RAILROAD TRACK CONDITION REPORTING AND MAINTENANCE USING A SUSTAINMENT MANAGEMENT SYSTEM

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INTRODUCTION

The U.S. Army, Navy, Air Force, and Marine Corps together own and operate on the order of several thousand miles of railroad track. This track is of strategic importance to the movement of equipment, munitions, and supplies, and requires a consistent inspection and condition assessment process to ensure that reliability and mission requirements can be met for each local network in a cost efficient manner. While these railroad track networks represent an important infrastructure asset to support military transportation operations, they sometimes experience extended periods of disuse until an event warrants mobilization. Like all physical infrastructure assets, military railroad track networks require periodic maintenance, repair, and capital planning to ensure both short term and long term performance requirements to support mission. Since track infrastructure competes for funding with other type of civil infrastructures at a military installation, track may undergo long periods of little or no sustainment and capital renewal expenditures if it is not actively being used. These unpredictable sustainment funding cycles are coupled with a shrinking pool of knowledgeable and experienced personnel resources at many installations necessary to effectively manage these rail assets. The result is a potential for catastrophic network failures when the rail system experiences a surge in use.

In order to maintain readiness, military railroad track undergoes periodic safety inspections which identify critical defects that may cause a potential derailment. The frequency of these safety inspections is weekly, monthly, or semi-annually based on the use of the track (Ref 1). Because these inspections only addresses critical and catastrophic issues, they do not provide the rigorous basis for determining and reporting a comprehensive track condition measure or identifying comprehensive repair and capital renewal needs. As a result of these aspects, the management practices for low-speed, low volume networks often involve reactive maintenance and repair, correcting deficiencies that adversely affect near term operations as they arise. Experience has shown that this practice has a long term adverse impact on the track network condition, due to compounding deterioration from repeated wheel loads and deferred maintenance and repairs on all but the most critical deficiencies. This highlights the importance and need for a standardized, robust, and meaningful condition assessment process to provide decision support for a more proactive repair and capital renewal planning strategy.

The Class I and some regional line haul railroads have developed their own railroad management and inspection processes, but military railroad networks require a unique infrastructure management approach due to their size and operational characteristics. While the overall scale of military track is on par with a small Class 1 or major regional railroad, this track is spread across installations worldwide, with each installation's network operating relatively independently akin to a short line or industrial network. Train speeds and traffic are usually lower, track assets may be geographically fragmented, and the use of production scale inspection equipment, such as automated track geometry vehicles, are often cost prohibitive or impractical. To address these issues, the RAILER Sustainment Management System (SMS) was developed. RAILER is a railroad track asset management system designed as a decision support tool for evaluating track conditions and planning track sustainment, restoration, and modernization (SRM) activities on military, short line, and industrial track networks. It utilizes an objective visual inspection process to produce both a track condition metric and operational restriction levels based on the track distresses identified. This information provides the basis for readiness reporting and maintenance and repair plan development.

WHAT IS RAILER SMS

RAILER SMS is a member of the Sustainment Management System of tools developed at by the U.S. Army Corps of Engineers, Engineering Research and Development Center, Construction Engineering Research Lab (ERDC CERL). Other SMS tools include PAVER, ROOFER, and BUILDER. The RAILER® methodology is a systematic management approach which provides information and support to engineers, facility planners, and policy makers in managing rail infrastructure on a network level and project level basis (Ref 2). This approach includes: 1) Categorizing the rail assets and organizing attribute information about the track network; 2) Providing a standardized detailed inspection process for identifying, classifying, and recording component defects and deficiencies; 3) Reporting operating restrictions imposed by governing track standards due to present defects; and 4) Using the inspection defect information to objectively quantify track condition. All of this information is then used in a systematic method to develop recommended short and long term corrective repair and capital renewal strategies. Based on the most recent track inspection, the system reports condition, operating restrictions and needed repairs using both tabular reporting and GIS features.

Implementation of the RAILER SMS methodology includes network inventory collection, track inspection, condition assessment, and work planning, each of which is discussed in detail below.

