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Operational Response to Extreme Weather Events

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Any operational response to extreme weather should consider both the immediate risk that it mitigates, and any secondary risk that the operational response will introduce. A whole system risk model has been produced that is designed as a decision support tool for the railway industry to improve the current operational responses to extreme weather events. This initial iteration of the model considers how speed restrictions may be applied to mitigate the immediate risk from soil cutting failures during extreme convective rainfall. However, the scope of considering whole system risk can be extended to other extreme weather scenarios and operational responses.

Keywords: extreme weather, rainfall, earthworks, operational risk.

1. Introduction

During periods of extreme weather, a whole system approach to risk needs to be taken to ensure that any operational controls (speed restrictions or service suspension) limit the overall risk and not just the immediate risk posed from extreme weather. A whole system approach also considers the hazards that operational controls may introduce (crowding, signals passed at danger and fatigue) and the associated risks that accompany these hazards. With this balance of risk, a more informed decision can be made as to what the operational response should be during an extreme weather event.

2. Model Development

A statistical model has been developed based on analysis into the frequency of extreme convective rainfall events and their impact on soil cuttings on the Great Britain (GB) mainline railway. Gilchrist et al. (2022). The model takes the output of this analysis to consider the likelihood of failure of any soil cutting given the characteristics of the cutting in a range of extreme convective rainfall events. Ganthy (2022). The train service over the section of line is fed into the model and this is used to determine the probability and consequences of a train striking an obstruction caused by a cutting failure. Statistical analysis is then used to derive the risk from any operational controls that are imposed. The two risk values are accounted for in the model to determine the impact on the overall risk by the operational controls in that given scenario.

The immediate risk is calculated in two parts: the likelihood and associated speed of a train derailing, and the determination of the average consequences of such a derailment. An event tree is used to determine the first part of this, using a number of variables including the probability of a cutting failure and the train running speed. The consequences have been adapted from the event trees used in the Safety Risk Model, also developed at the Railway Safety & Standards Board (RSSB). The consequences are expressed in Fatalities & Weighted Injuries (FWI).

The model determines the delay minutes by considering the increased sectional running times from running at a reduced speed along with considering whether drivers need to be stopped and cautioned by signallers. Reactionary delays can also be calculated by the model, which depends on the location of the response.

Earlier work by RSSB looking at the Global System for Mobile Communication for Railways (GSM-R) failures established a strong correlation between train performance and certain types of hazards such as slip, trips & falls and passenger assaults. Gilchrist and Griffin (2016). The model uses the methodology of this work to convert the delay minutes into FWI, so that it can be compared with the immediate risk.

The model splits the outputs by operational route section. Within each section the model considers the immediate and secondary risk for each train type that runs across each section. This is determined by the characteristics of both the train type and the track that the trains are running on. Such characteristics include train speed, line speed, number of trains per day and the type of train (passenger, empty coaching stock or freight). As operational route sections can be short, the model can suggest a single operational response across multiple consecutive sections. This would consider the immediate and secondary risk across all the sections to suggest the most appropriate, and drivable, operational response.

3. Applying the model

The output of the model can be used to assist in any decision making for imposing operational controls on sections of the GB mainline railway. It can suggest the optimal operational response for a section of the network given the amount of convective rainfall that has been experienced over that section. This can range from no reduction in speed to a full suspension of services. The outputs of the model show the tradeoff between the reduction of the immediate derailment risk and the possible increase of other risks that may be introduced by the given operational response. The numerical values for both the immediate and secondary risk vary depending on the operational characteristics of the route and the severe weather being experienced.

Alongside the optimal operational response, the model outputs also show the overall risk balance for a range of other operational responses. This enables the user to understand how the risk balance changes as the operational response changes. As a decision support tool, the model outputs would need to be considered along with other operational factors. For instance, the final response would need to be drivable, without increasing the workload for railway staff. The risk posed from other hazards on the railway outside the modelling scope would also need to be factored into any final plan.

3.1. Model Trial

To determine how the model could be used as part of a wider whole system response, RSSB worked with Network Rail in March 2023 to apply the model across multiple route sections as part of a desktop exercise. The outputs of the model were not used on the network at this time, but the trial demonstrated how the model could be used as a decision support tool. A framework to incorporate the model as part of a larger decision making process has been drafted based on this exercise. RSSB continues to work with Network Rail to embed the model and any future iterations of it into the process for imposing speed restrictions during extreme weather.

4. Further development

The model currently focusses on convective rainfall and its impact on soil cuttings but the whole system approach could be applied to a far wider range of possible events that the railway faces. Future development of this model could consider frontal rainfall and how the operational response may need to be different in this scenario. Failures from embankments could also be incorporated into the model which would give a more holistic view of the risk posed by all earthworks on the railway. Development of a user interface for the model with fully automated inputs could enable the model to be used more widely and have a greater impact on the way operational controls are imposed across the whole GB mainline railway.

Even though the short term focus remains on using the model to provide operational decision support, the system risk-based view at operational route section level could be used in future to prioritise investment decisions. For example, instead of focussing remedial work on the asset in the worst condition, this approach could switch to focussing on the asset that poses the largest contribution to whole system risk.

References

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