SELF-ADAPTIVE ALGORITHM FOR SCHEDULING RAIL TESTS

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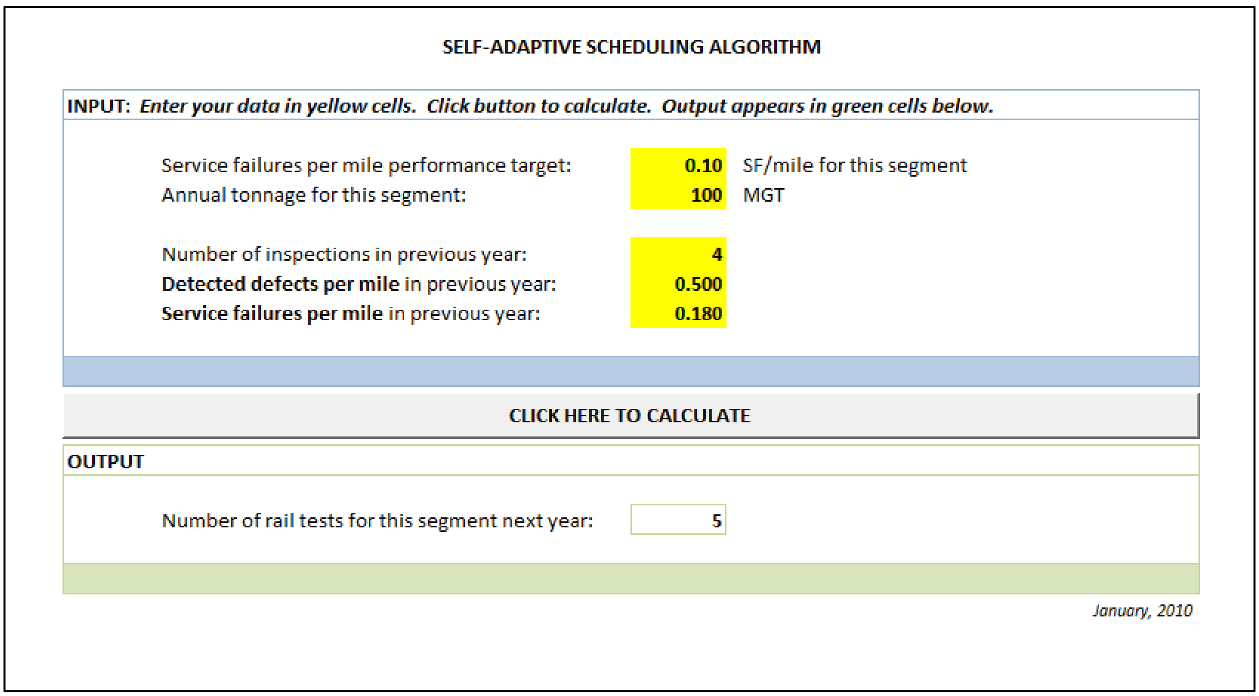
A guide [1] was developed in the late 1980s for scheduling rail tests to find defects which form and grow from metal fatigue. The development of this guide was based upon results from several years of research sponsored by the Federal Railroad Administration [2]. Moreover, the guide is an algorithm designed to adjust the frequency of rail tests according to observed changes in track conditions in terms of the number of detected defects and service failures over a segment of track.

The algorithm has been encoded into a computer program using Visual Basic for Applications (VBA) within Microsoft Excel. The figure below shows an example of the menu that appears after the Excel file is opened.



The algorithm requires five (5) input parameters to characterize the track conditions of a particular segment of track:

(1) Performance target for service failures per track mile projected over a year,
(2) Annual tonnage for the segment of track,
(3) Number of rail tests conducted in the previous year,
(4) Detected defects per track mile from the previous year, and
(5) Service failures per track mile from the previous year.

The input parameters are highlighted in yellow in the Excel VBA menu.

The output from the program is the annual number of rail tests that should be conducted over the segment in order to maintain an acceptable or tolerable level of risk. In this context, risk is the number of service failures per mile in a segment of track for a one-year period. In the self-adaptive algorithm, the tolerable level of risk is referred to as the performance target. A performance target of 0.1 service failures per track mile per year is generally assumed, but should be reduced if trains are expected to carry passengers and/or hazardous materials. The value of 0.1 service failures per track mile per year represents the national industry average over the past two decades. Based upon deliberations of the Rail Integrity Task Force, a subcommittee of the Track Safety Standards Working Group of the Rail Safety Advisory Committee, the following standard industry practices for the performance target were developed in the Notice for Proposed Rulemaking:

- No more than 0.1 service failures per track mile per year for all Class 4 and 5 track;
- No more than 0.09 service failures per track mile per year for all Class 3, 4 and 5 track that carries regularly-scheduled passenger trains or is a hazardous material route; and
- No more than 0.08 service failures per track mile per year for all Class 3, 4, and 5 track that carries regularly-scheduled passenger trains and is a hazardous material route.

In addition, the following assumptions have been encoded into the algorithm for scheduling rail tests:

(1) The rate at which internal defects develop or occur in rail is estimated using the Weibull probability distribution. The Weibull distribution has been used to correlate fatigue life data in general since the 1950s [3] and rail defect data in particular since the 1970s [4].
(2) The growth of internal rail defects is characterized by the slow crack-growth life, which is defined as the tonnage to grow a defect from barely detectable size to the size at which rail failure may be expected to occur under the next train. In the algorithm for scheduling rail tests, a slow crack-growth life of 40 million gross tons (MGT) is assumed. The value of 40 MGT is a factored number based on results from an analytical model that was validated with experimental data obtained from the Facility for Accelerated Service Testing (FAST) in Pueblo, Colorado [2]. Assuming operational and environmental factors representative of revenue service, crack growth life of 50 MGT was calculated. The assumption of 40 MGT rather than 50 MGT is intentionally conservative to reflect variations in revenue service conditions.
(3) The performance or reliability of equipment to detect internal rail defects is characterized by a probability of detection (POD) curve. The POD curve assumed in the algorithm is less stringent than the AREMA-recommended specification. Assuming a less stringent POD curve provides additional conservatism into the scheduling guide.

Assuming the input parameters shown in the example, the algorithm calculates 5 rail tests for the next year. This example shows the self-adaptive nature of the algorithm as follows. The number of rail tests for the next year is greater than the previous year (5 versus 4) because the service failures per mile in the previous year exceeded the performance target (0.18 versus 0.10).

REFERENCES

[1] O. Orringer, 1990: "Control of Rail Integrity by Self-Adaptive Scheduling of Rail Tests," Final Report DOT/FRA/ORD-90/05.

[2] O. Orringer, Y.H. Tang, J.E. Gordon, D.Y. Jeong, J.M. Morris, and A.B. Perlman, 1988: "Crack Propagation Life of Detail Fractures in Rails," Final Report DOT/FRA/ORD-88/13.

[3] W. Weibull, 1951: "A Statistical Distribution Function of Wide Applicability," *Journal of Applied Mechanics, Transactions of the American Society of Mechanical Engineers*, pp. 293-297.

[4] P.M. Besuner, D.H. Stone, M.A. DeHerrera, and K.W. Schoeneberg, 1978: "Statistical Analysis of Rail Defect Data (Rail Analysis – Volume 3)," AAR Chicago Technical Center, Report Number R-302.