 2 shows the test matrix.

Table 2. Test Matrix for the Evaluation of Automated Turnout Inspection Systems

Direction	Mainline		Diverging	
	Facing Point	Trailing Point	Facing Point	Trailing Point
No. Passes	2	2	2	2
Speed * (MPH)	5, 10, 20, 30, 40	5, 10, 20, 30, 40	5, 10, 20, 30, 40	5, 10, 20, 30, 40

*Subject to maximum allowable speed in the turnout.

Comparison of results between manual/visual and automated inspections:

- Total number of defects detected by each of the inspection methods.
- Percent of known defects detected by each method.
- Percent change in the number of defects detected by the automated system as a function of track (main line or diverging) direction (facing or trailing point), speed, and number of passes for repeatability.

Automated System Inspection Reports

The automated inspection systems should provide a report to include the following for each turnout, in addition to the basic turnout ID, date, time, track, direction of travel, and weather information:

- As found condition; i.e., critical dimensions and measurements.
- Safety standard and maintenance limit status.

Summary reports should provide statistical data with which to track critical component failure, degradation rates, and other information that can be used to predict maintenance cycles and component life.

CONCLUSION

Turnout inspection programs that integrate the manual/visual method with automated systems will likely experience improvements in efficiency, consistency, accuracy, and safety in the turnout inspection process.

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