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DRAFT - Proposed Hump Classification Yard Railcar Rollability Study

Objective

The objective of this study is to improve understanding of freight car rolling resistance at the low speeds typical of railway classification yards, validate current rolling resistance factors are develop new factors to characterize freight car rollability and with advanced analytical approaches..

Background and Methodology

An understanding of railcar rolling resistance is critical in the design and operation of railroad hump yards. The American Railway Engineering and maintenance-of-Way Association (AREMA) recommends specific rolling resistance factors for use in the calculation of hump height, gradient and retarder requirements at each yard. The current AREMA factors date to a 1982 Federal railroad Administration (FRA) study (Railroad Classification Yard Technology Manual – Volume 3: Freight Car Rollability) that remains the definitive resource on the topic. However, the data in this study are over 30 years old and do not include 286,000-pound gross rail load freight cars or any of the improvements in bearings and premium truck components made since that time. Although comprehensive data is presented in the study, the data is inconclusive on some points. For example, even at low speeds, it was observed that rolling resistance does increase with increasing speed. Also, rolling resistance of individual railcars was shown to change after they negotiated curves and turnouts. Neither of these effects is accounted for in the AREMA rollability calculations. Given this result, the study identified a number of open research questions that have not been addressed in the literature since. It is unclear if any of the classification yard speed control systems are accounting for these effects explicitly.

Internationally, there has been much research in China where a large number of hump classification yards have been constructed over the past two decades. Unfortunately almost all of these papers are in Chinese-language journals. Also, these results would only apply to Chinese rolling stock. There are a handful of recent English-language papers on rollability but they do not present new data. Instead they discuss different mathematical algorithms for predicting rollability and over-speed coupling incidents. These papers either use old 1970's data for training or data from China that might not be representative of the North American railcar fleet.

The potential exists to apply emerging analytical approaches to newly-collected freight car rollability data from active hump classification yards to gain new insight on the causal factors and relationships governing railcar rolling resistance. Using funding from the National University Rail Center (NURail), the Rail Transportation and Engineering Center (RailTEC) at the University of Illinois at Urbana-Champaign (UIUC) proposes to partner with one or more railroads to collect and analyze new rollability data from hump classification yards. The analysis will determine if current rolling resistance factors still adequately describe the rollability behavior of the freight car fleet or if new factors and relationships need to be considered in both design and operation of hump classification yards.

Research Tasks and Data Requirements

The proposed research project will be divided into several tasks to isolate different factors and hump yard rollability relationships. The scope of later tasks may be refined as the results of earlier tasks reveal interesting relationships to be investigated further.

Task 1 – Data Collection

To facilitate statistical analysis, a robust sample of railcar rollability data is requested from one or more hump classification yards. The requested rollability data is information that can be obtained using existing yard sensing devices (velocity, position and time) or is already derived from the hump yard control system (calculated estimates of rollability). Ideally the raw rollability data would be supplemented by additional information that describes the railcar, the yard and other local conditions. Specific items of interest include:

- **Calculated Rollability** in pounds per ton or equivalent grade for each railcar. Some understanding of how the yard control system calculates this value would be required to interpret its meaning. For example, is it static based on an initial test section or continually updated as the railcar progresses down the hump from the crest and passes additional timing points?
- **Time-speed-and-distance** data for each railcar either in the absence of calculated rollability or as a supplement to it. Within this information, maximum measured speed is the most important based on previous research linking rollability to speed even at yard speeds.
- **Gross railcar weight** (total given weight of load or empty condition).
- **Railcar type** according to AAR Mechanical Designation or similar identifier.
- **Railcar length** and/or **distance between truck centers.** Previous research has shown that longer cars have a higher curve resistance and a higher tangent rolling resistance after negotiating a tight curve or turnout.
- **Truck type** if the railcar features an improved steering design or standard three-piece trucks.
- **Reporting mark and car number** can allow the research team to look up railcar type, length and other attributes in UMLER if they are not directly included in any collected rollability data.
- **Wind speed and direction** at the time the railcar was humped.
- **Temperature**.
- **Moisture conditions** such as rain and snow.
- **Target distance from crest to couple** as uncertainty and errors compound the farther a railcar needs to roll.
- **Target track** assigned to the railcar together with the **yard layout** will allow the research term to deduce the pattern of switches and curves negotiated by the railcar. Previous research has suggested that not only does rollability increase in curves and turnouts but that the increased rollability persists on the tangents following curves and turnouts due to truck warp and resistance of the center bowl and side bearings to truck twist.

