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# ORBIT DETERMINATION ACROSS UNKNOWN MANEUVERS USING THE ESSENTIAL THRUST FOURIER COEFFICIENTS

**Abstract**

Tracking Earth orbiting objects in the space catalog is made difficult when these objects perform non-announced maneuvers, causing them to either be refit from scratch or "lost". We develop a method by which an unobserved maneuver can be fit through a tracking arc to the satellite data arc to be continued. An important part of this analysis is to understand how orbit covariance maps through an unobserved maneuver. Any maneuver performed by a satellite transitioning between two arbitrary orbital states can be represented as an equivalent maneuver involving Thrust-Fourier-Coefficients (TFCs). The selected "essential TFC set" consists of 6 constant coefficients : one in radial, two in normal and three in circumferential direction. With the essential TFC set, the basis of an unknown maneuver acceleration can be constructed and we are able to interpolate between two separate states across an unknown maneuver. This representation of an unknown acceleration using the essential TFCs facilitates the analytical propagation of uncertainties of the satellite state, which allows for the usage of existing covariance information to compute the orbit uncertainty at specific epoch after the unknown maneuver.

To verify that the state uncertainty propagated by the essential TFCs is similar to the true state uncertainty, analytical and numerical computation of the state transition matrix are examined for different orbit maneuvers. Orbit maneuver samples are based on either a low or high thrust maneuver and the orbit uncertainty is propagated using an unknown maneuver representation. Simulation results show that the linear propagation of state covariance using the essential TFCs can approximate the true distribution of the orbit even after an unknown maneuver. We also show that this should be true analytically.

To understand how measurement errors affect the performance of this approach, we apply the essential TFCs for orbit determination problems with simulated tracking data to compute the state uncertainty over the post maneuver arc. Using a batch filter, values of the essential TFCs are estimated and the uncertainty of the post maneuver state necessary to link two separate states is computed. The strength of this method is to maintain the state covariance of the space object across an unknown maneuver and be able to blend a new post-maneuver observation to decrease the state uncertainty. Development of this approach could allow us to reconstruct and characterize the maneuver. Also, this methodology can be developed to more easily correlate a newly acquired track with a known object.