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Improving Railroad Safety with Risk Management

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Perspective

Railroad safety and the prevention of derailments remain a major concern of railroads worldwide. As railroads continue to work to reduce derailments, a new generation of innovative risk management techniques have been introduced to help railroads locate and identify potential derailment sites as well as improve inspection procedures and schedules [1-5]. These new techniques focus on the derailment causes them and develop specific risk management tools that quantify and analyze the "risk" for each key derailment or accident area. This has led to the development of risk based tools to identify high risk locations in the track and provide guidance for improved inspection and/or preventive maintenance to reduce that level of risk.

For example, track caused derailments represent one of the largest derailment categories both in US and worldwide. In the US, it represents approximately 30% of all FRA reported derailments. The major failure types identified under the track caused derailment category are: broken rails, track geometry, turnouts and roadbed. In each of these cause areas, research has resulted in new risk based tools aimed at helping maintenance officers pinpoint potential derailment location and take action to reduce the risk of a derailment. These include risk based tools that look at:

i. Broken rail risk; to quantify the risk of occurrence of a broken rail/broken rail derailment with a focus on adjusting ultrasonic test schedules to reduce that risk [4,6].

ii. Risk based scheduling of track safety audit inspections to optimize safety audit inspections, particularly on high speed or high density track [5].

iii. Track geometry defect risk; to quantify the risk of occurrence of a critical geometry defect (FRA violation) with a focus on adjusting track geometry car test schedules to reduce that risk [1,2].

iv. Inter-relation between track geometry defects and the development of rail defects that increase the risk of a rail defect developing at a given location [7,8].

v. Vehicle/track geometry risk; to identify and prioritize locations with track geometry conditions that have a high potential for vehicle/track geometry related derailments [9].

vi. Turnout condition; to quantify the condition of a switch (turnout) based on the potential for derailment [10].

vii. Track buckling risk; to identify and prioritize locations of high potential buckling risk for follow up maintenance action [11].

Table 1: Broken Rail Risk Guidelines.

Risk [service defects (rail breaks)/mile/ year]	Traffic Type
0.09 to 0.10	General freight route (no passenger or Hazmat)
0.07 to 0.08	Key freight line
0.06 to 0.07	Freight route with Hazmat but no passenger traffic
0.04 to 0.06	Freight with limited passenger traffic
0.01 to 0.03	Low-speed passenger route (less than 90mph)
0.005 to 0.01	Moderate-speed Passenger route (90 to 125mph)
0.001	High speed passenger line route (125mph and higher)

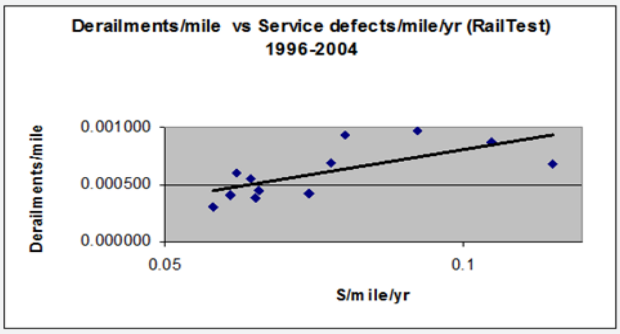

Figure 1: Derailment rate sensitivity to service defect rate.

For example, broken rail risk management includes using service defect rate to determine allowable levels of risk (Table 1) and determine ultrasonic rail test schedules. While service defects represent only about 10% of all defects, they have a very strong correlation to derailment occurrence, as shown in Figure 1. Recent studies indicate that a broken rail derailment occurs approximately every 133 service defects for a derailment per service defect rate of 0.0075 [6]. As such they form the basis for a risk based scheduling methodology as described in References 4 and 6. Actual implementation of this risk based scheduling approach has shown a very well defined reduction in derailments [6].

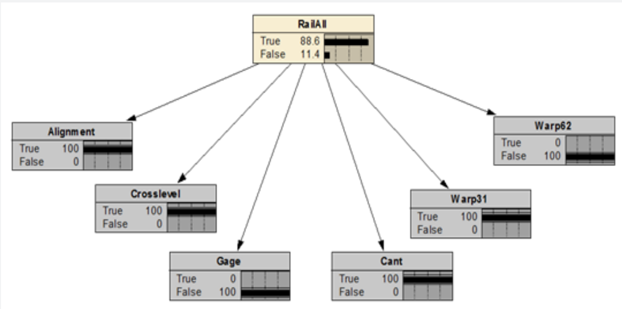

Figure 2: Bayesian network risk analysis for a warp 31, a rail cant, a cross-level, and an alignment defect.

A further application of risk management calculates the probability that a site with one or more geometry defects will develop a rail defect [7,8]. This is illustrated in Figure 2 where a Bayesian model calculated an 88.6% probability of rail defect developing at the site with multiple track geometry defects over a period of five years.

Yet another risk management application is for the determination of when and where to conduct safety audit inspections. This risk management approach process first establishes an acceptable level of risk for having a safety violation in a given territory, and then taking into account defect history and real-time track conditions, schedules audit inspections based on those conditions. Figure 3 illustrates the risk based audit inspection approach, where the frequency of audits is directly related to the level of defects found in previous inspections. The other referenced approaches follow the same principal

i. Defining a relationship between the risk sensitive parameters and safety as defined here by occurrence of derailments (Figure 1).

ii. Quantifying the relationship (Figure 2).

iii. Quantifying the level of risk acceptable under a range of operating conditions (Table 1).

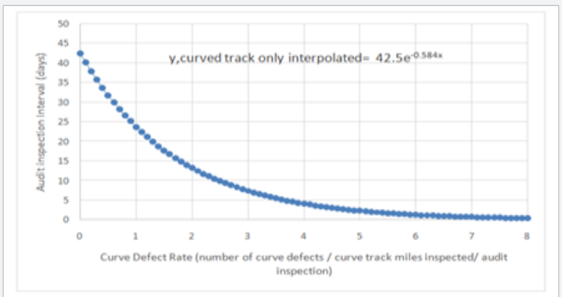

Figure 3: Optimal curved track walking audit inspection interval curve

iv. Developing a relationship between risk parameter and inspection/other action to reduce risk and improve safety (Figure 3).

As can be seen, a new generation of track safety management tools has been developed to quantify and analyze the “risk” associated with key track failure modes. These risk based assessment tools have been shown to contribute directly to a reduction in track failures through their ability to selectively identify high risk locations and bring remedial action to bear on these identified locations. The model classes presented here all rely on research that has been developed over the last several decades, and are designed to be used in large-scale applications, to identify potential failure sites across an entire route or railway system.

The results have been clear and impressive. Use of risk-based test scheduling techniques reduces the risk of derailments. For example, in the case of broken rail derailments, use of risk based assessment and rail test scheduling to determine optimum rail test intervals, has resulted in a reduction in the rate of broken rails and broken rail derailments by 30% or more on several major US railroads.

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