

Virginia Tech Transportation Safety Index (VTTSI)



Jason Cusati[†], Cheng-Shun Chuang[†], and Victory Uhunmwangho[†]
Computer Science, Virginia Tech

MOTIVATION

Current commercial navigation platforms (e.g., Google Maps) prioritize efficiency over safety. Traditional safety analysis relies on lagged historical crash data, failing to capture real-time operational turbulence.

The Goal: To create a transparent, cloud-native framework that fuses long-term crash history with real-time connected-vehicle telemetry to produce an interpretable **Safety Index (0-100)** updated every 15 minutes.

PROBLEM STATEMENT

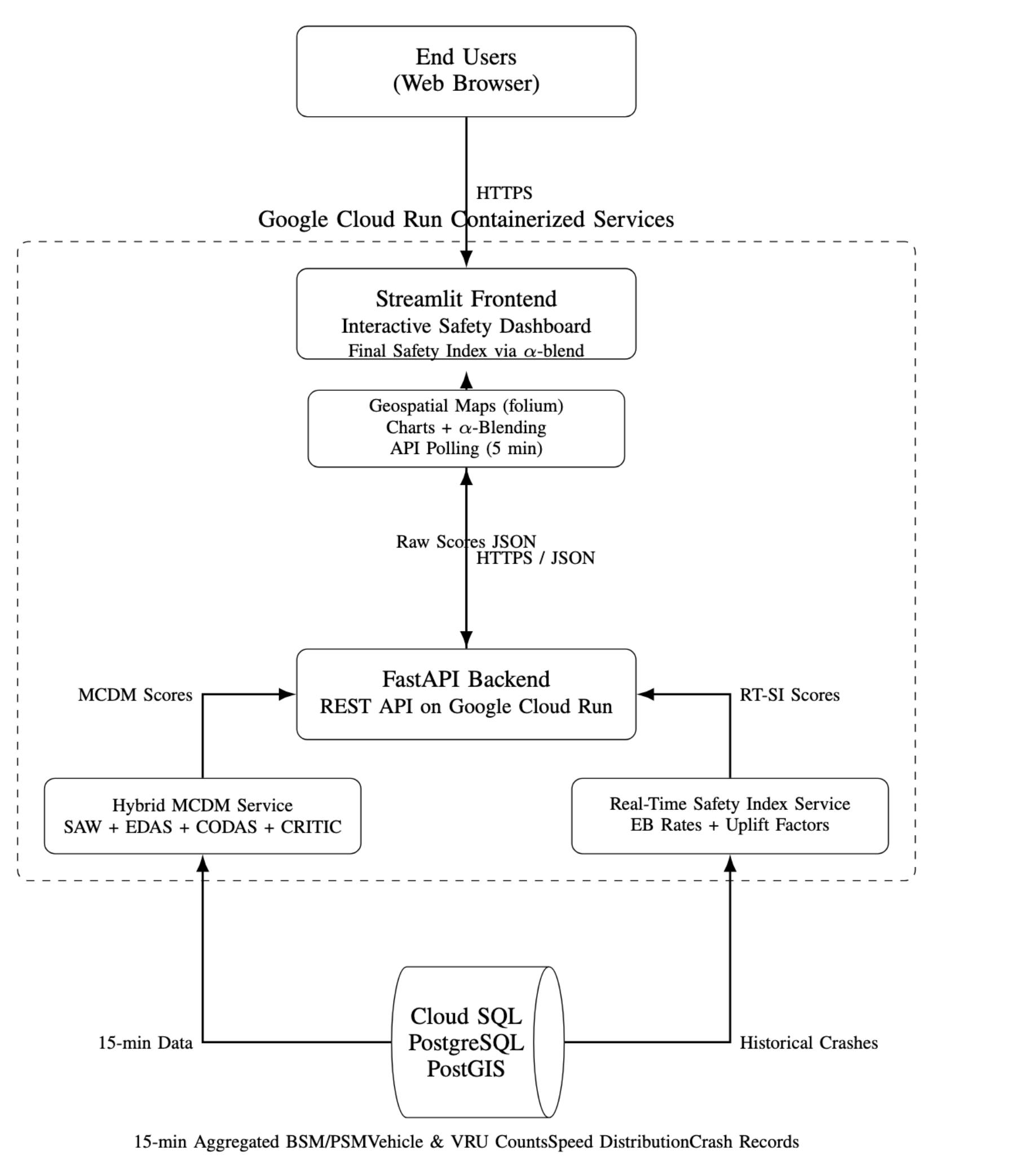
- Lagged Data:** Raw crash counts ignore real-time exposure and temporal variability.
- Black Box Scoring:** Vendor solutions lack transparency regarding algorithms and weighting.
- Integration Gaps:** Lack of integration between historical crash records (VDOT) and real-time telemetry.

