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Derailment Risk Calculation Incorporating Specific Track Maintenance Action

Background & Problem Statement

- It is widely recognized that derailment and safety risks for vehicles traveling over track can be functions of multiple factors happening over a span of track rather than just at a single location.
- Many vehicle dynamics caused derailments are a result of multiple track features interacting with vehicle characteristics over a distance at a given speed of travel.
- Vehicle dynamics simulation/calculation is a widely used method of accounting for these large numbers of important variables and providing a reasonably accurate method of identifying high risk vehicle dynamics locations along the track.
    - "Performance Based Track Geometry"
    - "Real-time VAMPIRE"
    - Neural Networks
- However, most (if not all) of these simulation risk identification methods lack the ability to assess the effects of actual maintenance practices on risk prediction.
- In other words, simulations can tell you that you have a risk, but can't say much from a practical standpoint about what can or should be specifically be done about it.

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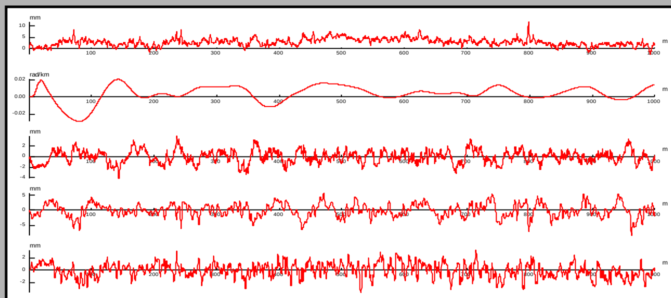
Background & Problem Statement

Questions this proposed study aims to help answer:

- What specific maintenance can or should be done to mitigate the predicted vehicle dynamics risk?
- Over what specific distance should the maintenance be performed? Specifically from where to where?
- What is the shortest distance that can be maintained to acceptably mitigate the risk?
- Is there more than one maintenance practice that will acceptably lower the risk? If so, which one best fits into the railroad's maintenance budget and plan?

Current State of the Art (based on my limited findings)

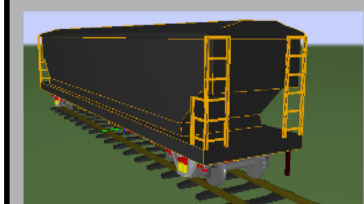
Simulation Process

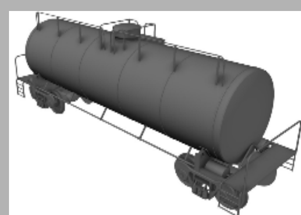


Measured Track Data Processed for Simulation

- **Gauge**
- **Cross Level**
- **Curvature**
- **Lateral Alignment**
- **Vertical Alignment**

Vehicle Simulation Models





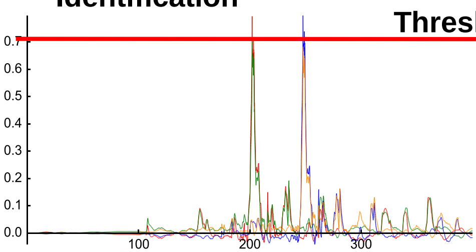
Report

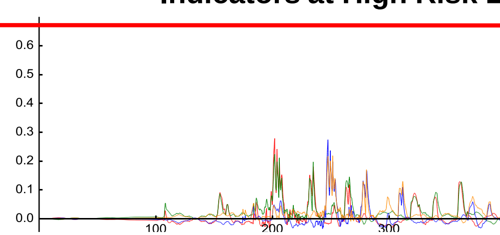
- **Derailment Indicator (e.g., L/V Ratio)**
- **Track Location**
- **Track Geometry Feature Most Contributory to Risk (e.g., Cross Level)**

High Risk Location Identification

Effects of *Estimated* Changes to Specific Track Features on Derailment Indicators at High Risk Locations

Threshold





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Some Problems with the Current State of the Art

- Current practice for modeling the “maintained” or “repaired” track seems to be to assume the effects of maintenance by arbitrarily smoothing or theoretically eliminating all or individual track geometry variations (e.g., individually make the cross level perfect and/or individually make the gauge perfect)
- This removes both amplitude and frequency content from the track model.
- Actual track maintenance practices cannot necessarily make things perfect (i.e., amplitudes of deviations are lowered but may not be completely eliminated and therefore frequency content is not eliminated either).
- Actual track maintenance practices likely will not exclusively affect just one track geometry feature, so assuming the correction or changing of one feature alone may not be realistic.
- Distances chosen over which to “Correct” the track geometry feature(s) are often arbitrary and may not be consistent with actual track maintenance practices.
- These current practices are not necessarily realistic and the results are not very practically useful to a track maintainer.
- A more useful report would indicate specifically what maintenance practices could or should be done and indicate from where to where on the track they should be performed.

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How Can We Improve the State of the Art?

- One potential avenue is to analyze track geometry measured before and immediately after known maintenance (as it turns out, this is much easier said than done).

