22nd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Operations in Space Debris Environment, Situational Awareness - SSA (7)

Author: Dr. Darren McKnight
LeoLabs, United States

Ms. Erin Dale
LeoLabs, United States
Mr. Christopher Kunstadter
Triton Space LLC, United States

MODELING SHORT-TERM SPACE OBJECT POPULATION GROWTH IN LEO

Abstract

The rapid growth of operational satellites, mostly in a few large constellations, coupled with continuing on-orbit breakup events, and the abandonment of massive intact derelicts (collectively, "primary growth") have all contributed to a chaotic and dangerous environment. Each component of the population (i.e., constellations, clouds of fragments, and clusters of intact derelicts) has differing sources, complex inter-dependencies, self-regulating features, and uncertain future growth. We must characterize and quantify the ways this population may evolve over time to help with space traffic coordination, space safety, and constellation resiliency. The growth of the three components is modeled independently and the interaction between each component through collisions and other interactions, (collectively, "secondary growth") is added to the primary growth rates to create a total environment growth model. This predictive model will adhere to the forecasting best practice of looking backward twice as far as the model looks forward. As a result, trends over the last ten years will be used to create a model for the next five years.

The population evolution will be generated as the probability of events occurring "by" a certain year, not "in" a certain year, by accounting for long-term constant risk exposure. Considering objects that started interacting with each other decades ago and will continue to do so for decades to come as, effectively, long-term "conjunction experiments," allows us to determine the long-term average population growth. This can be affected by such diverse causes as space weather variations and anti-satellite tests. The pure examination of annual probabilities discounts these enduring collision risk dynamics. The growth of intact derelicts (rocket bodies and non-operational payloads) will be examined by number and mass. Secondary growth options for intact derelicts include explosions and collisions with fragments and other intact derelicts.

Primary fragment growth is a function of explosions or anti-satellite tests while the secondary growth is driven by collisions with intact derelicts. For certain altitudes, the onset of major debris-generating collisions between massive derelicts will be a major secondary source.

Operational satellite growth is the most speculative of the three primary growth components and there is no secondary generation. Historical deployment rates will be blended with proposed constellations with both funding and initiated regulatory submissions to determine their growth.

Model results are used to estimate the benefits of active debris removal, shortened post mission disposal (PMD) thresholds, and greater constellation reliability.