TRACK NETWORK INVENTORY

The track inventory organizes and classifies the track related assets to be managed. Key to this inventory process is the decomposition of a track network into a logical hierarchy of areas, tracks, and track segments (Figure 1). Areas subdivide the network based on track use or geographic location, and are comprised of a group of tracks. A track is the main designation for describing a physical linear portion of the network. Each track has a station location referencing system, which serves to locate inventory features and defects along the length of the track. Because some tracks can be very long, track segments are established to divide the track into smaller "management units." Typically, segment boundaries are established at point of switch (POS) locations, but may also be located at mile markers, grade crossings, etc. Inspection, condition assessment, and maintenance planning is performed individually on each segment.

After the track network hierarchy is established, the attribute information associated with each track is defined. This attribute information describes the track layout (curves and grades), the track structure (rail weights, tie specifications, etc), track clearance issues, and track related items such as turnouts, rail crossings, grade crossings, drainage culverts, and bridges. Inventory information about these track attributes can be quite detailed, but much of this detail is optional. The benefits of a complete and accurate track inventory are two-fold: 1) It provides a quick record of the properties of the track network for operations, and 2) it provides information about the existing track materials at a specific location when maintenance or repair is needed.

TRACK INSPECTION

Once the track inventory is defined, a standardized inspection process is performed to observe, identify, and record defects present in the track structure and track related items. This inspection process consists of identifying and recording defects associated with the track subgrade, ballast, geometry, ties, rails, turnouts, grade crossings, and other track materials such as fasteners, joint bars, etc. A standardized and finite list of defects exists to cover the multitude of track related problems that may occur, especially those identified in the Unified Facilities Criteria (UFC) for Railroad Track Maintenance and Safety Standards (Ref 3). Associated with each recorded defect is the quantity or density affecting the track, along with the track station location of the defect.

The RAILER process supports a number of different inspection methods, including: 1) detailed control inspections, 2) safety inspections, 3) non-destructive testing (NDT) evaluations, or 4) operational inspections. The detailed inspection is usually performed annually (or less frequently), and its main purpose is to identify work requirements and generate a backlog estimate of maintenance and repair. The detailed inspection identifies all track defects and deficiencies, even if those problems are unlikely to be corrected in the short term maintenance cycle. Conversely, the safety inspection process may be performed weekly, monthly, or less frequently, (usually depending on traffic and use) to identify only safety related defects that represent an elevated risk of causing a derailment. The defects identified during a safety inspection would usually be corrected immediately with a work order issued, or during the next maintenance cycle. The NDT assessment is an internal flaw assessment to identify internal rail defects that are not visible during the visual inspection. A NDT assessment is usually recommended at a minimum of every five years. Both critical and non-critical defects may be identified by the NDT process, but all findings can be stored in the RAILER system. Finally, an operational inspection is used to identify defects that may present themselves under load from a car or locomotive, and may be accomplished in conjunction with a detailed and/or safety inspection.

As these inspections are performed, the inspection results are electronically collected via a mobile tablet computer running field inspection software that keeps track of the segment, location, and types of defects identified. This software also displays defect findings from the previous inspection for verification if the defect was fixed or still remains. In addition, it displays the operating restriction for a recorded defect in real time based on the governing track standard. The described inspection process provides for consistent and repeatable condition information (Ref 4). After inspection, this information is uploaded to the RAILER system, where condition assessment and work requirements identification is performed.

CONDITION ASSESSMENT

Using the information collected during the inspection process, RAILER automatically links each defect to: 1) operation or speed restrictions based on the governing track standard, 2) condition index metrics, and 3) a local work action to correct or repair the defect. Through this process, one inspection feeds three separate reporting requirements.

Governing track standards limit or restrict train movements over track segments that contain defects of a potentially catastrophic nature. When these defects are identified, the risk of a derailment is mitigated by limiting train speeds or restricting operations completely, and the program denotes the location of these defects accordingly.

