21st IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 21st IAA SYMPOSIUM ON SPACE DEBRIS (IPB)

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QUANTIFYING IMPROVEMENTS IN DEBRIS RISK ANALYSIS USING A CONSTELLATION OF SPACEBORNE OPTICAL SENSORS

Abstract

As the number of resident space objects (RSO) increases, operators face growing pressure for more accurate surveillance and collision risk analysis systems. Most of the space situational awareness domain depends today on ground-based telescopes and radar sensors, which have the disadvantage of being highly constrained in terms of their potential geographic positions. A more versatile approach may instead be using a constellation of spacecraft carrying space-based sensors. Such a distributed network of orbiting sensors can cover any desired orbital region allowing for complete coverage of RSOs, enabling a more accurate state estimation and consequent collision risk analysis. This work investigates quantitatively the benefits that an eventual network of orbiting sensors in LEO would bring to the current capabilities of the space surveillance network, in terms of improvement of the accuracy of predictions and number of detected conjunction assessments among RSOs. Collision risk assessment is performed through covariance analysis using unscented transform techniques and unscented Kalman filtering and assessed using Monte Carlo analysis. The simulation is carried out in three different scenarios: ground-based sensors only, space-based sensors only, and hybrid ground- and space-based sensors. Each of such scenarios is analyzed based on parametric analysis and trade-space explorations obtained by varying the optical features of the sensors, the orbital parameters and the number of satellites. Performance is evaluated in terms of accuracy on the orbit estimation, number of detected conjunction events, and probability of collisions calculated over short- and long-term prediction horizons. The outcome of the work is the performance evaluation in terms of collision risk assessment for each parametric analysis. After the scenarios are compared and discussed, the obtained results are used to inform the space community how to best use a combination of ground- and space-based sensors for enhanced collision risk analysis.