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ANALYSIS OF ODMSP-COMPLIANT NEAR-CIRCULAR GPS DISPOSAL ORBITS AND RESULTING LONG-TERM COLLISION RISK

Abstract

The U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP) released in December 2019 include several disposal options that are applicable to GPS satellites. One option is to leave a satellite on a near-circular disposal orbit with limited long-term eccentricity growth. A second option is to use eccentricity growth to reenter the Earth's atmosphere within 200 years subject to several conditions. For the second option, the satellite must be able to target argument of perigee (AOP) of the disposal orbit to assure enough eccentricity growth. Many currently orbital GPS satellites will not be able to target AOP and are planned to move to disposal orbits above the GPS operational constellation and minimize eccentricity. Due to limited delta-V budget, the disposal orbits will be below the BeiDou Satellite System (BDS). The conditions in the ODMSP specify that GPS disposal orbits not cross the semi-synchronous zone (altitude range 20,182 +/- 300 km, occupied by GPS) or the BDS operational altitude for 100 years. Meeting these conditions will require a lower level of eccentricity growth than has been historically achieved. The ensuing increase in spatial density may result in an increase in collision risk between disposed GPS satellites. This is a concern because a collision will generate large amounts of debris that cross the GPS and BDS operational satellite altitude ranges. An analysis was performed to determine ways to achieve ODMSP-compliance of near-circular GPS disposal orbits and associated collision risk. A range of disposal orbits were propagated over 200 years using The Aerospace Corporation TRACE precision integration tool. These propagations were used to determine the available semi-major axis (SMA) range for compliant disposal orbits. Initial eccentricity values of 0.0003 and 0.001 were considered. Next, the GPS constellation and satellite disposals were simulated over a 200-year time frame. The disposal orbits were propagated using The Aerospace Corporation MEANPROP mean element tool. The collision probability between disposed satellites was then evaluated. Cases included selecting SMA at the mid-point between GPS and BDS and uniformly spreading the SMA over the available SMA range as satellites are disposed. Preliminary results show an available SMA range of 363 km for an initial eccentricity of 0.0003 and a range of only 3 km for an initial eccentricity of 0.001, which cover worst-case eccentricity growth scenarios. The overall study results and lowest collision risk strategy will be presented in the paper.