This serves the purpose of managing the short-term repair requirements of the railroad. These requirements mandate that the network or important corridors of operation be without restrictions at any point in time to support mission readiness or avoid efficiency lost from delayed shipments. Information about the operations level of each track segment is especially helpfully when viewed spatially in GIS (Figure 2).

Track condition is quantified through the Track Structure Condition Index (TSCI) metric (Ref 5). Based on the type, severity, and density of each defect identified in a track segment, a deduct value is calculated from the numerous deduct curves that have been developed (Figure 3). These deduct values are subtracted to reduce the overall condition index, producing a metric which represents the physical condition of the track components on an absolute 0-100 scale, with 100 being a segment of track completely free of defects (Figure 4). The TSCI is based on an aggregation of separate metrics for the ballast and subgrade (BSCI), ties (TCI), and rail, joints, and fastenings (RJCI). The TSCI is computed for each individual track segment, and is rolled-up for an overall track, area, or network using a weighted average approach based on the track length of each segment.

The TSCI, and its constitutive component CIs, are best used as a performance metric to gauge the health of the track and the overall state of the capital investment. The metric information can alert track managers to potential problem areas of track before critical safety defects occur which affect short term operations. Most importantly, it serves as a key indicator to monitor the long term performance of the network, and is an objective and repeatable measure of condition for upward reporting.

WORK PLANNING

The information collected during the inspection and compiled during the condition assessment phase directly supports the work plan development processes. Each defect type is associated with a localized work action to correct, along with a unit cost to perform the work. Since each defect is also linked to an operations restriction level, this relationship provides a quick prioritization of the most critical defects (no operations or restricted operations defects being a high priority repair). This establishes the list of requirements to sustain operations in the near term.

However, an effective maintenance and repair strategy should also plan for the sustainment of the long term track performance. A track maintained in very good condition should have very few critical defects to address, although some may still arise due to random occurrences. But if non-critical work on a track is deferred, track deterioration accelerates and the number of critical issues can increase dramatically. For example, poor drainage issues can lead to premature cross tie decay and track geometry deviations, which in turn results in higher impact loads and increased rail section deflections. These conditions can spawn critical failures in the rails and joints. Correcting only these critical safety issues will only result in short term improvements. However, the use of the condition index metrics would likely alert work planners to an impending problem before critical safety issues even arose. As a result, using the TSCI series as a performance metric can direct resources toward the best long term solutions.

Therefore, in addition to high priority critical work items, the total list of non-critical corrective work actions are further prioritized based on track usage, segment importance, and segment TSCI. In addition, the CI's provides a justification and flag track segments that may require more global restoration, renewal, or reconstruction efforts versus corrective repair sustainment work. For example, a high TSCI above 80 would warrant spot repairs. Conversely, for a TSCI in the 60s or below, renewal of one or more of the major track components (rail, ties, and/or ballast) would likely be more efficient than correcting a large number of localized defects.

CASE STUDY/BENEFITS

The Fort Campbell railroad track network consists of 40 track-miles which serve force projections efforts and training activities (Ref 6). During the 1970s and 1980s, M&R funding for the railroad infrastructure was cut or significantly decreased as the network went into a state of disuse. Deferred track maintenance caused the rail network to deteriorate to a sub-standard level, affecting the ability to support a mobilization mission. As a consequence of issues deploying during the 1st Gulf War, millions were invested to recapitalize the network. After this extensive rehabilitation effort, the RAILER system was implemented in the late 1990's as an asset management tool to efficiently maintain track performance, and ensure future readiness. Annual track inspections are performed at Ft Campbell to support the RAILER condition assessment and M&R analysis. By considering critical track restrictions, segment importance based on critical areas of operation, and long term CI targets, a prioritized annual M&R plan is developed. This plan identifies track defects to be corrected, the associated repair work action, cost to fix, and contract line item number (Figure 5). The result is an automatically generated scope of work for annual railroad maintenance and repairs.

