20th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 20th IAA SYMPOSIUM ON SPACE DEBRIS (IPB)

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DEVELOPMENT OF IDENTIFIABILITY SCORES FOR THE DETECTABILITY, IDENTIFIABILITY, AND TRACKABILITY ANALYSIS OF THE SPACE SUSTAINABILITY RATING

Abstract

The Space Sustainability Rating (SSR) is an incentive system operated by the EPLF Space Center with a consortium led by the World Economic Forum aimed to encourage space operators to reduce debris and collision risk. The design of the SSR seeks to produce quantitative metrics describing the sustainability of existing and proposed satellite missions. Satellite missions are assessed in different characteristics including their orbital fragmentation risk, collision avoidance capabilities, data sharing, and overall contribution to the space debris environment. One module of the SSR – Detectability, Identifiability, and Trackability (DIT) - relates to quantifying the level of difficulty with which a target satellite may be detected, identified, and tracked by ground-based observers not associated with the mission. Improving these capabilities is important for increasing space situational awareness of the target satellite.

The Detectability and Tracking (D&T) scores are based on statistical measures of the observable passes of the target satellite over a representative network of ground-based sensors spread across the globe. These measures include average visual magnitude, probability of radar detection, average pass duration, and average interval between passes. In this work, we introduce additional geometric measures of the passes including the average relative motion across the sky. These metrics aim to provide a more robust measure of the effectiveness of observations in improving the orbit determination and space situational awareness of the target satellite.

Previous publications have provided an in-depth overview of the D&T analyses currently implemented in the provisional version of the SSR. In this work, we develop new concepts for defining the Identifiability score, which aims to quantify how difficult it is to identify a target satellite based on orbital and photometric information derived from observation data. One potential metric for the Identifiability score is a measure of the density of cataloged objects in the vicinity of the target satellite. The study investigates the application of Kernel Density Estimation and k-nearest neighbor methods to generate density measurements in various multi-dimensional spaces related to the satellite's orbital elements or specific angular momentum components. An alternative approach is also investigated using distance-based metrics, quantifying the similarities of the target object to other objects in the catalog. We investigate various distance metrics computed in cartesian, angular momentum, and Keplerian element spaces. We evaluate these metrics for a range of representative satellite classes in order to determine their appropriateness for use as the Identifiability score in the SSR system.