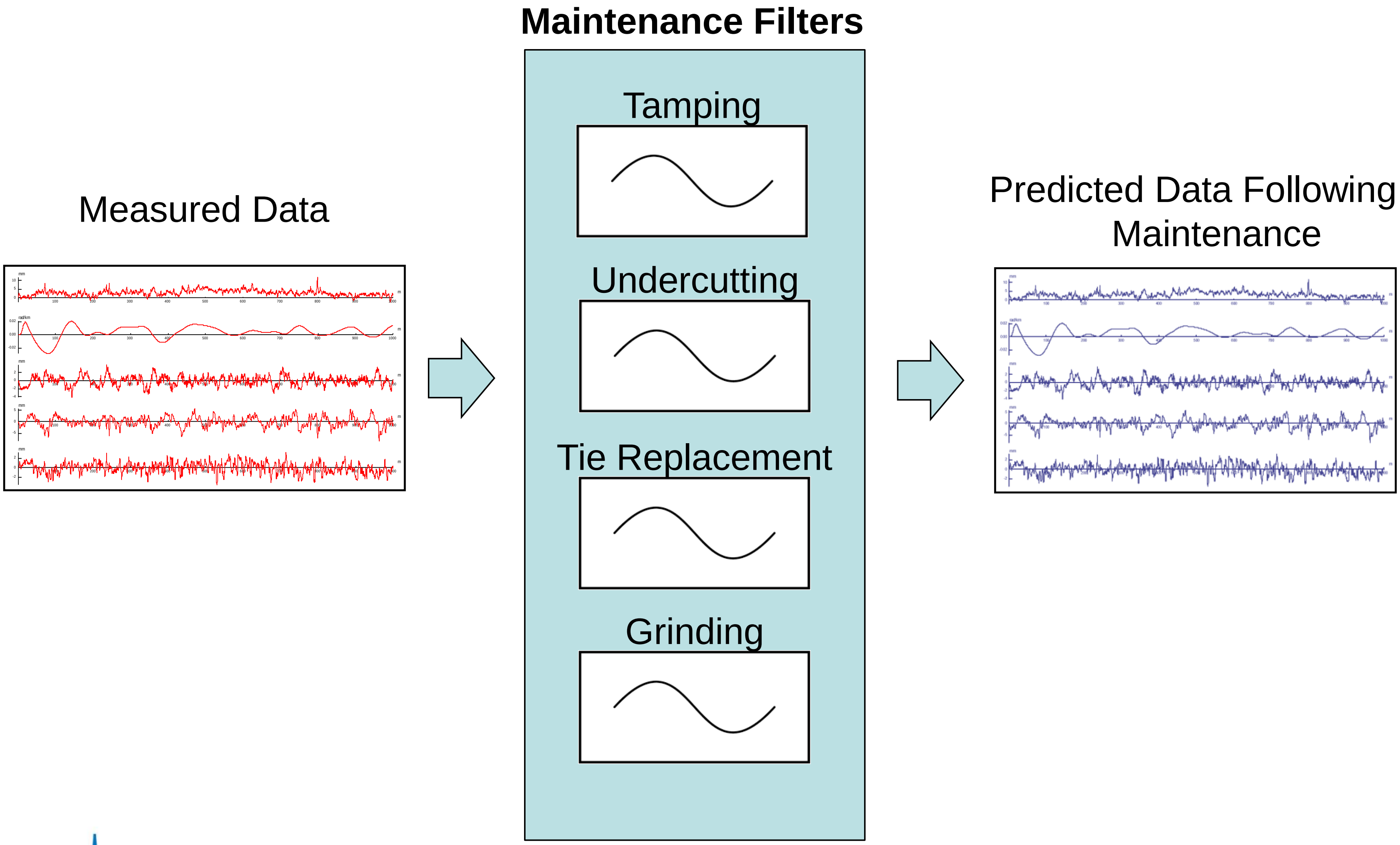
- This data could be analyzed to determine typical effects of specific maintenance actions on the amplitudes and frequencies of the constituent track geometry components (i.e., cross level, gauge, alignment, etc.).

- Track geometry from both before (input) and after maintenance (output) could be analyzed for amplitudes and frequencies to determine typical outputs from maintenance as well as any relationships between the inputs and outputs.

- From this type of analysis, typical "maintenance filters" can be devised that when applied to measured track geometry will give more realistic output geometry useful for predicting maintenance effects on vehicle dynamics.

- Further, when considering the minimum distance over which maintenance must be done to effectively mitigate the vehicle dynamics risk, actual maintenance practices should be considered. For example, if cross level variation is found to be the main contributor to high risk vehicle dynamics in a curve and tamping is the recommended maintenance action, the simulation must consider and take into account in the application of the maintenance filter that tamping done in a curve is done throughout the entire curve including the spirals.

Track Geometry Maintenance Filters



What Do We Need?

We need lots of before and after maintenance track geometry data and folks willing to analyze it (probably for free).

- Data from FRA geometry vehicles is not necessarily collected very frequently over a given route and has no connection to any maintenance that has been done so it's very difficult to say from the data alone what has been done or to separate the effects of maintenance from normal degradation due to traffic between infrequent successive geometry runs.

- Railroads may be able to help, but some who have been approached about this idea indicate that there is not necessarily a connection between the maintenance folks and the measurement folks. The railroad would have to create a special project and dedicate personnel that would head up efforts to correlate specific maintenance to before and after geometry car run data.

- Likely need to pull from multiple sources to get a representative picture which can be difficult to coordinate.

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