The Updated GEO Population for ORDEM 3.1

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The limited availability of data for satellite fragmentations and debris in the geosynchronous orbit (GEO) region creates challenges to building accurate models for the orbital debris environment at such altitudes. Updated methods to properly incorporate and extrapolate measurement data have become a cornerstone of the GEO component in the newest version of the NASA Orbital Debris Engineering Model (ORDEM), ORDEM 3.1. For the GEO region, the Space Surveillance Network (SSN) catalog provides coverage down to a limit of approximately 1 m. A more statistically complete representation of the GEO population for smaller objects, which can pose a high risk to operational spacecraft, is thus dependent on dedicated observations by instruments optimized to observe debris smaller than the SSN cataloging threshold. For ORDEM 3.1, optical data from the Michigan Orbital DEbris Survey Telescope (MODEST) provided the input for building the GEO population down to approximately 30 cm (converting absolute magnitude to size). For smaller sizes, the size distribution of debris in the MODEST dataset was extrapolated down to 10 cm, and orbital parameters were estimated based on the orbits of the larger objects.

When compared to previous versions of the model, significant improvements were made to the process of building the GEO population in ORDEM 3.1, both in the assessment of fragmentation debris in the data and assignment of orbital elements within the model. A so-called “debris ring” filter, based on a range of angles between an orbit’s angular momentum vector and that of the stable Laplace plane, was applied to the data to reduce biases from non-GEO objects, such as objects in a GEO-transfer orbit. In addition, a new approach was implemented to assign non-circular mean motions and eccentricities to the fragmentation debris observed by MODEST because the short observation window (5 min) in GEO requires a circular orbit assumption for assigning orbital parameters. For ORDEM 3.1, non-circular orbital elements were assigned using relationships that were identified between mean motion and the angle between the orbit plane and the stable Laplace plane, as well as between mean motion and eccentricity, for breakup clouds modeled by the NASA Standard Breakup Model. This approach has yielded a high-fidelity GEO model that has been validated with data from more recent MODEST observation campaigns.