The benefits of the RAILER system have been two-fold. The objective identification of defects and corrective work actions has helped the local public works department develop a justifiable and actionable budget request that better communicates actual condition and work requirements to support mission. Before RAILER implementation, the network was only receiving a small fraction of the annual sustainment requirements estimated in the DoD sustainment model (Ref 7). Over the course of eight years of RAILER support at Ft Campbell, this improved work requirements identification process has helped the railroad annual sustainment funding increase from 20% to as much as 75% of the DoD sustainment estimate in some years. In addition, the backlog of repairs and sustainment funding requirements as identified by RAILER has begun to drop in the past two years. The public works department has the critical information to fund railroad sustainment resources efficiently, and this has resulted in driving future sustainment requirements down.

This is due to the continually improving condition of the track, even with less than full sustainment funding by DoD estimates. By allocating the M&R resources to work actions that produce the most beneficial impact on long term condition, the overall network TSCI index has improved from 83 to 93, while still providing for short term operational constraints to support mission.

CONCLUSIONS

Fundamental to any successful facility infrastructure investment strategy are the objectives to 1) minimize lifecycle ownership costs, 2) maximize facility performance, and 3) manage risk. The SMS methodology described above provides the decision support to help railroad managers achieve these objectives. The RAILER SMS process is an improved approach to the management of low-speed, low-volume railroad track when compared to safety inspections and reactionary critical repairs alone. A consistent and objective TSCI metric supports both condition reporting and repair/renewal decisions. This helps in prioritizing repairs and allocating sustainment resources to realize long term performance improvements for the network, even under tight funding constraints.

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DISCLAIMER

The views of the authors do not purport to reflect the views or policies of the U.S. Army or the Department of Defense.

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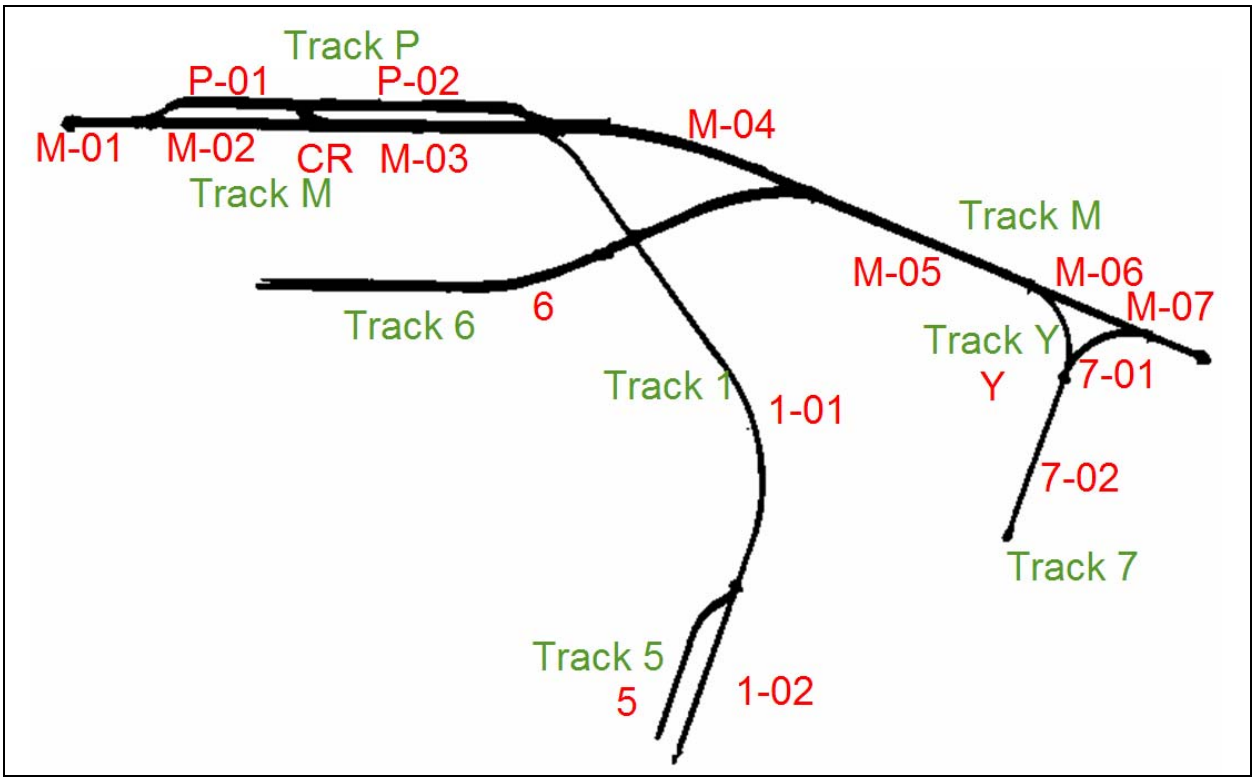

