## Sparse Grid Approach to Orbit Uncertainty Propagation

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## **Summary**

A sparse grid approach to orbit uncertainty propagation is presented. Efficient and accurate uncertainty propagation methods for nonlinear dynamic systems have been of enormous interest to space object tracking. Recent methods include those based on the time evolution of the probability density function, the statistical moments, the random samples, or a sum of Gaussian components. The idea of the sparse grid method for orbit uncertainty propagation is to represent the initial uncertainty by a sparse grid, propagate the sparse grid points individually through the nonlinear orbit dynamics, and compute the statistical moments from the propagated sparse grid points. The Smolyak rule is used to generate the sparse grid through linear combinations of low-level tensor products; the number of the resultant sparse grid points is polynomial in the dimension of the state. The sparse grid based uncertainty propagation may be considered a generalization of the Unscented Transformation (UT) of the well-known Unscented Kalman Filter but can achieve much higher accuracy levels than UT. Two examples of orbit propagation in different dynamic environments are used to show the efficacy of the sparse grid approach.