



Abstract Title: Risk Targeted Speed Restrictions

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Background / Context

Gale-force winds can result in trees falling onto railway lines, posing serious safety risks and operational disruption. With climate change driving an increase in the frequency of extreme weather events, rail operators have traditionally responded by imposing blanket speed restrictions (BSRs) whenever gusts exceed a certain arbitrary threshold. While this precaution is sensible for rare occurrences, its repeated use is leading to significant, and increasing, delays, customer dissatisfaction at poor performance, and financial penalties.

As these events become more common, the cost and disruption associated with BSRs grow – not only for rail companies, but also for the wider economy due to disrupted public transport. This underscores the need for a more proportionate and targeted approach: one that safeguards passengers while avoiding unnecessary delays and costs. A response based on quantitative risk assessment offers a more balanced and sustainable solution

ADL developed and deployed a web-based decision support tool called GUSTO, a next-generation, web-based decision platform that dynamically quantifies the trade-offs between storm-induced speed restrictions and operational delay costs. Powered by data engineering and predictive analytics, GUSTO transforms asset, incident and weather data into actionable insights, enabling real-time, risk-informed decision-making at scale. The tool is currently in use across the UK, where it has already delivered significant cost savings and continues to generate measurable value



Objectives

How can rail organisations:

- Develop a robust, quantified estimate of the risk posed by treefalls during high wind conditions, by exploiting disparate data sources such as historical weather patterns, derailment risk and disruption data
- Support informed decision making regarding the timing and location of speed restrictions, while leaving room for the exercise of subjective professional judgement
- Remove the historical approach based on blanket speed restrictions by enabling more targeted, risk-based and geographically localised interventions
- Ensure the proposed approach maintains public and network safety, and remains legally defensible given that the removal to speed restrictions may be seen to decrease levels of safety.

Methods / Approach

The successfully delivered approach adopts a structured, data-driven approach to evaluating the risk of treefalls along transport corridors during gale force wind events. Primary data sources include incident records and meteorological data from proximate weather stations. The model analyses the frequency of delay-inducing tree falls and correlates these with wind conditions recorded on the same day. Events are categorised by wind speed to establish a probabilistic relationship.

The strongest correlation identified is between treefall frequency and the maximum gust speed over a 24-hour period, indicating that short-duration gusts are the principal drivers of disruption. Geospatial techniques are employed to align incident locations with the most relevant weather stations, ensuring accurate environmental attribution.

Risk distribution across the network is further refined using lineside vegetation data, captured via advanced technologies such as LIDAR-equipped drones. These datasets assess tree structural integrity and other vulnerability indicators. Lineside vegetation management is excluded from the model due to its limited impact on the overall risk profile for tree-fall events.

Additional model components include:

- **Debris Risk Estimation:** Accounting for other objects blown onto the line, such as signage or fencing.
- **Consequence Modelling:** Simulating outcomes of high-impact events (e.g. derailments) using scenario-based tools.
- **Wind Direction:** Considering how the probabilistic relationship between incidents and gust speed varies in a given geography.

Future enhancements aim to explore compound meteorological interactions – particularly the combined effects of wind direction, rainfall, and soil saturation – to improve predictive accuracy and operational resilience.

Results / Findings



Most treefall incidents on the railway occur during low wind conditions, due to their prevalence. However, when adjusted for exposure, there is a clear correlation between gust speed and treefall risk – higher winds significantly increase the likelihood of vegetation obstructing tracks.

While train-tree collisions are typically minor in terms of passenger safety, they are often highly alarming for drivers and cause superficial damage. Serious outcomes, such as derailments, are rare but possible. Nonetheless, the operational impact of such events is considerable, particularly when blanket speed restrictions are imposed during gale-force winds.

Cost-benefit analysis, especially when accounting for the costs associated with delays which can be estimated from socio-economic analysis or from allocated costs for each minute of disruption that exists on some railways, demonstrates that widespread speed reductions are rarely justified. . In the United Kingdom, where the model has been developed and deployed, the cost of delay is often grossly disproportionate to the marginal safety benefit, which under UK safety law means such measures are not necessary for the duty holder to discharge their obligations. Yet, doing nothing is not an acceptable option.

To address this, we adopted a targeted approach, applying speed restrictions only to high-risk segments of track. This strategy is guided by existing standards and typically activates around the 60mph threshold. By analysing topography, vegetation data, and historical incidents, our model identifies vulnerable areas with precision.

During its trial, we enabled selective restrictions that kept low-risk routes open, saving an estimated 10,000 minutes of delays during the recent Storm Isha in the UK’s Western Route alone. This outcome validates the effectiveness of data-driven, localised interventions in enhancing safety while preserving operational efficiency.

Conclusions

The model directly addresses the challenge of managing wind-related treefall risks while maintaining operational efficiency and public safety. By quantifying risk using topography, vegetation data, and incident history, it enables informed, proportionate decisions about where and when to apply speed restrictions. This supports a shift away from blanket measures toward targeted, risk-based interventions that uphold public and network safety under the ALARP principle. In practice, it has delivered material savings – most notably during Storm Isha, where it helped avoid an estimated 10,000 minutes of delays by keeping low-risk routes open. The tool has been well received across deployed routes and recognised with two major industry awards in 2024: the Railway Innovation Award and the Network Rail National Performance Award. GUSTO exemplifies how intelligent, data-led approaches can enhance resilience, reduce disruption, and support legally sound, cost-effective decision-making in adverse weather conditions.