Dhruv
Jain
Kayhan Space
Vishal Ray, Kayhan Space
Siamak Hesar, Kayhan Space
Poster
Satellite operations in Very Low Earth Orbit (VLEO) present severe challenges, primarily driven by complex atmospheric dynamics and high sensitivity to space weather perturbations. This study characterizes predictive state uncertainty in VLEO by isolating the impacts of space weather forecasting errors, specifically deviations in the Ap geomagnetic index and F10.7 solar flux, alongside horizontal wind modeling and maneuver execution errors. A reference-based framework is employed across varying space weather conditions to isolate secular trajectory deviations driven by atmospheric forecast inaccuracies, contrasting propagation with and without horizontal wind models to quantify their contribution to positional uncertainty. To complement this environmental assessment, a mission operations analysis isolates maneuver execution errors via a targeted Monte Carlo campaign evaluating thrust magnitude, direction, duration, and start delay. Results demonstrate that in-track dispersion dominates state uncertainty, growing most rapidly at lower altitudes (~250 km) where sensitivity to drag and unmodeled winds is maximized. Forecasting errors in Ap and F10.7 during elevated geomagnetic activity act as primary catalysts for this growth. Concurrently, the operational analysis reveals burn duration drives in-track and radial errors, while thrust direction dictates cross-track deviations, combining for up to 8 km of in-track uncertainty over a 3-day horizon. Finally, conditional geostorm probability analysis contextualizes these deviations, distinguishing nominal uncertainty evolution from high-impact tail risks. These findings provide important insights to enhance VLEO operations, improve space traffic coordination, and inform resilient operational services.
Poster session day
Wednesday, April 29, 2026
Poster location
35
Meeting homepage
2026 Space Weather Workshop
Download to PDF