Paper ID: 78705
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student

21st IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Space Debris Detection, Tracking and Characterization - SST (1)

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A SUFFICIENT GROUND-BASED MEASUREMENT SYSTEM CONFIGURATION TO ACHIEVE SPACE SAFETY REQUIREMENTS

Abstract

With the continuous increase of resident space objects (RSO) in near-earth space, it has become challenging to safeguard our space assets with the available ground resources. Computation of collision probability is an essential part of the safety assessment of active satellites, which requires estimating the position and velocity probability density function (PDF) of the active satellite itself and other potential candidate RSOs that can cause a collision. The estimation of position and velocity of RSO, is generally performed from range, range rate, azimuth, and elevation observations from ground stations. The 3-σ position estimation accuracy of less than 200m is recommended for an operational collision probability threshold of 0.001. It is well known that 200m of 3-σ accuracy in the tracking of RSO is only available sometimes due to multiple resource constraints, such as the limited number of sensors and physical constraints of the measurement system itself. In this article, we have analyzed the ground-based measurement accuracy and the number of ground station requirements to achieve 200m of 3-σ accuracy. This analysis is performed considering the RSO position and velocity estimation problem in a maximum a posteriori estimation framework and calculating the required measurement standard deviation and the number of observations to achieve the 200 m of 3-σ accuracy. It should be noted that the observations can be available in intervals, and the orbit uncertainty is propagated during this interval. We compute the maximum propagation time required to exceed the 200m accuracy threshold for various orbits, which provides insight into the maximum allowable propagation time interval. It can be deduced that maintaining 200 m of 3-σ threshold requires a trade-off between the number of ground stations, propagation time and accuracy of measurement systems. This analysis will aid sensor tasking and ground station allocation for space situational awareness.