Overview

Analyzing track geometry defects is critical for keeping freight and passenger trains moving safely. Understanding when a defect will need to be fixed can help with preventive maintenance planning and reduce the probability of track failures.

Railroad companies use track geometry vehicles to periodically take track measurements – e.g., track gage, alignment, curvature, and cross level – to help identify geometric defects. Track defects are classified into two severity levels – red tags and yellow tags. Red tag defects violate Federal Railroad Administration (FRA) track safety standards and must be treated as soon as possible after they are detected. Yellow tag defects satisfy FRA standards, but do not meet the particular railroad’s own standards. Since yellow tag defects are within FRA standards, railroads are not obligated to fix them, but they might choose to for various reasons including track status, defect history, number of nearby defects, etc. If yellow tag defects are not fixed, they will eventually become red tag defects.

Being able to proactively identify yellow tags that are turning into red tag defects, before they actually become red tag defects, allows railroads to more efficiently maintain the rail and remain in FRA compliance.

Challenge: Participants will be given historical detection readings for three types of defects – surface, cross level, and dip – and asked to predict when those defects will reach red tag levels.
Example

A railway line is given along with its layout description and some recorded traffic. A series of inspection runs are available along, with evaluation results. Given the location of current yellow tags (milepost), specify when they will become red tags. For a set of (dates, location), specify whether the reading will be yellow or red. This will be given as an answer sheet in an excel file.

Training data:

<table>
<thead>
<tr>
<th>Milepost</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.000</td>
<td>Feb</td>
</tr>
<tr>
<td>12.000</td>
<td>Apr</td>
</tr>
<tr>
<td>55.1234</td>
<td>Apr</td>
</tr>
<tr>
<td>12.000</td>
<td>Sep</td>
</tr>
<tr>
<td>55.1234</td>
<td>Sep</td>
</tr>
<tr>
<td>60.1234</td>
<td>Sep</td>
</tr>
<tr>
<td>12.000</td>
<td>Oct</td>
</tr>
<tr>
<td>60.1234</td>
<td>Oct</td>
</tr>
</tbody>
</table>

In the above example, the only open yellow tag that has not become red and not repaired is the one @ milepost 60.1234

Evaluation data includes the traffic recorded after the last inspection run, in this case 18 Oct, and the planned inspection runs. Let’s assume the next inspection runs is planned on:

<table>
<thead>
<tr>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec</td>
</tr>
</tbody>
</table>

The goal of the challenge is to determine the color of the tag at the date of the inspection run, that is in 61 days from the last measurement. The only information missing is thus the color of the recorded tag. Then, the basic question to be answered in this challenge is something like:
? @ milepost 60.1234, 10 dec

If the predicted answer is:

Yellow @ milepost 60.1234, 10 dec

And the actual reading is:

Red @ milepost 60.1234, 10 dec

Then the prediction is wrong, and that counts as one error, on the 10 December measurement. This error is a false negative (a real Red predicted as Yellow). A false positive will be a real Yellow predicted as Red.

The evaluation function counts how many prediction errors are done. False positive and False negative count the same. The objective is to have as few errors as possible.

The participants can use the recorded traffic, layout information, time series analysis etc. to find a suitable method that can help them predict when yellow tags will turn red. Moreover, every inspection run measures the extent of the degradation, which can also be used to determine the degradation rate.
Details

**Track geometry vehicles**
Track geometry vehicles measure various track geometries – e.g., track gage, alignment, cross level, curvature and track strength. The geometry vehicles are converted railroad passenger cars equipped with measuring devices and computers necessary to calculate track geometry. The geometry vehicles are also equipped with Global Positioning System (GPS) to accurately identify the location where measurements are taken.

**Geometric Defect Types**
Defects fall into two categories – surface and gage. Within each category, there are several specific defect types. This competition will just deal with three defect types within the surface category – surface, cross level, and alignment.

(1) **SURFACE**
Uniformity of the rail surface is measured in short distances along the top of the rail. The left and right rail surfaces are measured over a 62-foot chord.

Surface exceptions are determined by
• dips or depressions (negative signal "-"), or
• humps (positive signal "+")

in the rail surface.

(2) **Cross Level**

Cross level is the difference in elevation between the top surfaces of the rails at a single point along a straight segment of track. Cross level is a low spot on one of the rails. It is measured by subtracting the difference in height between the top of one rail to the top of the opposite rail. On straight segments of track both rails should be the same height – i.e., zero cross level.

*Note: Crosslevel (cross level) should be used consistently.*
DIP31 is the largest change in elevation of the centerline of the track within a 31 foot moving window. Dip represents a depression (fall) in the track and the corresponding rise and approximates the profile of the centerline of the track. The change in elevation is determined using the average of the right and left surface over a 79’ wavelength. The value can be either positive or negative, with positive representing a rise (hump) in the track while negative represents a fall (dip).

A Dip 31 exception occurs when the running surface of both rails, measured over a 31’ chord, exceed the defect limits. Dip represents a uniform depression (fall) and hump (rise) of both rails within a short distance. The Dip exception can cause damage to car components, including buckling of cars, vertical separation of couplers, broken springs, bolsters, and truck frames, as well as damage to lading.
Assumptions

- **Measurement error**

  The track measurement system measures exception amounts in hundredths of an inch. This is reported directly in the data. To assign a Yellow or red tag to a value, the measurement is then rounded as in Figure. With this rounding adjustment, if the Red Tag limit is 1" and an exception is found within an amount of 0.98", a Yellow Tag is displayed, and with an amount of 15/16". If an exception is found within an amount of 1.02", a Red Tag is displayed, with an amount of 1 1/16".

- **Repeat defects**

  A defect found in the same location as a defect from the previous test may
be flagged as a repeat defect. Defects must be from the same defect type and found within 100 feet on either side of a previous defect to be considered a repeat defect.

- **Inspection cycle**

  Geometry cars will periodically test all tracks. Some tracks are inspected more frequently than others. However, time between inspections for any given track will not necessarily be uniform. Also, a defect’s amplitude will not necessarily increase even if there was no repair performed between tests.

- **Corrections on yellow tags**

  Repairs for yellow tag defects are not always recorded in the database.

### Data summary

A supporting file that describes variable names, types and definitions is attached. This file includes three data sources and examples for each data source.

**GEOMETRY_DEFECT**

GEOMETRY_DEFECT tab on the file shows all variables related to defects. In the data set, each row represents a defect and its corresponding information. Twenty rows are included in this file. Participants will predict column “DEF_PRTY” for each defect in the testing data set. Sample data is shown on GEOMETRY_DEFECT_SAMPLE_DATA tab.

**TONNAGE**

TONNAGE tab on the file shows traffic information for the entire region. Each row represents traffic information associated with a specific location (indicated by line segment and milepost). Twelve columns are included in this data set. Sample data is shown on TONNAGE_SAMPLE_DATA tab.

**INSPECTION RUN**
INSPECTION RUN tab on the file shows Geometry car actual routing information for the entire region. Each row represents routing information for a track segment. Sample data is shown on INSPECTION_RUN_SAMPLE_DATA tab.