Research Project Brief

Report 26-R51: Analyzing and Predicting Truck Travel Time Reliability

VTRC Virginia Transportation Research Council

Background

Reliable truck travel time is essential to Virginia's economy, and truck travel time reliability (TTTR) is one of the performance measures required for federal performance reporting. Current forecasting methods rely mainly on historical trends and do not fully reflect major drivers of unreliability, such as crashes, traffic growth, or post-COVID travel pattern shifts. VDOT needs a more robust, data-driven approach to set appropriate reliability targets.

Research Objectives

- Identify locations and causes of unreliable truck travel times.
- Determine the most influential factors affecting TTTR.
- Develop improved models to predict future TTTR for planning and PM3 target setting.

Approach

The study analyzed 2019–2025 National Performance Management Research Data Set truck travel time data for 1,743 interstate segments alongside traffic, roadway, crash, incident, and weather information. Three modeling approaches were tested: a hierarchical Bayesian model, random forest models for each period analyzed (AM peak, midday, PM peak, overnight, and weekends), and a simple linear trend baseline.

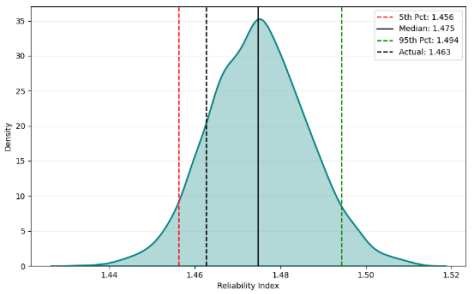
Outcomes

- COVID-19 caused a major statewide shift, increasing unreliability—especially at night and on weekends.
- About 21% of corridors that were stable before 2020 now show worsening patterns.
- Highly unreliable truck travel times were observed exclusively on urban interstates with high volumes and complex traffic dynamics.
- Key drivers of unreliability are high volumes and crash frequency. More travel lanes and higher posted speed limits were associated with more reliable truck travel times.
- The Bayesian model offers the best support for federal target setting because it incorporates uncertainty, detects structural changes, and generalizes better to new data than trend-based methods.

Research Benefits

The improved modeling framework helps VDOT set credible TTTR targets, identify critical freight bottlenecks, and prioritize high-value investments.

Network Level Prediction



Predictive Distribution of Truck Travel Time Reliability Index

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Research Findings

Systemwide Trends

Virginia's interstate TTTR has shifted significantly since the COVID-19 pandemic. Truck travel time reliability became much more unpredictable after 2020, and although conditions improved after 2022, reliability has not fully returned to pre-pandemic levels. Nighttime and weekend periods continue to show the greatest long-term decline.

Regional and Corridor Patterns

Unreliability is not evenly distributed. Northern and Eastern Virginia exhibit the most variability, driven by heavy traffic, complex interchanges, and bottleneck conditions. About 21% of studied corridors transitioned from stable to deteriorating between 2019 and 2024. The most consistently unreliable sites are on urban interstates near constrained facilities—including I-664E, I-495N , and I-395N—where congestion, high crash rates, and weaving movements amplify delays.

Key Factors Affecting TTTR

Across all analyses, **the strongest predictors of poor reliability are traffic volume, crash frequency, lane count, and speed limit**. Terrain and weather played comparatively minor roles.

Modeling Insights

Modeling results show that although random forests provide the most accurate point forecasts, the hierarchical Bayesian model is the most useful for planning because it captures uncertainty and structural changes in traffic behavior. Trend-only models overfit and are not reliable for forecasting.

Overall Conclusion

Virginia's interstate network has undergone meaningful shifts in TTTR since 2020, with clear high-risk corridors and recurring congestion patterns. Advanced, data-driven modeling—particularly hierarchical Bayesian forecasting—provides VDOT the tools needed to set credible PM3 targets and support smarter, reliability-focused investment decisions.