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INCREASED DEBRIS CLOUD DENSITY DUE TO PRECESSION OF ARGUMENT OF PERIGEE

Abstract

Several concepts have been proposed for reducing the orbital lifetime of small debris that involve creating "artificial atmospheric drag." These concepts suggest launching dust particles, frozen liquid, or high density gas into ballistic trajectories or short lived orbits to interact with debris objects in a manner similar to the Earth's atmosphere, thereby decreasing their orbital velocity and decreasing their orbital life. However, these concepts are expected to be somewhat inefficient. This is due to the relatively low spatial density of the debris, which results in very few interactions between the debris and the artificial atmosphere. Some have suggested that these methods could be more effective in response to an on-orbit breakup event. Initially all fragments from a breakup will pass through a "pinch point" during their orbit – the location in inertial space where the mishap occurred. The high spatial density at this location would make these methods much more efficient. Unfortunately, perturbations cause this pinch point to quickly dissipate. The J2 effect in particular causes the right ascension of ascending node of the fragments to precess at different rates due to the variations in their inclinations, semi-major axes, and eccentricities. As a result, the pinch point spreads out over hundreds of kilometers in a matter of days. Fortunately, the J2 effect also causes the argument of perigee of the fragments to precess. As a result the pinch point, where the debris are at nearly the same altitude, will drift either to the north or south, contracting as it travels. After several days to a few weeks (depending on the parent object's original orbit and the location of the collision or explosion) the pinch point will reach a maximum density at the orbit's extreme northern or southern declination. This delay in the re-coalescing of the pinch point will allow sufficient time to launch a response if pre-positioned assets are available. Using NASA's standard breakup model and an SGP4 propagator, this paper demonstrates that for two major breakup events a majority of fragments passed within a few tens or hundreds of kilometers of their pinch points even several weeks after the breakup. This would have provided sufficient debris spatial density for an artificial atmospheric drag concept or other debris remediation method to be effective. It also provided sufficient time for a pre-positioned response effort to be launched, had one been available.