IMPROVING INSPECTION OF TURNOUTS

Developing technologies aim to enhance the accuracy and effectiveness of turnout inspection.

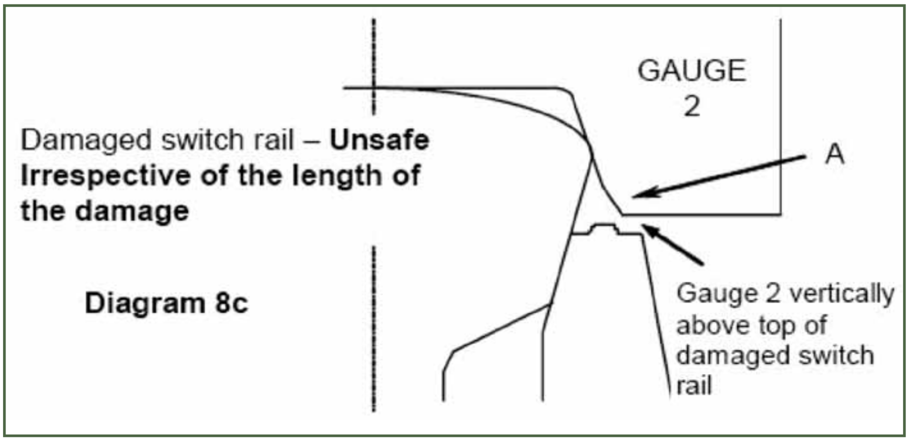

Figure 1a, top, shows an inspection of switch rail damage (U.K.). Figure 2b, shows gauge for inspection of switch rail damage (U.K.).

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Inspection of railway systems in general, and of track and key track components in particular, has been the subject of new and innovative technology designed to more accurately monitor the condition of the track structure and its key components and provide timely and accurate information to the responsible maintenance-of-way officers. These new technologies represent significant research and implementation activities by government agencies, suppliers and the railroads themselves.

However, one area that has been lagging in the implementation of new inspection technology has been the area of turnouts and the key turnout components such as switches, frogs and the switch mechanism. While other areas of the track structure use a combination of visual and automated inspection, as reflected by Federal Railroad Administration and railroad track standards, turnouts still rely very heavily on visual walking inspections. This likewise is reflected in the turnout standards, which include key provisions that are qualitative rather than quantitative, such as FRA 213.135 (h), which addresses chipped or worn switch points and states, "unusually chipped or worn switch points shall be repaired or replaced."[1]

Since turnouts are a design "discontinuity" in the railroad track structure, representing a change not only in track geometry, but also in the stiffness of the track structure, high levels of force are generated as a vehicle negotiates the turnout. These high force levels result in rapid degradation of the turnout and its key components and in the worst case, derailments. Derailments in turnouts are a major derailment category representing more than 20 percent of the track caused derailments. Analysis of derailment cause severity by the University of Illinois[2] ranked derailment causing turnout component defects as follows.

1. Switch point - worn or broken
2. Other frog, switch and track appliance defects
3. Turnout frog - worn or broken
4. Switch connecting or operating rod - broken or defective
5. Switch point - gap between switch point and stock rail

This is consistent with a separate Transit Cooperative Research Program (TCRP) study,[3, 4] which listed the following derailment causing turnout conditions.

- Wear/failure of stock rail
- Failure of the switch mechanism
- Improper adjustment of switch
- Wear/failure of frog, wear/failure of the switch point

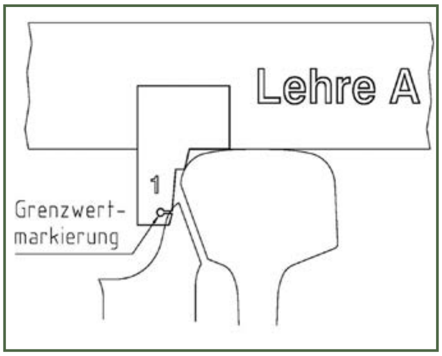


Figure 2, left, show an inspection of switch rail damage/wear (SBB). Table 1 is a summary of potential measurements in the switch area.

Rail Type	Measurement
Stock rail opposite a switch rail	Vertical wear
	Gauge side wear
	Gauge face angle
	Gauge corner radius
Switch rail	Gauge face angle
	Breaking or chipping
	Gauge corner radius
Stock + switch rails	Vertical height difference
	Lateral gap width
	Wheel contact point through switch point
Closure rails	Vertical wear
	Gage side wear
	Gage face angle
Guard rail	Guard flangeway gap width
	Relative height of guard rail
Frog nose and wing rail	Relative height of nose and wing rail
	Wear/Batter on Wing Rail
	Batter/damage to frog nose or wing rail
	Flangeway depth
	Flangeway width
	Surface damage: Batter, chipping
	Wheel contact through frog
	Wing rail profile (within field of view)

- Gap between switch point and stock rail

These component/defect areas represent potential opportunity areas for improved inspection techniques and technologies, as well as improved standards.

This opportunity area of improved inspection of turnouts is currently being addressed at several levels by different research programs and studies.