SYSTEM ARCHITECTURE

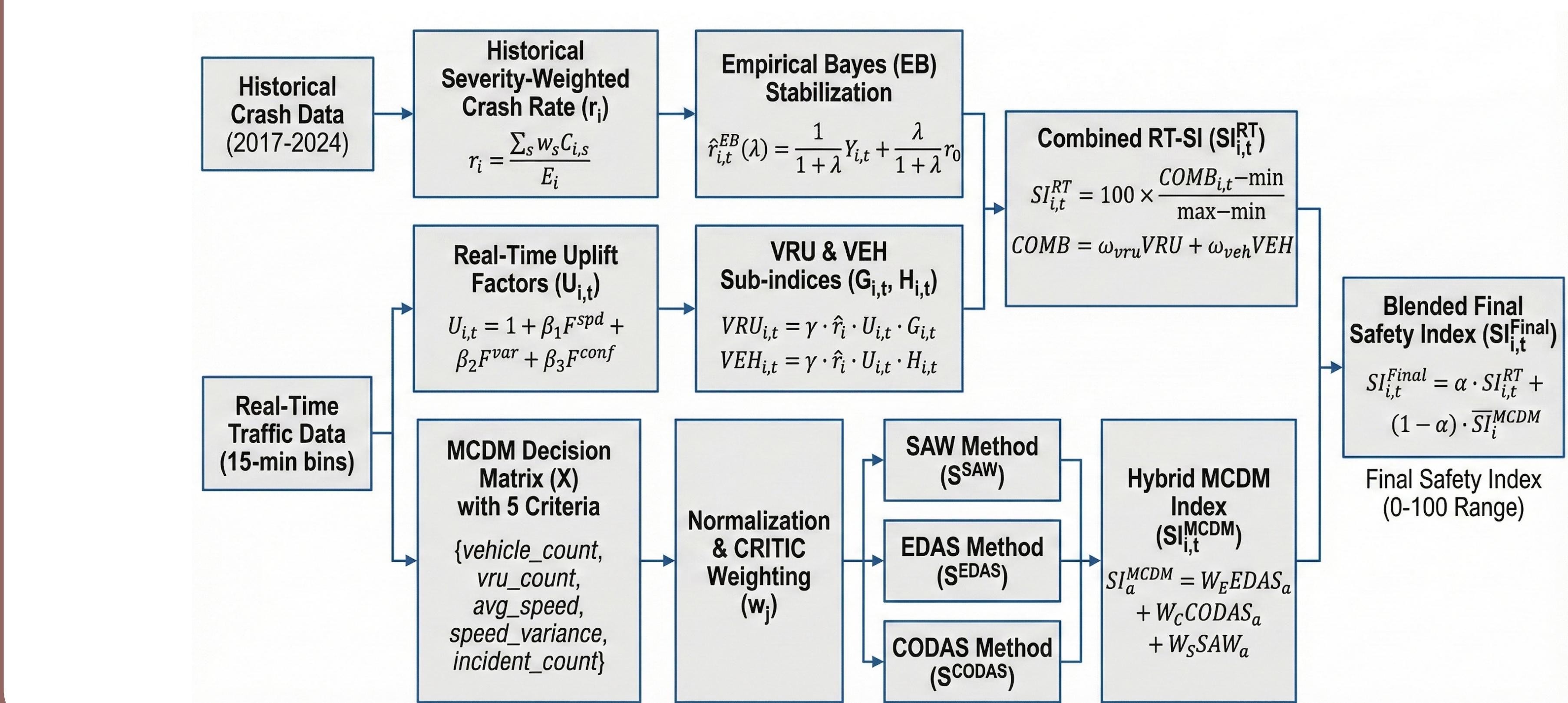
The VTTSI platform is a vertical cloud-native system hosted on **Google Cloud Run** and **Cloud SQL**:

- Frontend:** Streamlit dashboard for interactive geospatial visualization and α -blending control.
- Backend:** FastAPI (Python) service handling parallel computation of RT-SI and MCDM scores.
- Database:** Cloud SQL (PostgreSQL/PostGIS) storing VDOT crash history (2017-2024) and 15-min aggregated BSM/PSM data.

