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SPACE DEBRIS SYMPOSIUM (A6)
Modeling and Risk Analysis (2)

Author: Ms. Alana Muldoon
University of California, United States, newmoon@soe.ucsc.edu

Dr. Gabriel Elkaim
University of California, United States, elkaim@soe.ucsc.edu
Mr. Brian Weeden
Secure World Foundation, United States, bweeden@swfound.org
Mr. Ian F. Rickard
(country is not specified), inio@soe.ucsc.edu

IMPROVED ORBITAL DEBRIS TRAJECTORY ESTIMATION BASED ON SEQUENTIAL TLE PROCESSING

Abstract

On 10 February 2009, an Iridium satellite collided with a defunct Russian satellite, destroying both and creating a cloud of debris that will remain on orbit for decades to centuries. A conjunction assessment on that day using the publicly available positional data for both objects, the US military's Two Line Elements (TLEs), calculated a predicted miss of just under 600 meters, and that the Cosmos-Iridium conjunction was not among the top ten most probable that day.

This case clearly demonstrates the need for better public positional data on all objects in Earth orbit. While TLEs, are useful for some purposes, they are provided as is, with no accuracy or covariance data. Further, each TLE has a steadily growing, oscillating error. Satellite owner/operators have very precise data on their own satellites but are generally not willing to share their more precise position data.

This paper summarizes our progress on two approaches to attempt to solve this problem:

(1) Using owner/operator data to validate the TLEs and improve other orbit data through a correlation analysis

(2) Using sequential TLEs to drive an underlying orbital model to improve orbit prediction and include covariance bounds on the position

Based on our prior studies of validating the TLEs from owner/operator data, it appears that the TLE reference frame has some systematic errors that can be corrected using truth data. These corrections have been shown to improve the prediction from the TLEs out as far as two years. Additionally, we present some basic cross-validation to show the benefits and limitations of using this technique to correct the orbits of other satellites in the same or similar orbits to those for which we have owner/operator data.

Using an underlying process model, and modern estimation methods, we process each sequential TLE as a new measurement update for our underlying model. By starting out with an initially large covariance, and by modeling the measurement noise covariance based on our studies of the truth validation models, we create not only a prediction capability for each TLE set, but also a confidence interval about the trajectory in the form of a process model covariance matrix. We show how well this works for satellites where we have owner/operator truth data, and demonstrate that this method is better than the existing TLEs.