At a fundamental level designed to support and improve current turnout inspection practice, a National Academy of Sciences IDEA Program[1] sponsored project is looking at improved inspection tools that can be used to reduce wheel climb derailments at switch points. This project is looking at international inspection practices aimed at reducing the risk of wheel climb at switch points and the potential application of these practices for U.S. freight and passenger railways.

An example of such an improved inspection practice for track inspectors is shown in Figures 1 and 2, which show gauges used to measure switch point chipping and/or wear. Figure 1a and 1b show a gauge used in the U.K. on Network Rail and Figure 2 is a related gauge used in Switzerland by the Swiss Federal Railways (SBB).

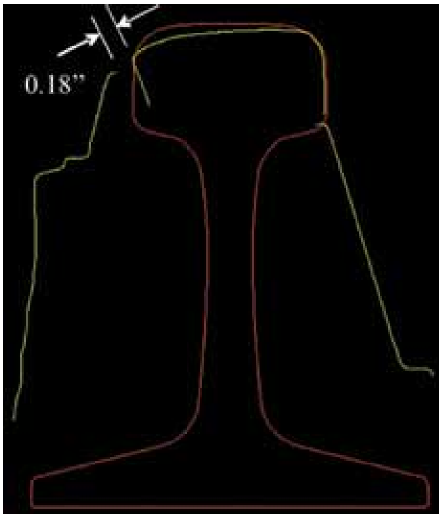
Other manual gauges are used to look at wheel contact through the switch point, frog damage, etc.

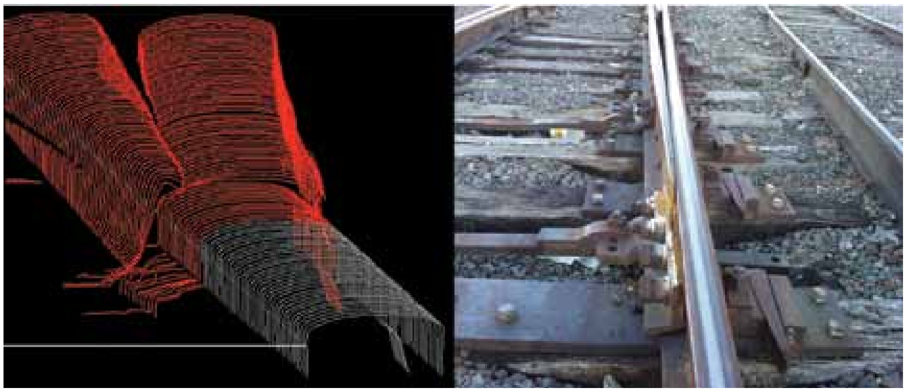
However, since the movement in track inspection is towards automated inspection technolgies that complement the track inspector, several research programs are looking at using existing or emerging technologies to look at the turnout areas to include the different turnout parameters listed in Table 1.

One such research activity, funded by supplier Harsco Rail with support from Network Rail (U.K.) and the FRA's BAA research program led to the development of a new generation Automated Switch Inspection Vehicle (ASIV) for automated inspection of the rail portions of turnouts to include switch point, frog, stock rail and closure rails on both the open and closed sides of the switch.[5, 6] The inspection vehicle uses a new generation high-speed rail profile measurement system to measure the switch and frog profiles and then analyzes these profiles using newly developed state-of-the-art switch analysis software. The system inspects and analyzes the rail portions of all of the major component areas of the turnout to include the switch points, frog, stock rails (straight and curved) and closure rails (straight and curved). Thus, key areas of the turnout are inspected to include such key safety parameters as the gap width between switch point and stock rail, vertical and side wear on the stock rail, relative height of the switch point and stock rail, gauge face angle and corner radius of the switch point, relative height and angle of the frog nose and wing rails, etc.

The high-sampling-rate profile acquisition system used in the ASIV collects sufficient rail profile data to develop three-dimensional (3-D) composite images of the turnout and its key components. These 3-D images, which are composite images made up of one-inch cross-sectional slices of the switch and frog sections, are then used to measure the key maintenance and safety parameters, compare these measured values to defined standards and identify defects as either red defects that exceed safety

1. National Academy of Sciences Transportation Safety Technology Project SAFETY-23 Reducing Wheel Climb at Switch Points to Reduce Derailments.





