TECHOLOGY DIGEST

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APPLYING THE TRACS* RAIL-WEAR MODEL

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Summary

Norfolk Southern, in cooperation with the Association of American Railroads and and Massachusetts Institute of Technology, has demonstrated the calibration of the Total Right-of-Way Analysis and Costing System (TRACS) wear model for one of its coal routes. By adjusting the wear coefficients, adding additional levels of lubrication effectiveness, and using actual grinding rates, NS was able to match predicted and actual wear rates for tangent track and for curves ranging from 1 to 10 degrees. A similar process could be used by any railroad to calibrate the TRACS wear model for route-specific analysis.

A user may apply the software to perform incremental track-degradation studies with the programmed defaults. However, to more accurately perform analysis for a specific railway line, the rail-wear model can be calibrated to the route under study. The software includes a comprehensive set of track-degradation and costing models designed to assist railroads in the analysis, planning, and budgeting of track right-of-way maintenance activities and technologies. The calibration process follows this process:

- Selection of the route of study.
- Information gathering and data reduction for the selected route.
- Construction of the route, traffic, and rail-wear model files and sample runs.
- Tuning of the TRACS rail wear model coefficients to achieve TRACS rail-wear outputs which approximate revenue service experience.

Once calibrated, the data files associated with the calibrated route should be kept intact and safely stored to prevent accidental corruption during the course of future analysis efforts.

Total Right-of-Way Analysis and Costing System

***Norfolk Southern*

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Suggested Distribution:

- ❑ Maintenance of Way
- ❑ Planning & Analysis
- ❑ Track Maintenance
- ❑ Maintenance Planning

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INTRODUCTION AND CONCLUSIONS

The software program TRACS is a comprehensive set of track-degradation and costing models designed to assist railroads in the analysis, planning, and budgeting of track right-of-way maintenance activities and technologies. In a cooperative effort between the Association of American Railroads, Norfolk Southern, and the Massachusetts Institute of Technology, the calibration process for a typical eastern North American coal-haul route has been demonstrated. By following a prescribed logical process, the project team calibrated the study route to a correlation of 0.99 from an initial pre-calibration correlation of 0.44. A correlation of 1.0 would be considered perfect correlation.

At the heart of the TRACS rail-degradation analysis model is the rail-wear model. Although a user may apply the software to perform incremental track-degradation studies with the programmed defaults, to more accurately perform analysis for a specific railway line, the rail-wear model can be calibrated to the route under study. The calibration process follows this process:

- Selection of the route of study.
- Information gathering and data reduction for the selected route.
- Construction of the route, traffic, and rail wear model files and sample runs.
- Tuning of the TRACS rail wear model coefficients to achieve TRACS rail wear outputs which approximate revenue service experience.

Once calibrated, the data files associated with the calibrated route should be kept intact and safely stored to prevent accidental corruption during the course of future analysis efforts.

SELECTION OF STUDY ROUTE

Only those routes for which good data on traffic mix, traffic density, rail metallurgy, rail wear, and lubrication and grinding practices can be accurately calibrated. While TRACS is useful for a host of analytical studies, route-specific calibration requires detailed information. The coal-haul route selected for study carries 69 million gross tons (MGT) annually, and rail-wear and traffic data on this route is well documented.

INFORMATION GATHERING AND DATA REDUCTION ON THE SELECTED ROUTE

Traffic Mix and Density

TRACS calculates rail wear based on individual car weights, and the frequency those individual cars travel over the prescribed route. The route selected for this project has a wayside information system installed that provides axle-load and frequency data. Using data collected from this wayside system, TRACS traffic mix and density files were constructed. These modeled traffic comprising 4 percent 200-ton (six-axle) locomotives, 82 percent 100-ton coal cars (263-kip gross weight on rail [GVW]), 8 percent 110-ton coal cars (286-kip GVW), and 6 percent 150-kip GVW mixed freight.

Rail Metallurgy and Wear

This particular route has 136RE-300BHN standard rail and 136RE-360BHN premium rail installed. Standard rail is used on tangents and curves up to 2 degrees. Premium rail is used on curves equal to and greater than 3 degrees.