FIGURE 1 Railroad Network Identification of Tracks (Green labels) and Segments (Red Labels).

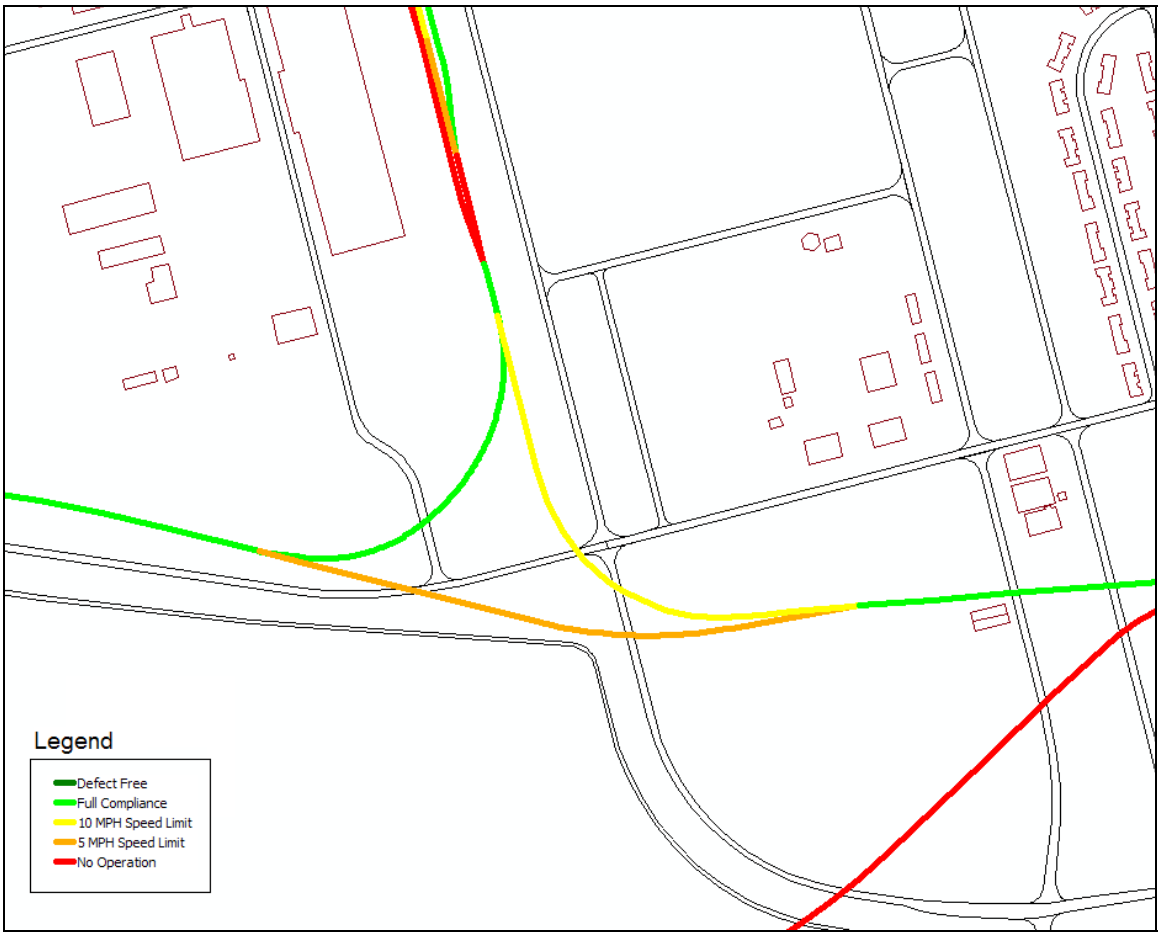

