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Orbital Safety and Optimal Operations in an Increasingly Congested Environment (Joint Astrodynamics/Space Debris Session) (10-C1.7)

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UNCERTAINTY AND DATA OBSERVABILITY ANALYSIS FOR RSO MASS/ALBEDO-AREA ESTIMATION

Abstract

It has been shown that under idealized assumptions, it is possible to infer features such as mass and albedo-area for Resident Space Objects (RSOs) by exploiting the mutual information content in multiple electro-optical data sources, such as astrometric and photometric data. Further work has demonstrated the need to use accurate and physically consistent reflection models for both synthetic light curve and Solar Radiation Pressure modeling. The authors have further built upon this work by exploiting the physical link between SRP albedo-area and Observed albedo-area, and showing improvements in mass and albedo-area estimation performance for an idealized scenario with simulated data. However, there is much work to be done in order to apply this theory to an actual RSO using real electro-optical data.

The proposed research aims to quantify the sensing requirements, both from a quality and observability standpoint, to achieve unique identification and characterization of an RSO (specifically in terms of mass and albedo-area). Measures of information, such as Fisher Information, will be assessed. The RSO chosen for this work is the Meteosat Second Generation Satellite (MSG-2) cooler cover, which is essentially a spinning but apparently non-tumbling flat plate covered in MLI. The first phase of this research shall consist of modeling and simulation. The RSO will first be modeled in simulation with different initial conditions, sensor bias, measurement noise, and observability conditions. From a parameter estimation standpoint, of specific interest is how uncertainties in initial conditions affect the estimation process. An Unscented-Schmidt filter will be utilized to gain intuition of the observability of parameters by analyzing the Fisher information for each state parameter that is estimated. For assessing data quality and observability, the goal will be to model cadences in astrometric and photometric data, as well as develop a technique to normalize photometric data from different sources so as to render the data sensor-independent. The second phase of the proposed research shall aim at model validation. The results from modeling and simulation shall be used to develop and execute a data collection campaign in collaboration with the Astronomical Institute, University of Bern and Applied Defense Solutions for the MSG-2 cooler cover. Astrometric and photometric data on the MSG-2 cooler cover will be obtained and the techniques developed shall be used on this set of real data so as to analyze how the estimation process works on a real test case.