From the route's track-geometry database, randomly selected rail-wear data samples were collected for each track curvature from tangent to 10 degrees. In most cases, 10 samples were taken for each curvature value. From the known rail wear, rail-installation date and historical traffic, the actual rate of wear per 100 MGT was determined. This provided the basis to which the calibration would be performed.

Lubrication and Grinding Practices

The initial precalibration run of TRACS was performed using the TRACS default lubrication policies. Another run was made after selecting alternative policies. These are discussed in the section "Sample Runs."

It is known that on the route being calibrated, most curves 2 degrees and greater have lubricators installed. Consequently, as opposed to using the standard set of default lubrication policies, a set of staged coefficient-of-friction values was constructed in the TRACS Rail Maintenance Lubrication database. These values were set to initial assumptions based on previously collected data. Further adjustment of these values is a part of the calibration process.

Likewise, current grinding practices for the route were input to the TRACS Rail Maintenance Grinding database.

Construction of route model files

The last step in constructing the calibration database is to construct a route file. The route file used to calibrate the rail-wear model was simple, containing one route segment for tangent through 10 degrees of curvature, for a total of 11 segments. The TRACS route file brings together the route curvature, traffic mix and density, rail metallurgy, lubrication, and grinding practices. Once fully constructed, sample runs may be performed.

SAMPLE RUNS

TRACS input files are text based and "data-location" rules must be followed. In addition, most of the inputs must fall within reasonable ranges. Sample runs are performed to accomplish three purposes: to validate that all input files are properly constructed, to validate that all inputs fall within reasonable ranges, and to produce the initial starting point for the route calibration.

The rail-wear results from the first run produced a correlation of 0.44 and indicated a need to modify the initial assumptions. Based on initial conservative assumptions, TRACS significantly overestimated gage-face wear and underestimated low- and high-rail head wear (Exhibit 1). A second run was performed after making additional less-conservative selections on lubrication policies. This provided an immediate 50-percent improvement in estimates to a correlation of 0.67 (Exhibit 2). Additional runs were then performed in an interactive process in which adjustments were made to lubrication policies, grinding policies, and rail-wear equation coefficients.

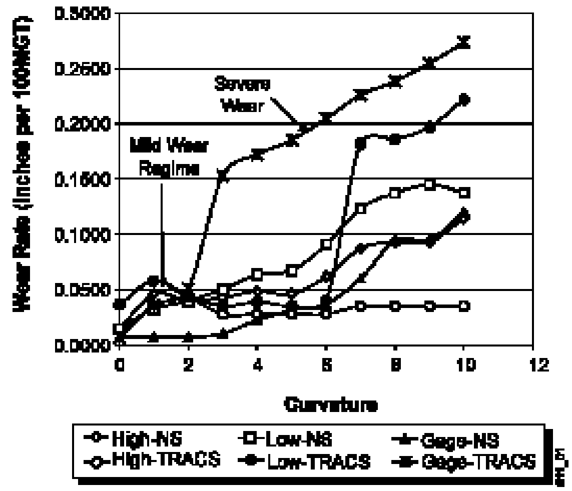

Exhibit 1. Initial Uncalibrated Wear-Model Output: Head and Gage-Face Wear

MANIPULATION OF THE TRACS RAIL-WEAR MODEL COEFFICIENTS

In calibrating the wear model, it is important to understand the method by which TRACS identifies, and then estimates, rail wear in two distinct wear regimes: mild and severe. The step increase from mild wear to severe wear is easily seen in the uncalibrated case, as shown in Exhibit 1. Mild wear estimates are generated using a combination of tonnage, lubrication, grinding and curvature, and are assumed to be independent of axle load. Severe wear estimates are generated using a combination of axle load, lubrication, grinding, curvature and tonnage. As axle loads and curvature increase, it is assumed that longitudinal creep begins to occur between

