ORBITRISK

Satellite Conjunction Risk Modeling

Applied orbital analytics / research release 0.1

Abstract

OrbitRisk demonstrates a transparent public-data workflow for satellite close-approach screening. It ingests an attributed CelesTrak Stations TLE snapshot, propagates compatible elements with SGP4 in the TEME inertial frame, screens object pairs geometrically, and refines candidate times of closest approach. Public TLE data lacks covariance, so real-data outputs are restricted to miss distance and relative velocity. A separate synthetic encounter-plane experiment demonstrates probability sensitivity under stated Gaussian assumptions.

Data and propagation

The catalog is CelesTrak GP Stations data. Each parsed record retains NORAD ID, name, source TLE lines, epoch, inclination, eccentricity, and mean motion. SGP4 produces TEME position and velocity in kilometers and km/s. TEME is not treated as an Earth-fixed frame. Source retrieval time, individual epochs, and a SHA-256 snapshot checksum are published through the API.

Screening method

For each object pair, states are sampled at a 10-minute interval during a bounded prediction window. Pairs whose coarse minimum is plausibly near the screening threshold are refined by bounded scalar minimization of relative Euclidean distance. The resulting TCA, miss distance, and relative velocity are geometric estimates. This is a research screen rather than a conjunction-data-message or operational screening service.

Synthetic uncertainty experiment

For a controlled two-dimensional encounter plane, a Gaussian relative-position distribution with an explicit mean offset of two standard deviations is sampled with a fixed random seed. A hard-body radius gives a Monte Carlo collision frequency. The noncentral chi-square CDF is also reported under the same isotropic assumptions. These results are illustrative, not attached to any public-TLE event.

Validation and limitations

The test suite confirms that the preserved catalog parses, produces a valid SGP4 state vector, and yields reproducible seeded Monte Carlo output. It does not claim operational accuracy. Public TLE epochs can be stale, orbital state errors grow with time, and covariance is unavailable. Operational use requires authoritative state vectors, covariance, independent screening, and mission-specific hard-body models.

References

1. CelesTrak. GP Data Formats and Sources. https://celestrak.org/NORAD/documentation/gp-data-formats.php

2. Vallado, D. A. et al. Revisiting Spacetrack Report #3. AIAA 2006-6753.

3. Hoots, F. R., and Roehrich, R. L. Models for Propagation of NORAD Element Sets. Spacetrack Report No. 3, 1980.