The target distance and target track factors are only applicable if the provided data includes velocity measurements made at group and tangent point retarder locations downstream from the mater retarder and initial rolling test section. If only the initial crest rollability measurement and master retarder velocity is available, there will not be any means for investigating the resistance factors of curves and turnouts and information on target track and distance is not required.

Ideally the supplied data will span multiple weeks of yard operations during a warm period of the year and a similar timespan during colder months. Many analytical techniques require large datasets to yield statistically significant results so data for longer periods of time are preferred. However smaller datasets may facilitate initial pilot studies of the existing rollability factors.

The deliverable for this task is a clean dataset that has been merged with supporting data as necessary to be suitable for subsequent statistical analysis.

Task 2 – Analysis of Data to Validate Current Rollability Factors

Statistical analysis of the provided data will be conducted to determine if the current AREMA rollability factors still fit the observed data. Important parameters include 2.5th percentile of rolling resistance (easy roller) and 97.5th percentile of rolling resistance (hard roller) during the summer and winter months. The analysis would revisit correlations in the 1982 FRA study to determine if relationships between rolling resistance and car type, truck-center spacing, wind, temperature and moisture are still valid.

If time, speed and distance data can be obtained for group and tangent-point retarder locations in the yard, additional analysis will attempt to validate the resistance factors for curves and turnout frogs.

The deliverable for this task will be a report documenting the results of the validation exercise.

Task 3 – Analysis of Data for new Rollability Relationships

In addition to attempting to validate previous rollability relationships, the research team will take a fresh look at the rollability data and potential causal factors to potentially develop new relationships. To compliment basic regression techniques, the research team will investigate a variety of more advanced analytical techniques such as quantile regression, clustering algorithms, support vector machine classification, fuzzy logic and neural networks.

The deliverable for this task will be a report documenting the results of the investigation with advanced analytical techniques.

It is envisioned that the results of Task 2 and 3 will be combined into a tool that can generate a design rollability histogram based on an input distribution of railcar type/weights and local climate factors.

Possible Future Research Tasks

While this data request relates to the statistical validation of rollability relationships, there are other potential research directions closely related to this topic that RailTEC would like to consider exploring in the future:

<u>Future Topic 1 – Truck Performance Detector Data as a Predictor of Railcar Rollability</u>

Truck performance detectors measure the ability of a railcar truck to rotate while entering and exiting curves. One hypothesized cause of “hard rollers” is railcar trucks with very high resistance to rotation such that they do not align with curves and tangents in the yard, creating an angle of attack and additional friction at the wheel-rail interface that increases rollability.

The proposed research would cross reference truck performance detector data and hump yard rollability data by reporting mark and car number to determine if there are any correlations between poor truck detector performance and high rollability values. The analysis may need to account for time elapsed and distance travelled between the truck performance detector reading and the rollability measurement. A very large database may be required to obtain sufficient matching records to drive statistical analysis.

The proposed research would make sue of the same data provided for Task 1 but would require a partnering railroad to provide truck performance detector data for the same time period.

Non-Disclosure

The UIUC research team will sign a Non-Disclosure Agreement prior to working with any data deemed sensitive by the railroad. In publishing and presenting research results, any sensitive information will be masked or otherwise presented as generalized results so as not to reveal key operational details. The RailTEC group at UIUC has extensive experience working with sensitive railroad traffic data on projects sponsored by the Association of American Railroads and various Class 1 railroads. Thus we are familiar with railroad concerns in this regard and the required steps to protect railroad business interests.