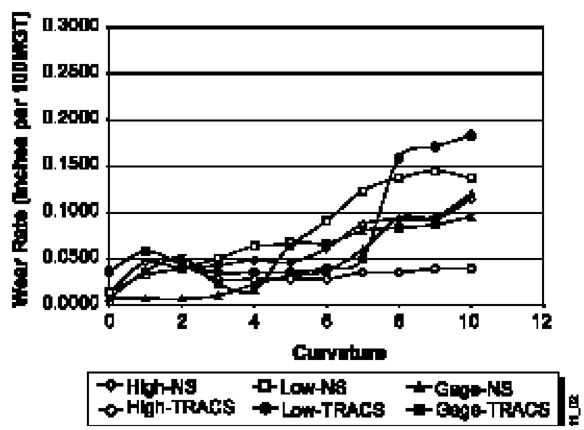

Exhibit 2. Improved Estimates after Second Run

the wheel/rail interface, thus promoting severe wear. The threshold point at which TRACS transfers between mild and severe wear is controlled by the user and should be adjusted in the calibration process. With the exception of very high axle loads and very low mild/severe threshold values, rail wear on track with curvature of 1 degree or less will be estimated in the mild wear regime.

Each rail metallurgy must be calibrated separately. Additionally, the mild and severe wear regimes must be calibrated separately for each rail metallurgy. This allows for the smooth transition from mild to severe wear seen in the NS field data. Beginning with the mild wear regimes and the lowest curvatures for each metallurgy, adjustments are made to various rail-wear-property coefficients to tune the model to the target wear rates. This is an iterative process in which an adjustment is made followed by a wear-model run, and repeated until the target wear rates are achieved.

RESULTS

The initial run of the TRACS rail-wear model produced a correlation of data between NS actual rail-wear rates and TRACS of 0.44. A second run produced an immediate 50-percent improvement to a correlation of 0.67.

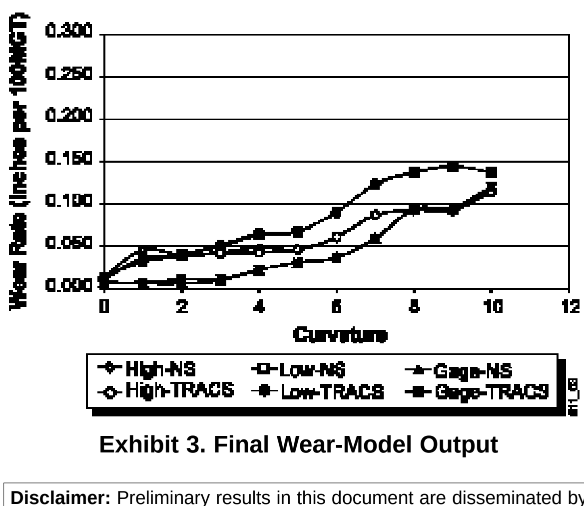

Exhibit 3. Final Wear-Model Output

Upon completion of the iterative calibration process, a correlation of 0.99 was achieved, as shown in Exhibit 3.

It is important to note that estimates of rail life are not totally dependent on rail wear. An excellent illustration of this is seen in the actual NS tangent rail-wear rate to which TRACS was calibrated. Gage-face wear for tangent track was measured to be an average of 0.007 inch per 100 MGT. With no defects, such wear rates would indicate a rail life of more than 5,000 MGT. Both TRACS rail-fatigue life estimates, and NS data indicate a more realistic life on the order of 1,400 MGT for this rail when fatigue considerations are taken into account.

The route file built for the calibration process will have one route segment for each track-curvature condition, and each rail steel applied in those curvatures. In this example, the route file used for calibration contained 11 segments (tangent through 10 degrees). When calibration is completed, the calibrated rail properties, lubrication codes, and grinding codes are applied to any study for this particular route. The actual route file may have as many segments as desired. Experienced users note that route files longer than 100 segments become somewhat cumbersome to work with; hence, a recommended practice is to consolidate very large routes in some logical manner or break them down into smaller subroutes. Analysis of other routes would require completion of the calibration process. By performing this step, a railroad could construct a set of calibrated route files ready to be used in performing analyses of how rail wear might vary with alternative maintenance, alternative or new component technologies, or modified traffic strategies.

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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780.