Figure 1: Cloud-Native Architecture



METHODOLOGY OF SAFETY INDEX



VALIDATION AND SENSITIVITY ANALYSIS

Figure 2: All variables comparison

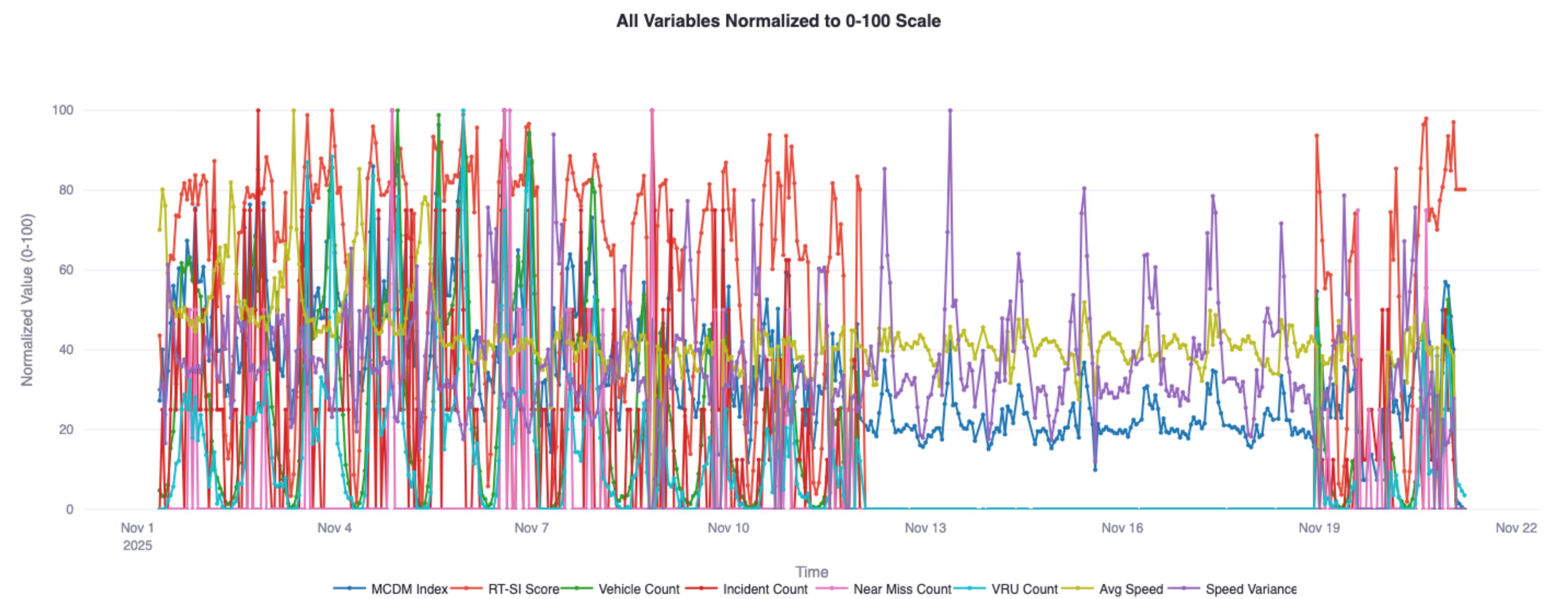


Figure 3: Final safety index blended

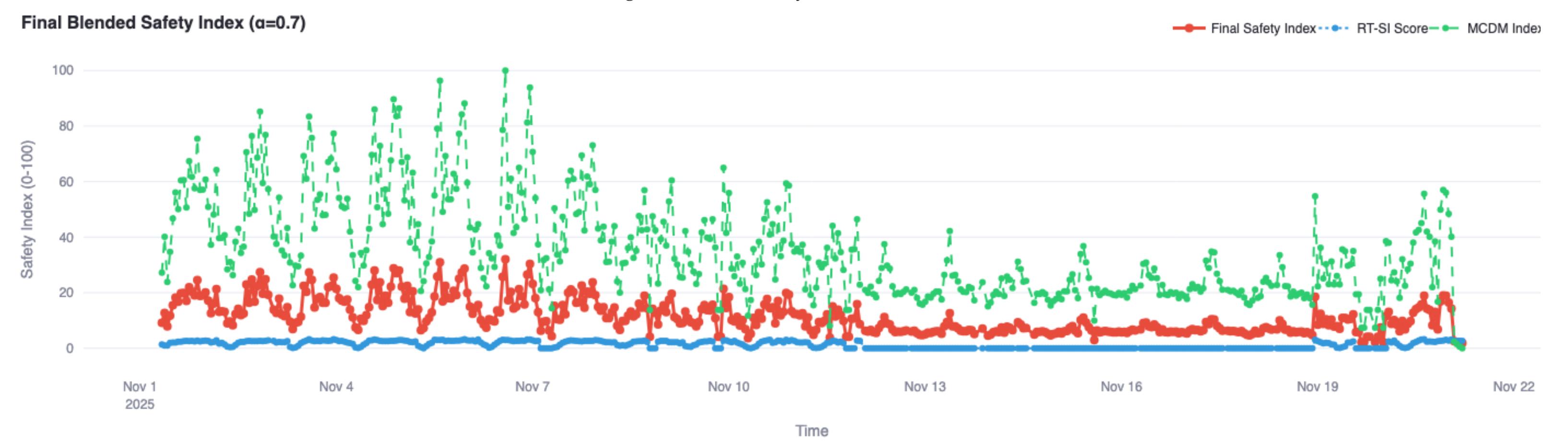
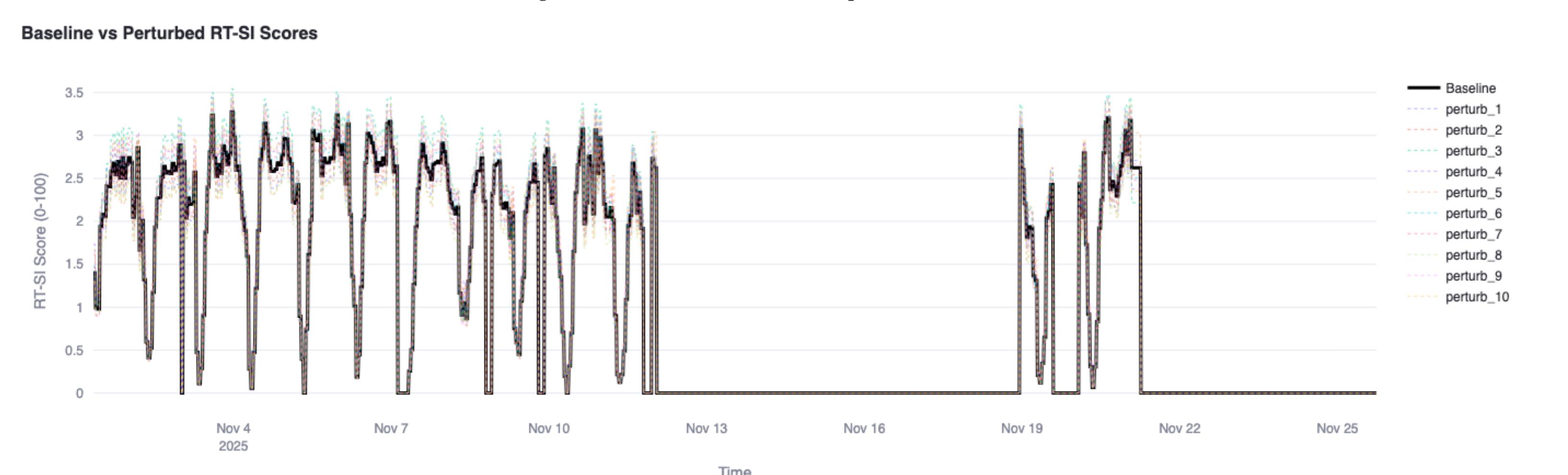


Figure 4: Perturbation results compared with baseline



- Case Study:** Glebe-Potomac Intersection (Nov 1-25, 2025).
- Temporal Consistency:** The index successfully captures diurnal traffic patterns (am/pm peaks).
- Responsiveness:** The MCDM component acts as an anomaly detector with spikes during high-volume/variance periods.
- Robustness:** Sensitivity analysis confirms the RT-SI is robust to parameter perturbations ($\pm 25\%$), with deviations generally remaining below 1 point on the 0-100 scale.
- Missing Data:** System degrades gracefully during sensor outages.

FUTURE WORK

- API Integration:** Expose VTTSI to Google Maps for safety-aware routing.
- V2X Ecosystem:** Standardized data exchange with Autonomous Vehicle (AV) control systems.
- Predictive Modeling:** Transition from reactive monitoring to AI-driven risk forecasting.