FIGURE 2 GIS Spatial View of Track Operating Restrictions.

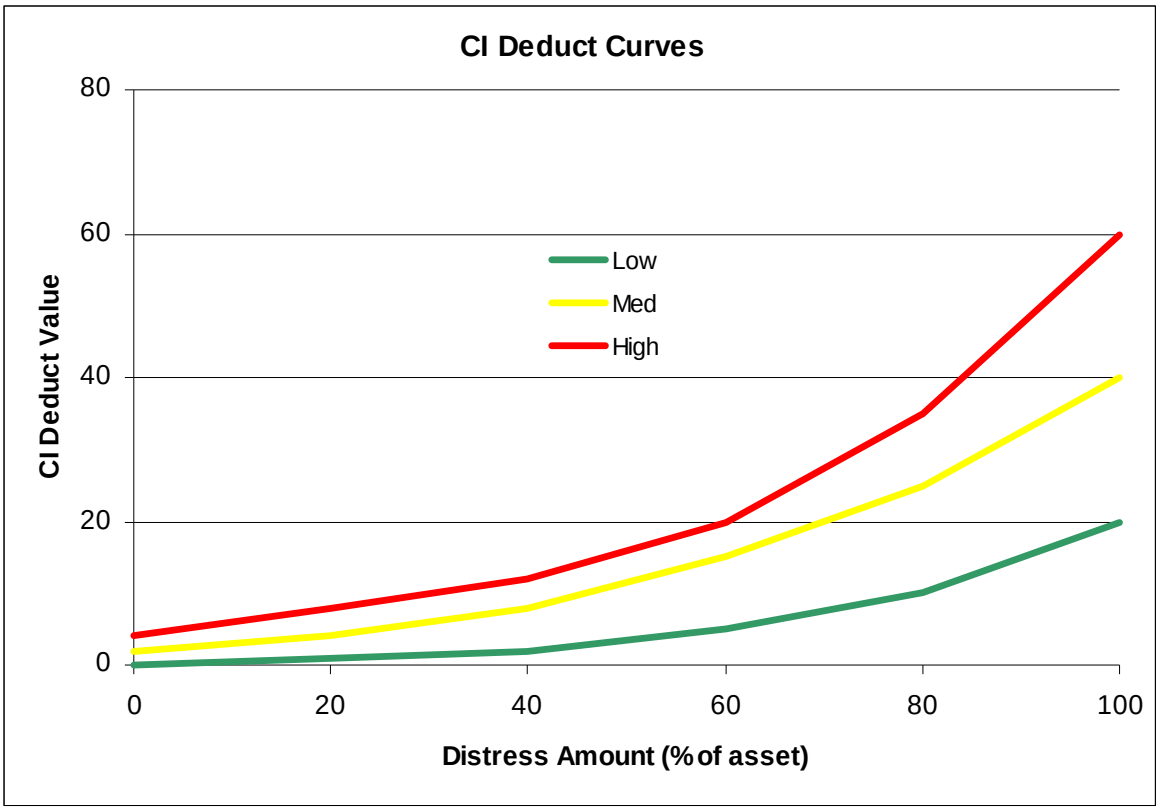

FIGURE 3 Deduct Curve for Defect/Distress Type, Severity, and Density.

