57th IAA SYMPOSIUM ON SAFETY, QUALITY AND KNOWLEDGE MANAGEMENT IN SPACE ACTIVITIES (D5)
Prediction, Testing, Measurement and Effects of space environment on space missions (3)

Author: Dr. Vishal Ray
United States

DATA-STREAMS FOR A CALIBRATED COMMERCIAL ATMOSPHERIC DENSITY MODEL

Abstract

Uncertainties in orbit prediction pose significant challenges in conjunction assessment and collision risk mitigation in the low Earth orbit (LEO) regime. The primary orbit determination and prediction errors in low Earth orbit (LEO) are a result of uncertainties in the thermospheric density modeling. There are several thermospheric density models currently used in satellite operations such as the Mass Spectrometer Incoherent Scatter radar (MSIS), Drag Temperature Model (DTM), and Jacchia-Bowman (JB) series of models. However, significant differences are observed in the density output of these models, especially during active space weather conditions. These discrepancies can introduce complications in the assessment of prediction uncertainties between ephemerides from different satellite operators that use different density models. Most of these models have been calibrated using historical density datasets and predict the current state of the thermosphere at any given location using near real-time space weather drivers. To be consistent with the current average state of the thermosphere as experienced by orbiting satellites, the assimilation of near real-time density datasets is required by these models.

The Air Force has a data-assimilative model in use to maintain and predict its space catalog called the High Accuracy Satellite Drag Model (HASDM). HASDM is a real-time data assimilation framework ingesting radar tracking data of around 80-90 space objects and is considered the gold standard for atmospheric densities for operations. However, it is not available for non-military operational use.

In this work, we will discuss the elements required for the development of a near real-time calibrated atmospheric model for commercial use. Ensemble modeling techniques that combine multiple density models to improve upon the density forecast will be reviewed. The primary focus of this work will be the data-streams that can be ingested in such a framework. Precise Orbit Determination (POD) data from the Spire constellation will be used to obtain density estimates for data-assimilation. The uncertainties in the density estimates resulting due to the POD data quality and cadence, uncertainties in spacecraft parameters such as the ballistic coefficient, and attitude information will be assessed. The estimated densities will be validated against historical HASDM data. The error quantification of densities derived from multiple Spire satellites will enable the identification and flagging of ‘corrupt’ data-sources – sources that result in biased or noisy density estimates. This work aims to outline the processes required to obtain density estimates that can be ingested in a data-assimilative atmospheric model.