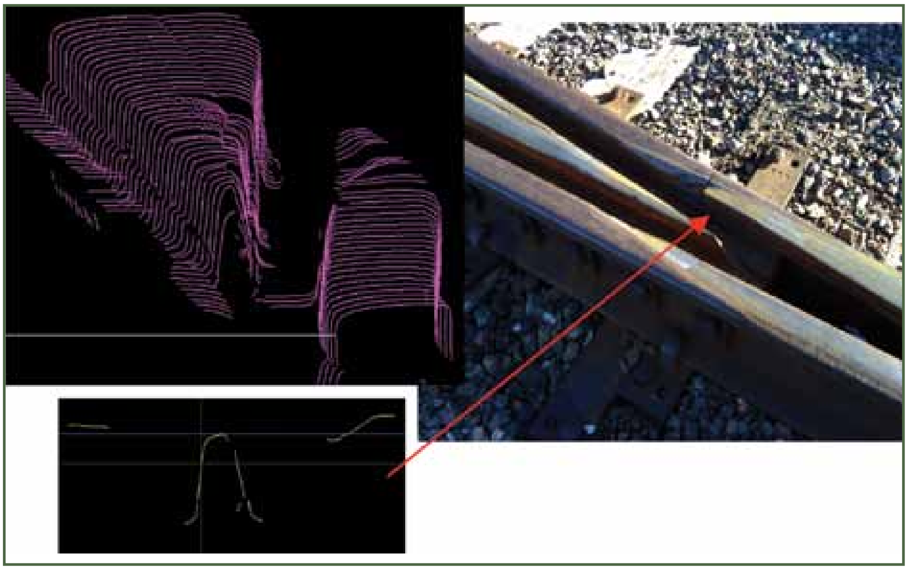


Figure 3a, top left, shows a large switch point gap. Figure 3b, top right, shows chipped/broken switch point with real and 3-D views. Figure 3c shows damaged wing rail with real and 3-D views.

standards or yellow defects that exceed maintenance standards. This is illustrated in Figure 3a, 3b and 3c, which show several significant (red) defects identified by this automated system.

Another ongoing research program geared towards automated inspection of turnouts is based on machine vision and association image recognition software. Machine vision systems are currently in use or under development for a variety of railroad inspection tasks. The University of Illinois at Urbana-Champaign (UIUC) is working on machine-vision research projects for turnout inspection (as well as inspection of other railway components) under the sponsorship of the various railroads, industry associations and government agencies.[2] Such a machine vision system consists of a video acquisition system for recording digital images of track and customized algorithms to identify defects within the images. It is this image recognition software that separates the machine vision inspection systems from the simpler video recording systems which require playback and manual (offsite) review of the recordings.

In the UIUC approach, turnouts are identified in track using algorithms to look for periodic components indicative of turnouts, such as frog bolts. Once the turnout area has been identified then inspection of components within the turnout takes place. Components currently being studied include switch rods, switch rod bolts, ties and switch points with a focus on identifying chipping of the switch point as shown in Figure 4.[7]

Yet another approach to switch inspection (and monitoring) is one that is being addressed in Europe via in-track switch monitoring systems.[8] This approach is somewhat different than the automated inspection technology discussed above, in that it uses instrumentation within the turnout to monitor key performance and safety parameters on an ongoing basis. These measurements include:

- Monitoring of switch-stock rail contact area
- Monitoring of open switch
- Monitoring of switch operating rods and/or switch locking system
- Monitoring of switch flangeway (between open switch point and stock rail)
- Measurement of force needed for each switch operation
- Monitoring of residual force in the switch (retaining force)
- Monitoring of current and time needed for operation of switch (motor)
- Monitoring of pressure in the switch machine
- Monitoring of the position of the rods
- Monitoring of impacts or strikes at the crossing point (indicating wear on check or wing rail)
- Monitoring of longitudinal force in rail
- Monitoring of rail and ambient temperature

While many of these technologies are still in the research, development or early implementation stages, they represent significant potential for complementing today's visual and manual inspection process with automated technologies that provide accurate and complete information about the condition of the turnout.□

References

1. U.S. Department of Transportation, Federal Railroad Administration, “Track Safety Standards Part 213,” CFR Title 49, October 2009

2. Molina Camargo, L.F., Resendiz, E., Edwards, J.R., Hart, J.M., Barkan, C.P.L. and Ahuja, N. 2011. “Condition Monitoring of Railway Turnouts and Other Track Components Using

Figure 5 shows detection and measurement of switch point using machine vision technology.

Machine Vision," Proceedings of Transportation Research Board (TRB) 90th Annual Meeting. Washington D.C., January 2011.
3. Zarembski, A. M., Holfeld, D. R. and Palese, J. W. "On the Derailment of Rail Vehicles Through Turnouts: A Review of Derailment Causes and Mechanisms." American Railway Engineering Association Turnout Symposium, Chicago, Ill., August 1996.
4. Zarembski, A. M., Holfeld, D. R. and Palese, J. W. "Derailment of Transit Vehicles in Turnouts." Transportation Research Board Annual Meeting, Washington, D.C., January, 1997.
5. Zarembski, A.M., Euston, T.L., Palese, J.W. "Development, Implementation, and Validation of an Automated Turnout Inspection Vehicle." IHHA 2011, Calgary, Canada, June 2011
6. Zarembski, A.M., Palese, J.W., Euston, T.L., Scheiring, W.R. "Development and Implementation of Automated Switch Inspection Vehicle." 2011 AREMA Annual Conference, Minneapolis, Minn., September 2011.
7. Hart, J.M., Camargo Molina, L.F., Resendiz, E., Edwards, J.R., Ahuja, N. and Barkan, C.P.L. 2011. "Development of a Machine Vision System for the Inspection of Heavy-Haul Railway Turnout and Track Components." Proceedings of the International Heavy Haul Association Conference. Calgary, Canada, June 2011.
8. Ekberg, A. and Paulsson, B., INNOTRACK: Concluding Technical Report, UIC, 2010.