Condition Index	Descriptor
100-85 Good	Slight or no serviceability or reliability reduction
85-70 Satisfactory	Serviceability or reliability is degraded but adequate.
70-55 Fair	Serviceability or reliability is noticeably degraded
55-40 Poor	Significant serviceability or reliability loss.
40-25 Very Poor	Unsatisfactory serviceability or reliability reduction
25-10 Serious	Extreme serviceability or reliability reduction
10-0 Failed	Overall degradation is total.

FIGURE 4 Track Structure Condition Index Scale and Description.

Segment ID	Component	Defect	Qty	Standard	Work Action	LineItem	Total Cost	UM
A(01)	Ballast	N/A	70	N/A	Skim lift after tie Replacement	3019AA	$120.40	TF
A(01)	FOTM	Bolts, Missing/Cracked/Or Broken (1 Bolt)	1	Full Compliance	Install or Replace One Bolt	3020	$8.33	EA
A(01)	FOTM	Tie Plate, Improper Size/Type, DS	1	Full Compliance	Install or Replace Double Shoulder Tie	3021AB	$18.15	EA
A(01)	Geometry	Alignment (1 in)	30	Full Compliance	Align Track	3019AE	$100.80	TF
A(01)	Geometry	Alignment (4 in)	30	10 MPH Speed	Align Track	3019AE	$100.80	TF
A(01)	Ties	Isolated Defective Tie Cluster (2 Ties)	6	Full Compliance	Install/Replace Two Ties (7"x9"x8.5')	3016AB	$824.40	EA
A(01)	Ties	Single Defective Joint Tie	2	Full Compliance	Install/Replace One Tie (7"x9"x8.5')	3016AB	$137.40	EA
A(01)	Turnout	Connecting Rod Bolts, Improper Position	1	Full Compliance	Reposition Connecting Rod Bolts	3015AS	$12.14	EA
A(01)	Turnout	Cotter Keys, Missing	2	Full Compliance	Install Cotter Keys	No Number	$0.00	EA
A(01)	Turnout	Cotter Keys, Missing	1	Full Compliance	Install Cotter Keys	No Number	$0.00	EA
A(01)	Turnout	Debris In Crib Areas	1	Full Compliance	Clean Switch Crib Area	3015AM	$93.89	EA
A(01)	Turnout	Frog Bolts, Improper Size	1	Full Compliance	Replace Frog Bolt Assembly	3015BC	$289.72	EA
A(01)	Turnout	Head Blocks, Defective	1	*5 MPH Speed*	Install/Replace Head Block	3017	$142.74	EA
A(01)	Turnout	Switch Stand, Loose	1	No Operation	Tighten/Respike/Adjust Switch Stand	3038AA	$4.83	EA
A(01)	Turnout	Switch Ties, Defective (10 ft)	2	Full Compliance	Install/Replace 10' Switch Tie	3017	$219.62	EA
A(01)	Turnout	Switch Ties, Defective (11 ft)	3	Full Compliance	Install/Replace 11' Switch Tie	3017	$362.34	EA
A(01)	Turnout	Switch Ties, Defective (13 ft)	1	Full Compliance	Install/Replace 13' Switch Tie	3017	$142.74	EA
A(01)	Turnout	Switch Ties, Defective (14 ft)	1	Full Compliance	Install/Replace 14' Switch Tie	3017	$153.72	EA
A(01)	Turnout	Switch Ties, Defective (8.5 ft)	1	Full Compliance	Install/Replace 9' Switch Tie	3017	$98.82	EA
A(01)	Turnout	Switch Ties, Defective (9 ft)	1	Full Compliance	Install/Replace 9' Switch Tie	3017	$98.82	EA
A(01)	Turnout	Switch Ties, Defective (9 ft)	1	Full Compliance	Install/Replace 9' Switch Tie	3017	$98.82	EA
A(01)	Turnout	Switch Ties, Defective Joint (14 ft)	1	Full Compliance	Install/Replace 14' Switch Tie	3017	$153.72	EA

FIGURE 5 Maintenance and Repair Corrective Work Actions, Estimated Costs, and Contract Line Items.